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Original Research

Effects of temperature variation between neighbouring days on daily hospital visits for childhood asthma: a time-series analysis

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ABSTRACT

Objectives: To identify the relationship between temperature variation between neighbouring days (TVN) and hospital visits for childhood asthma in age- and sex-specific groups.

Study design: An ecological design was used to explore the effect of TVN on hospital visits for childhood asthma.

Methods: A Poisson generalised linear regression model combined with a distributed lag non-linear model was used to analyse the association between TVN and hospital visits for childhood asthma. All hospital visits for childhood asthma from June 2010 to July 2013 were included ($n = 17{,}022$). Daily climate data were obtained from Hefei Meteorological Bureau.

Results: A significant correlation was found between TVN and hospital visits for childhood asthma in age- and sex-specific groups. For different gender groups, the effect of TVN on childhood asthma was the greatest at 3 and 5 days lag for males and females. For different age groups, the effect of TVN on childhood asthma was the greatest at 1 and 5 days lag for 0–4 years and 5–14 years children, respectively. A 1 °C increase in TVN was associated with a 4.2% (95% confidence interval 0.9–7.6%) increase in hospital visits for childhood asthma.

Conclusions: TVN is associated with hospital visits for childhood asthma. Once the temperature change rapidly, guardians will be urged to pay more attention to their children's health, which may reduce the morbidity of childhood asthma.

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Introduction

Asthma poses serious risks to human health.[1,2] Worldwide, approximately 180,000 patients die each year due to asthma, and approximately 1% of all disability-adjusted life years lost are attributable to asthma.[3,4] The World Health Organisation estimated that approximately 300 million people suffer from asthma, and projected that the prevalence of asthma is increasing at 50% per annum (particularly among children). It has been estimated that the number of people with asthma will reach 400 million by 2025.[4–6] In China, the prevalence of asthma among children was 1.5% in 2000,[7] which was less than the world average (between 1% and 18%[8,9]). However, given the large population in China, the increasing prevalence of childhood asthma is an important public health problem.[10]

Associations between asthma and environmental factors have been found in previous studies. Numerous environmental factors (e.g. temperature, humidity, rainfall, wind, intensity of solar irradiation and barometric pressure) have a significant effect on the prevalence and morbidity of asthma.[11–13] In particular, the relationship between temperature and childhood asthma has attracted increasing attention in recent years, because children seem to be more vulnerable to respiratory diseases.[5] Some studies have shown a significant negative correlation between asthma and temperature factors (daily mean temperature, lower minimum temperature[14,15]), and implied that a low or cool temperature was the main environmental factor leading to asthma attacks. However, other studies have found a positive relationship between asthma and the diurnal temperature range and daily mean temperature.[16,17] It has also been found that extremely hot temperatures could trigger asthma attacks.[12,15] Previous studies have shown that asthma attacks are sensitive to regional climate.[18,19] These factors indicate that asthma attacks may be attributed to rapid temperature variation rather than the simple temperature index.

Studies on asthma have not been undertaken evenly across the world, and most have been based in developed countries. However, developing countries have poorer resources for adapting to and preparing for weather variance than developed countries, so developing countries are at greater risk.[20] Although the relationship between climate factors and asthma has been studied extensively, the view is not uniform in different regions with different levels of development. Therefore, more studies are urgently required to discover the true relationship between hospital visits due to asthma and temperature variation in developing countries. This study was designed to explore the relationship between hospital visits for asthma and temperature variation between neighbouring days (TVN) among Chinese children in age- and sex-specific groups.

Methods

Data collection

Hefei is located in the east of China (31°52′ N, 117°17′ E), and is the capital city of Anhui province. It is one of the most populous cities in China, with a total population of over 7.6 million in 2014 and land area of approximately 11,400 km^2. Hefei has a subtropical monsoon climate with four distinct seasons.[21] The daily data on hospital visits for asthma from 1 June 2007 to 31 July 2013 were obtained from Anhui Provincial Children's Hospital, which is the largest children's hospital in Anhui province, responsible for the health and medical care of almost 20 million children. Asthma cases were diagnosed by clinicians. Data were divided into age groups (0–4 years and 5–14 years) and sex groups. Daily meteorological data were obtained from Hefei Meteorology Bureau, including maximum temperature (°C), mean temperature (°C), minimum temperature (°C) and relative humidity (%) in Hefei during the same period. The TVN was calculated as the mean temperature of one day minus the mean temperature of the following day. In this study, all patient information was de-identified prior to analysis, and there was no conflict of interest with patients or other organisations.

Statistical analyses

Daily hospital visits for childhood asthma followed a Poisson distribution.[22] The relationship between TVN and hospital visits for childhood asthma was explored in the different age and sex groups using a Poisson generalised linear regression model combined with a distributed lag non-linear model (DLNM), which showed the effect of lagged and non-linear.[23,24] The model was designed to describe response of two-dimensional TVN relationship with the dimensions of childhood asthma and lag day by using function of cross-basis. First, a significant relationship was found between the number of hospital visits for childhood asthma and temperature variation using time-series analysis. Second, as several previous studies had found potential confounding effects due to relative humidity, mean temperature, seasonal patterns and long-term trends, these factors were controlled in this study using natural cubic splines.[22,25,26] Moreover, the day of the week (DOW) was adjusted in the model as a potential confounding factor. Finally, throughout the process, the optimal degree of freedom (df) was selected based on the minimum Akaike's Information Criterion (AIC), and the model fit was evaluated by analysis of residuals. The model is as follows:

$$Yd \sim Poisson(U_d)$$

$$\mathrm{Log}(U_d) = x + y\mathrm{TVN}_{d,l} + y(\mathrm{MT}_{d,5}) + z\left(\mathrm{Humidity}_{d,4}\right) + z(\mathrm{Time}_{d,7}) + g\mathrm{DOW}_d$$

In the model, d is the day of observation; l is the number of lag days; x is the intercept of the model; z is natural cubic spline; y and g are the vectors of coefficients for $\mathrm{TVN}_{d,l}$ and DOW_d, respectively; $\mathrm{TVN}_{d,l}$ is a matrix obtained by using the DLNM to TVN; $\mathrm{MT}_{d,5}$, $\mathrm{humidity}_{d,4}$ and $\mathrm{time}_{d,7}$ were used to control the mean temperature, relative humidity and seasonal patterns and long-term trends with 5 df, 4 df and 7 df, respectively; and DOW_d is the categorical day of the week with Sunday as a reference.

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