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Air pollutants and asthma patient visits: Indication of source influence

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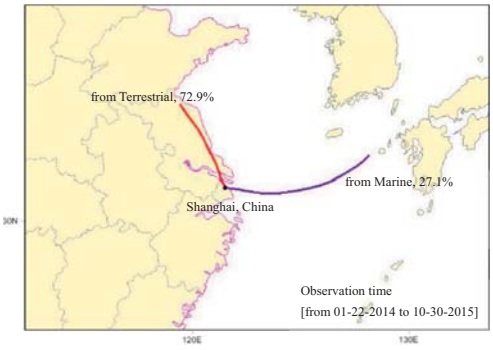
HIGHLIGHTS

- All of the pollutants except O_3 mainly come from terrestrial during observation.
- All of the pollutants except NO_2 displayed the highest effect for relative risk of asthma in the spring.
- $PM_{2.5}$ and CO are major pollutant affecting the relative risk of asthma patient visits in Shanghai.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Sources of air pollutants are significant factors for adverse health effect. Few current studies explored the linking of sources influence and ambient pollutants to asthma patient visits in Shanghai, China.
Objectives: This study explored the associations between short-term exposures to ambient pollutants and asthma morbidity with terrestrial and marine source influence in Shanghai.
Methods: Generalized additive model (GAM) was used to explore the association of daily patient visits and ambient pollutants. These analyses were calculated in R statistical software in mgcv package. PSCF modeling was used to locate potential source areas contributing to the concentrations of pollutants.
Results: We found that per IQR of $PM_{2.5}$, PM_{10}, NO_2, SO_2, O_3 and CO in terrestrial source were associated with an increase of 6.63% (95% CI: −0.27% to 14%), 6.48% (95% CI: 0.06% to 13.3%), 1.68% (95% CI: −2.68% to 6.24%), 2.81% (95% CI: −1.42% to 7.22%), −0.60% (95% CI: −5.94% to 5.04%) and 16.6% (95% CI: 8.68% to 25.2%), respectively in asthma patient visits. Per IQR of $PM_{2.5}$, PM_{10}, NO_2, SO_2, O_3 and CO in marine source were associated with an increase of 5.34% (95% CI: 0.42% to 10.5%), 3.84% (95% CI: 0.08% to 7.74%), 3.21% (95% CI: −0.92% to 7.52%), 2.58% (95% CI: −1.02% to 6.30%), 1.42% (95% CI: −3.10% to 6.15%) and 8.81% (95% CI: 2.56% to 15.4%). The PSCF show all of the pollutants except O_3 mainly come from terrestrial during observation. We also found that all of the pollutants except NO_2 displayed the highest effect in the spring for relative risk of asthma morbidity.
Conclusions: Ambient air pollutants that cause an increase in asthma patient visits, such as $PM_{2.5}$, PM_{10}, NO_2, SO_2 and CO are mainly produced from terrestrial sources, while O_3 is primarily from marine sources. The association of ambient pollutants and asthma patient visits is closely related with seasons, especially with spring. $PM_{2.5}$ and CO are major air pollutants increasing the relative risk of asthma patient visits in Shanghai.

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1. Introduction

Exposure to ambient air pollution affects a range of clinical aspects of asthma from 2010 (Deng et al., 2016; Mirabelli et al., 2016). Acute exposure to particulate matter with an aerodynamic diameter < 2.5 μm ($PM_{2.5}$) is linked to increase risk of asthma mortality, pneumothorax and respiratory failure exacerbation (Jouneau et al., 2014; Ko et al., 2007; Liu et al., 2016; Wang et al., 2016). Epidemiological studies also suggest that exposure to nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ozone (O_3) may increase asthma morbidity (Bao et al., 2014; Dijkema et al., 2016; Wigenstam et al., 2016). The children, elderly and those with potential diseases, for example, asthma diseases, are particularly susceptible to affect the health of PM and gaseous pollutants (Cakmak et al., 2011; Ding et al., 2017). However, current evidences for the hazards of PM and gaseous pollutants from different sources on asthma patients are inconclusive (Guarnieri and Balmes, 2014).

Understanding the relative contributions to ambient air pollutants from anthropogenic and natural sources, as well as terrestrial and marine sources, is imperative to make realistic decisions about reducing their health impact on human health. Regarding terrestrial sources, recent literatures have showed a possible effect of the traffic emission on asthma morbidity (Delfino et al., 2014). For example, 348.19 million tons of coal equivalent was consumed by the transport sector in China in 2013, which led to serious air pollution (Lu et al., 2015). Specifically, the emissions of CO, NO_x and PM from passenger vehicles were 18.95, 18.89 and 0.12 million tons, respectively. Such emission levels exceed the global and national standards (Vahlsing and Smith, 2012). Empirical evidence suggests that transport-related air pollutants have serious effects on human health, by increasing the risk of lung cancer (Reungoat et al., 2003), respiratory (Ramos et al., 2016) and cardiovascular disease (Bonyadi et al., 2016). Accordingly, air pollution generated from traffic-related source is responsible for a significantly excessive number of deaths and hospital admissions. The emissions from the combustion of biomass and coal in the houses where people resides were also found to be caused high asthma morbidity (Jie et al., 2014). Other studies have evaluated the sources of exposure to air pollutants and found increase in asthma morbidity risk with thermal power plants (Li et al., 2011), industrial (Morin et al., 2012) and diffused biomass burning (Laumbach and Kipen, 2012). Regarding marine sources, they are also a major sources of air pollutants that affect the health of people living in the neighborhood of the source and also contribute to regional air pollution problems. Marine sources include marine vessels, locomotives, trucks etc. (Bailey and Solomon, 2004).

China, is the largest developing country, and its economic expansion has led to a dramatic increase in emissions of ambient air pollutants. As a result, China is now facing the worst air pollution levels, which cause public health problems (Tao et al., 2014). The inhabitants of some of the most developed and largest cities, most notably Beijing (Gao et al., 2015), Shenyang (Zhai et al., 2013), Shanghai (Shan et al., 2016) and other developed cities (Wu et al., 2016) are suffering from severe asthma. With the rapid industrialization and urbanization in China, some environmental troubles are becoming vital factors of asthma increase (Tan and Bernstein, 2014). Previous studies investigated the association of ambient air pollutants with hospital outpatient and emergency room visits (Pan et al., 2014), but the impact of the source variation in the association between asthma and air pollutants has not been studied in detail. To date, to the best of our knowledge, few studies have investigated the association between asthma patient visits and levels of air pollutants generated from both terrestrial sources and marine sources in Shanghai.

The aim focus of the present study was to investigate the correlation between sources of air pollutants and asthma patient visits in Shanghai, in particular terrestrial sources and marine sources.

2. Methods

2.1. Study area

Shanghai is the most famous city in China, and is located in the Yangtze River Delta in east China. The city has a moderate subtropical climate, with abundant rainfall and distinct seasons. The population of Shanghai at the end of 2014 was 24.26 million inhabitants, with an area of 6341 sq. km. The study areas comprise the eight urban districts of Shanghai (259 km^2). These urban districts are Putuo, Yangpu, Luwan, Qingpu, Hongkou, Jing'an, Xuhui, and Pudong. The data of the cases of asthma in this study were obtained from Shanghai Pulmonary Hospital, the only a pulmonary hospital in Shanghai. These urban districts were selected to be investigated because of their adequate air pollutants monitoring data.

2.2. Asthma patient visits

The data of asthma patient visits were collected from Shanghai Pulmonary Hospital, including 7200 asthma patient visits. Asthma patient visits refer to all the clinic visits who related respiratory disease symptoms, which is suspected or confirmed in asthma. The cases were selected basing on the code in International Classification of Diseases (ICD). The basic information, including sex, date of admission, diagnostic and residential address was used in this study. According to the residential address, the patients who lived in Shanghai were included.

2.3. Environmental data

According to relevant rules of the Chinese government, these stations should not be in the neighborhood of industrial or traffic source. In addition, the local pollution should not affect the location and should avoid waste-burning boilers, furnaces and buildings. If a station had >25% of the values missing for the whole period of analysis, the whole data should be excluded from the analysis. The meteorological data were obtained from the Shanghai Meteorological Bureau, including daily mean temperature and relative humidity. The data were collected according to the World Meteorological Organization (WMO) standard. We testify that the data were representative and authentic.

2.4. Statistical analysis

From January 22, 2014 to October 30, 2015 (500 d of daily patient counts except weekend, around 647 d of air pollutants and meteorological data), a total of 7200 emergency room visits were recorded in the study population, including a mean male (~7) and female (~7) individuals per day. The association between air pollution and asthma patient visits were examined by GAM methods. Participants who have asthma are included. The data from the weekends and holidays were deleted because the collecting stations were not open on those days. Air pollutants data were obtained from the Shanghai Environmental Monitoring Center (SEMC), which provides representative data. Daily mean temperature and relative humidity were obtained from the Shanghai Meteorological Bureau in the study area.

In some developed countries, for example European countries and the US, some patient visits are usually scheduled by appointment. However, patient visits records from a hospital may not reliably reflect the real morbidity. In China, especially in Shanghai, hospital patient visits usually are unscheduled, and patient visits are first-come first-serve basis. Thus, it represents an advantageous approach for data collection.

The Pearson correlation coefficients were computed to study the association between air pollutants and asthma because they may influence the asthma morbidity. The Pearson correlation coefficients were used to assess the inter-relations between air pollutants. The daily asthma patient visits are attributed to small probability event, and they fit a Poisson distribution. In this study, GAM was used to explore the