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Public Health

journal homepage: www.elsevier.com/puhe

Association between air pollution and upper respiratory tract infection in hospital outpatients aged 0–14 years in Hefei, China: a time series study

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ARTICLE INFO

Article history:
Received 12 January 2017
Received in revised form
30 May 2017
Accepted 7 December 2017

Keywords:
Air pollution
Children
Upper respiratory tract infection
Generalised additive model

ABSTRACT

Objective: To investigate the association between air pollution and upper respiratory tract infection (URTI) in children aged 0–14 years in Hefei, China in 2014–2015.

Study design: An ecological method (i.e. generalised additive model [GAM]) was used to explore the effects of air pollutants on paediatric hospital outpatients with URTI.

Methods: GAM was used to evaluate the lag effects (including lag0 to lag6, lag01 and lag06) between daily changes in particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3) and carbon monoxide (CO) and the number of hospital outpatients with URTI in 2014–2015, after controlling for the confounding effects of long-term trends, seasonality, day of the week, public holidays and meteorological factors.

Results: PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO in the single-pollutant models had significant positive effects on the number of paediatric hospital outpatients with URTI. It was found that per 10 $\mu g/m^3$ increasing in concentrations of PM_{10} at lag3, $PM_{2.5}$, SO_2, NO_2 and CO at lag06 were associated with an increase of Excess risk (ER) with 0.15% (95% CI: 0.07%~0.23%), 0.38% (95% CI: 0.17%~0.60%), 2.92% (95% CI: 1.88%~3.97%), 4.47% (95% CI: 3.69%~5.25%) and 0.05% (95% CI: 0.02%~0.08%), respectively. Only NO_2 remained significantly positively associated with the number of hospital outpatients with URTI in the full-pollutant models, and ERs were 4.72% (95% CI = 3.76%–5.69%) and 4.70% (95% CI = 3.76%–5.65%) per 10 $\mu g/m^3$ increase in NO_2 in Model 1 (including PM10, SO_2, NO_2, O_3 and CO) and Model 2 (including $PM_{2.5}$, SO_2, NO_2, O_3 and CO), respectively.

Conclusion: This study showed that short-term exposure to air pollution was associated with increased risk of URTI among paediatric hospital outpatients aged 0–14 years in Hefei. NO_2 was the major air pollutant affecting the daily number of paediatric hospital outpatients with URTI.

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https://doi.org/10.1016/j.puhe.2017.12.006

Introduction

Respiratory diseases are the predominant cause of death in China[1] and globally, affecting more than one billion people worldwide.[2] Upper respiratory tract infection (URTI) is responsible for 81% of emergency room hospital outpatients for respiratory diseases in children aged 0–18 years.[3] A recent cross-sectional morbidity study in Hong Kong revealed that 26.4% of hospital outpatient cases were due to URTI.[4]

Air pollutants, such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3), cause irritation and constriction of the large airways.[5] Various studies have indicated that particulate matter is associated with increased morbidity from respiratory infections.[6,7] Many epidemiological studies have demonstrated that a short-term increase in outdoor air pollutants, such as PM_{10}, $PM_{2.5}$, NO_2, CO and O_3, is associated with an acute increase in the number of children attending hospital as outpatients with URTI.[7–9] However, the majority of these studies were conducted in Western countries, where the demographic characteristics differ from those in Asian countries. These studies demonstrated that the increased risk of hospital outpatients associated with a short-term increase in outdoor air pollution was primarily due to respiratory outpatients. Studies on the adverse effects of air pollution on hospital outpatients with respiratory diseases are quite scarce in Asia, with even fewer in China. To the authors' knowledge, studies have only been undertaken in Beijing,[10] Guangdong,[11] Hong Kong[5] and Taiwan,[7] and no previous studies have examined the association between air pollution and paediatric hospital outpatients with URTI in Anhui Province. Air pollution and population characteristics vary from region to region. There is a need to express the uniqueness of Hefei region and to replicate the findings in other Chinese cities.

With rapid development of the economy, Hefei has experienced slight transient air pollution and severe air pollution, with a sharp increase in air pollutant emissions. Air pollution is now a worldwide phenomenon and has attracted attention in terms of its adverse effects on human health.[12,13]

Children are more vulnerable to air pollutants than adults and should receive greater attention[14,15] because of their higher breathing rate, narrower airways, developing lungs and immune systems and more frequent exposure to outdoor air.[9]

The aim of this study was to evaluate the short-term effects of daily air pollutants (including PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO) on paediatric (age 0–14 years) hospital outpatients with URTI in Hefei in 2014–2015 using the generalised additive model (GAM). Various limitations of previous studies were addressed by examining lagged effects and the moving average effects of air pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO). The results of this study will provide evidence for health risk assessment and development of public health policies.

Methods

Study areas

Hefei (32° N, 117° E), the capital of Anhui Province, covers an area of 11,434 km^2 and had a total population of 761.1 million in 2013. The weather in Hefei is generally mild and moist, with four distinct seasons: a warm spring, a hot rainy summer, a cool autumn and a cold winter. The highest temperatures occur in July and August, and the lowest temperatures occur in January and February.

Data collection

Hospital outpatient data

Data were collected for hospital outpatients with URTI, aged 0–14 years, attending Anhui Province Children's Hospital between 1 January 2014 and 31 December 2015. Data included date of birth, age, sex and International Classification of Diseases 10th Revision (ICD-10) diagnostic codes. URTI (J00–J06) in this study included cold, rhinitis, sinusitis, pharyngitis, laryngitis, angina, tonsillitis, acute URTI, viral URTI and bacterial URTI.

Ambient air pollution data

Daily ambient air pollution data were provided by Hefei Environmental Monitoring Station, which included measurements of 24-h PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO, and 1-h O_3 between 1 January 2014 and 31 December 2015. Daily air pollutant data were calculated by averaging the data from 10 monitoring stations in Hefei. If data were missed for a particular monitoring station on a given day, the daily average values were calculated using the data recorded from other monitoring stations. Fig. 1 shows the location of Hefei in China and the distribution of the 10 monitoring stations in Hefei.

Meteorological data

Daily meteorological data, including daily average temperature, daily average barometric pressure, daily average relative humidity (RH), wind speed and precipitation between 1 January 2014 and 31 December 2015 were obtained from Hefei Meteorological Bureau.

Statistical analyses

GAM with log link function and Poisson family was employed to explore the associations between air pollutants and daily hospital outpatients, since the daily hospital outpatients approximately followed a Poisson distribution, and the relationships between hospital outpatients and explanatory variables were mainly non-linear.[16] A non-parametric smoothing spline function was used to control for the confounding effects of long-term trends, seasonality, day of the week, public holidays and meteorological factors.

First, the basic model was constructed, without an air pollutant and with other covariates, including time, day of the week and public holidays. Smoothing spline functions were then introduced to control the meteorological factors. Akaka's Information Criterion (AIC) was used to measure how well the model fitted the data. The smallest AIC value indicates the preferred model. Daily average temperature, daily average barometric pressure, wind speed, RH and precipitation were included step by step into the model. If the AIC value was smaller when a new variable was introduced, the variable remained in the model. Due to the colinearity between RH and