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Original Research

Effect of diurnal temperature range on the outpatient visits for acute bronchitis in children: a time-series study in Hefei, China

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ABSTRACT

Objectives: To determine the relationship between diurnal temperature range (DTR) and outpatient visits for childhood acute bronchitis (AB) in Hefei, China, to analyze whether DTR effect was delayed, and to explore the susceptible populations.

Study design: An ecological study.

Methods: A Poisson generalized linear regression model combined with a distributed lag non-linear model was used to analyze the relationship between DTR and childhood AB from Hefei, China during 2010–2013, after adjusting for long-term trend and seasonality, mean temperature and relative humidity.

Results: An adverse effect of DTR on childhood AB was observed, and the impact of DTR was greatest at three days lag, with a 1.0% (95% confidence interval = 0.5–1.6%) increase of AB cases per 1 °C increment of DTR. Female children and children aged 0–4 years appeared to be more vulnerable to DTR effect than other children.

Conclusions: Our study suggests that large DTR may increase the incidence of childhood AB in Hefei, particularly for those who are female and young. Caregivers and health practitioners should be made aware of the potential threat posed by large DTR.

Introduction

Acute bronchitis (AB) is an inflammation of the large bronchi (medium-size airways) in the lungs that is mainly characterized by cough.[1] This disease is one of the most common outpatient illnesses, with a higher incidence in the winter.[2,3] Currently, the typical therapies for managing acute bronchitis symptoms have been shown to be ineffective,[4] so it is particularly important to identify potential risk factors, in order to develop effective prevention and control strategies.

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Previous studies have documented that a variety of factors including viral infections, bacterial infections and climatic factors may promote the occurrence of AB.[5,6]

As climate change proceeds, the meteorological factors have attracted more and more research attention,[7–9] and ambient temperature has been found to be associated with bronchitis.[10,11] In recent years, diurnal temperature range (DTR), calculated as the daily maximum temperature minus the daily minimum temperature within one day, is a meteorological indicator closely associated with urbanization, global climate change and reflects the stability of the weather.[12] DTR has been suggested as an independent risk factor for human health by an increasing number of epidemiological studies.[13–16] Previous studies have identified that DTR is correlated with cardiovascular and respiratory diseases,[15,17] and it has been found that stress on the respiratory system increases during periods of extreme temperature change. Nonetheless, the potential impact of DTR on children's health has received less attention, and little is known about the relationship between DTR and childhood AB.

In the light of the above considerations, we hypothesized that large DTR may pose a threat to childhood AB. The aim of this study was to examine the relationship between DTR and outpatient visits for childhood AB, analyze whether DTR effect was delayed and explore the susceptible populations.

Methods

Data collection

The study was conducted in Hefei, the capital city of Anhui province, located in the eastern region of China (31°52 N, 117°17 E). Hefei has a temperate climate with four distinct seasons. It has an area of 11,434.25 km^2 and at the 2014 census, a population of 7,128,100 inhabitants (National bureau of statistics of China).

Data on daily counts of AB among children aged 0–14 years from 1st June 2010 to 31st July 2013 were obtained from Anhui Province Children's hospital. The data including gender, age, address, date of onset and diagnostic code were extracted by two authors (X.M. and Z.D.). The cases were included according to the International Classification of Disease, 10th version (ICD-10) for acute bronchitis (ICD-10 codes: J20). Ethical approval was obtained from the Ethics Committee of Anhui Medical University prior to the acute bronchitis cases being collected.

In addition, daily meteorological data including maximum, minimum, and mean temperature and relative humidity were collected from Hefei Meteorological Bureau. DTR was calculated as the daily maximum temperature minus the daily minimum temperature.

Statistical analyses

Winter (December–February) was chosen as the main study period because it has a relatively high incidence of childhood AB. As the daily counts of AB generally follow a Poisson distribution, a statistical analysis using Poisson distribution was used. Meanwhile, previous studies have shown that the relationship between DTR and human health was lagged and best described as a non-linear curve.[18] Therefore, a Poisson generalized linear regression model combined with a distributed lag non-linear model (DLNM) was applied to quantify the effect of DTR on childhood AB.[19–21] DLNM is a modeling framework, which can describe complex non-linear and lagged dependencies in time-series data.[22] This model is rested on the definition of a cross-basis, a bi-dimensional functional space describing concurrently the shape of the relationship along both the space of the exposure and the lag dimension of its occurrence. A smooth function of time to capture the effect of confounders changing slowly over time in the model, expressed as seasonality or long-time trends.

A model was built, in which mean temperature, relative humidity, seasonality, long-term trend and day of week (DOW) were considered as the potential confounders. In this paper, mean temperature and relative humidity were controlled by using a natural cubic spline with 3 degrees of freedom (*df*). Seasonal patterns and long-term trends were controlled by using a nature cubic spline with 2 *df* per year. DOW was controlled as a categorical variable. In all cases, the Akaike Information Criterion and analysis of residuals were applied to evaluate the choice of *df* and the model fit. The basic model was:

$$Y_t \sim \text{Poisson}(\mu_t)$$

$$\text{Log}(\mu_t) = a + bDTR_{t,l} + ns(MeanT_t,3) + ns(RH_t,3) + ns(Time_t,2) + cDOW_t$$

Where t is the day of the observation, Y_t is the daily number of childhood acute bronchitis on day t and a is the model intercept. b is vector of coefficients for $DTR_{t,l}$. $DTR_{t,l}$ is a matrix obtained by applying the DLNM to DTR, and l is the lag days. ns denotes the natural cubic spline. c indicates the vector of coefficient for DOW_t.

We found the effect of DTR on childhood AB was negligible for lags above six days. All effect estimates were presented as relative risk, using a reference DTR of 10.9 °C, which corresponded to the 75th percentile of DTR level covering the whole study period. The percent change of childhood AB associated with a 1 °C increase in DTR was used to reflect the influence of DTR on childhood AB. Furthermore, we performed the stratified analyses by gender (male and female) and age group (0–4 years and 5–14 years) to identify the susceptible populations.

Sensitivity analyses were performed to assess the impact of model choices by varying the *df* for time (1–2 *df*/year), mean temperature (3–5 *df*) and relative humidity (3–5 *df*). All data analyses were performed using the R statistical environment (version 3.1.1) with the 'dlnm' package to fit the regression model.[22] For all statistical tests, two-tailed $P < 0.05$ was considered statistically significant.

Results

There were 14,055 cases of AB among children aged 0–14 years in Hefei across the whole study period. There were more male cases with a male-to-female sex ratio of 2.4:1 (9918:4137). Table 1 shows the basic information, including meteorological