



Association between air pollution and cardiovascular mortality in Hefei, China: A time-series analysis[☆]



Chao Zhang^{a,1}, Rui Ding^{a,1}, Changchun Xiao^{b,1}, Yachun Xu^a, Han Cheng^a, Furong Zhu^a, Ruoqian Lei^a, Dongsheng Di^c, Qihong Zhao^d, Jiyu Cao^{a,*}

^a Department of Occupational Health and Environmental Health, School of Public Health, Anhui Medical University, 81 Meishan Road, Hefei, Anhui 230032, China

^b Hefei Centre for Disease Control and Prevention, Hefei, Anhui, China

^c Department of Preventive Medicine, School of Public Health, Anhui Medical University, 81 Meishan Road, Hefei, Anhui 230032, China

^d Department of Nutrition and Food Hygiene, School of Public Health, Anhui Medical University, 81 Meishan Road, Hefei, Anhui 230032, China

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ABSTRACT

In recent years, air pollution has become an alarming problem in China. However, evidence on the effects of air pollution on cardiovascular mortality is still not conclusive to date. This research aimed to assess the short-term effects of air pollution on cardiovascular morbidity in Hefei, China. Data of air pollution, cardiovascular mortality, and meteorological characteristics in Hefei between 2010 and 2015 were collected. Time-series analysis in generalized additive model was applied to evaluate the association between air pollution and daily cardiovascular mortality. During the study period, the annual average concentration of PM₁₀, SO₂, and NO₂ was 105.91, 20.58, and 30.93 µg/m³, respectively. 21,816 people (including 11,876 men, and 14,494 people over 75 years of age) died of cardiovascular diseases. In single pollutant model, the effects of multi-day exposure were greater than single-day exposure of the air pollution. For every increase of 10 µg/m³ in SO₂, NO₂, and PM₁₀ levels, CVD mortality increased by 5.26% (95%CI: 3.31%–7.23%), 2.71% (95%CI: 1.23%–4.22%), and 0.68% (95%CI: 0.33%–1.04%) at a lag03, respectively. The multi-pollutant models showed that PM₁₀ and SO₂ remained associated with CVD mortality, although the effect estimates attenuated. However, the effect of NO₂ on CVD mortality decreased to statistically insignificant. Subgroup analyses further showed that women were more vulnerable than men upon air pollution exposure. These findings showed that air pollution could significantly increase the CVD mortality.

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1. Introduction

With the rapid industrialization and urbanization in recent years, air pollution has become an alarming problem in China. Since the 1990s, more and more evidence has shown that short-term exposure to air pollution could increase the risk of adverse health effects, mainly due to cardiovascular and respiratory disorders (Lee et al., 2015; Samek, 2016; Samoli et al., 2008). Many researches have explored the health effects of air pollution with time-series methods (Freitas et al., 2016; Lopez-Villarrubia et al., 2010; Wu

et al., 2016; Zhang et al., 2015). According to a report by the World Health Organization (WHO) in 2012, ambient air pollution caused 3 million premature deaths in both cities and rural areas across the world, and 88% of these premature deaths occurred in low- and middle-income countries (WHO, 2016). It is estimated that just in 2013, ambient air pollution led to 2.9 million deaths and 69.7 million disability adjusted life years (DALYs) in 188 countries (Forouzanfar et al., 2015). Studies in China also showed that ambient air pollution led to 1.234 million deaths and 250 million disability adjusted life years (DALYs) in 2010, which makes it the fourth burden of disease in China (Yang et al., 2013). Interestingly, accumulating evidence demonstrated that air pollution may increase oxidative stress and induce inflammation within vascular tissue, and therefore lead to vascular dysfunction to amplify the impacts of traditional risk factors of cardiovascular disease (Münzel et al., 2016). Therefore, it is urgent to further investigate the effects

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* Corresponding author.

E-mail address: qshq@163.com (J. Cao).

¹ These authors contributed equally to this work and should be considered co-first authors.

of air pollution exposure on cardiovascular mortality.

The characteristics of air pollution in different regions vary substantially, depending on the level of industrialization and other factors. Hefei, the capital city of Anhui province, is the economic, financial, cultural, and educational center of this province. In the past two decades, Hefei experienced a drastic urbanization and industrial expansion, which was accompanied with serious air pollution. In addition, the dramatic increasing of automobiles in the past few years also further aggravated the air quality in Hefei. However, no research has investigated the cardiovascular effects of acute air pollution exposure in Hefei to date.

In order to help set the priority of air pollution control, the public health burden of ambient air pollution should be evaluated (Guo et al., 2013; Li et al., 2016; Lin et al., 2016). Therefore, this study aims to evaluate the risk of daily mortality due to cardiovascular disorders and its relation to air pollution in Hefei between 2010 and 2015.

2. Materials and methods

2.1. Air quality and meteorological data in Hefei city

Hefei located at the east of China (31°52' N, 117°17' E), with an area of 11,408 km² and a population of approximately 7.61 million (Fig. 1). Hefei has a subtropical humid monsoon climate with cold winter and hot summer.

Ten air quality monitoring stations have been established by Hefei Environmental Protection Bureau (HEPB) (Fig. 1). In this study, daily average of air pollutant concentrations (SO₂, NO₂, and PM₁₀) between January 1, 2010 and December 31, 2015 were obtained from the HEPB. As, the data of O₃ and PM_{2.5} were not available until 2013, these data were not included in this study. Daily meteorological data including daily mean temperature,

atmospheric pressure, wind speed, and relative humidity during the same period were obtained from the China meteorological data network (available at: <http://data.cma.cn/>).

2.2. Mortality of cardiovascular disease

Death counts between January 1, 2010 and December 31, 2015 were obtained from the Hefei Centers for Disease Control and Prevention (Hefei CDC). For analysis, we selected the deaths due to total cardiovascular disease (CVD), which were classified according to the International Statistical Classification of Disease, 10th Revision codes (ICD-10: I00–I99). Data including date of death, cause of death, sex, and age were collected.

2.3. Statistical analysis

We used Microsoft Excel to establish the database. Daily cardiovascular mortality, air pollution, and meteorological data were described as mean ± SE and quartile. $P < 0.05$ was considered statistically significant. All descriptive analyses were performed using the SPSS software. Spearman's correlation was used to estimate the associations between air pollutants and meteorological conditions.

For the Time series analysis, daily cardiovascular mortality data are qualitative data, belonging to small probability events, and conforms to Poisson distribution (Samet et al., 2000). Therefore generalized additive model (GAM) was used to estimate the association between mortality and air pollutant exposure. In this study, time series analysis using Poisson regression in a generalized additive model was used to assess the association between daily counts of cardiovascular mortality and pollutants concentrations.

The model is as below:



Fig. 1. District map of Hefei, China, with air quality monitoring stations locations.

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