



Association between ambient particulate matter concentrations and hospitalization for ischemic heart disease (I20-I25, ICD-10) in China: A multicity case-crossover study

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ABSTRACT

Background: Ischemic heart disease is a serious cause of death. Ambient particulate matter pollution is similarly defined a national environmental issue in China. The objective of this study was to examine the association of particulate matter with hospital admissions for ischemic heart disease in 26 large Chinese cities.

Methods: The study identified 720,261 hospital admissions for ischemic heart disease by using electronic hospitalization summary reports from 1 January 2014 through 31 December 2015. Conditional logistic regression was used to estimate the percent changes with 95% confidence intervals (CIs) in ischemic heart disease admissions in relation to an interquartile range increase in ambient particulate matter concentrations. We also assessed the effect modification of ischemic heart disease risk by geographical region, gender, and age.

Results: The means of air pollutants were $63.5 \pm 50.6 \mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$, $106.8 \pm 71.9 \mu\text{g}/\text{m}^3$ for PM_{10} . The levels of $\text{PM}_{2.5}$ and PM_{10} concentrations in northern China were much higher than those in southern China. Both $\text{PM}_{2.5}$ and PM_{10} had the strongest effect for daily ischemic heart disease admissions on lag 2 days, with an interquartile range (IQR) increase in $\text{PM}_{2.5}$ ($47.5 \mu\text{g}/\text{m}^3$) and PM_{10} ($76.9 \mu\text{g}/\text{m}^3$) at lag 2 days corresponded to a 1.7% (95% CI, 1.5–1.9%) and 2.0% (95% CI, 1.7–2.3%) increase in ischemic heart disease admissions, respectively. Associations with both $\text{PM}_{2.5}$ and PM_{10} were stronger in northern China than in southern China in all lag structures. In northern China, an IQR increase in $\text{PM}_{2.5}$ and PM_{10} concentrations at lag 2 days was associated with a 1.8% (95% CI, 1.6–2.1%) and 2.1% (95% CI, 1.8–2.4%) increase in ischemic heart disease admissions, respectively. In southern China, negative associations were observed with $\text{PM}_{2.5}$ and with PM_{10} almost at all lag structures.

Conclusion: Short-term elevations in the levels of $\text{PM}_{2.5}$ and PM_{10} demonstrate significant associations with an increase in ischemic heart disease. In northern China, the associations between the increase of $\text{PM}_{2.5}$ and PM_{10} concentrations and IHD admissions were positive. In southern China, the associations were null or negative.

1. Introduction

Globally, deaths due to ischemic heart disease (IHD) increase by 16.6% from 2005 to 2015 (2016). The mortality of IHD in China also is showing an uprising trend, especially in the rural areas from 2004 to 2011 (Liu et al., 2014). In 2013, there are 1.4 million people died from IHD (Zhou et al., 2016) and in GBD 2015 study, IHD has become the 2nd leading cause of deaths in China (2016b). Thus, primary prevention efforts aimed at reducing the incidence of IHD from the public health is of great importance.

There are several published epidemiological studies linking ambient particulate matter concentrations (PM) with IHD. A prospective cohort study demonstrates that long-term exposure to ambient concentrations of fine particulate matter ($\text{PM}_{2.5}$) increases IHD mortality (HR = 1.36; 95% CI, 1.28–1.44) per $10 \mu\text{g}/\text{m}^3$ by Pinault et al. (Pinault et al., 2017). A study in Tehran estimated that long-term exposure to ambient $\text{PM}_{2.5}$ contributed to between 19.8% and 24.1% of mortality from ischemic heart disease (Faridi et al., 2018). The above studies provide the evidence for the occurrence of adverse IHD effects due to long-term particulate matter exposure. In addition, some studies focus on short-term

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relationships between particulate matter exposure and IHD. An increase of 10 mg/m^3 in $\text{PM}_{2.5}$ was associated with a 1.5% increase hospital admissions of ischemic heart disease in the elderly in the city of São Paulo (Gouveia et al., 2006). A $10 \mu\text{g/m}^3$ elevation in $\text{PM}_{2.5-10}$ concentrations associates with a 3% (95% CI, 2–4%) rise in IHD admissions in Kaohsiung, Taiwan (Chen et al., 2015). In Belgium, the estimated risk reduction for IHD admissions was 2.44% (95% CI, 0.33–4.50%), 2.34% (95% CI, 0.62–4.03%), for a 10% reduction in PM_{10} , and $\text{PM}_{2.5}$, respectively (Devos et al., 2015). A study in Beijing, China suggests that short-term exposure to particulate air pollution is associated with increased IHD mortality (Xu et al., 2014). Hospitalizations of IHD was strongly associated with short-term exposure to high levels of PM_{10} and $\text{PM}_{2.5}$ in Shanghai, too (Xu et al., 2017).

China is a major developing country with rapid rising levels of ambient concentrations of PM. Over the past decade, ambient PM pollution has also become a greatest environmental risk to human health in China (Ebenstein et al., 2017). This study was to examine the association of PM with hospital admissions for IHD in 26 large Chinese cities during 2014–2015. The National Healthcare Data Center of China collected electronic hospitalization summary reports (HSRs) of the top-ranked hospitals. And air pollution data was obtained from the National Air Pollution Monitoring System. Using the data above, we conducted this research by a time-stratified case-crossover design.

2. Methods

2.1. Study subjects

Data on daily hospital admissions for ischemic heart disease were extracted from electronic hospitalization summary reports (HSRs) of the top-ranked hospitals for care, safety, and quality, as evaluated by the National Hospital Performance Evaluation Project of the National Healthcare Data Center of China. The medical information recorded on the HSR is documented with basic demographics, dates of admission and discharge, hospitalization and discharge diagnoses and their corresponding International Classification of Diseases, 10th Revision (ICD-10) codes, treatments, discharge status (survival status, drug allergy, and hospitalization infection), and financial costs.

Daily hospital admissions with a primary discharge diagnosis ischemic heart disease (I20–I25, ICD-10) from 1 January 2014 to 31 December 2015 were identified. Individuals aged < 18 years were excluded from this study. In total, we identified 720,261 hospital admissions for ischemic heart disease, from 26 large cities in China (Liu et al., 2017).

2.2. Air pollution and meteorological data

Data on daily average $\text{PM}_{2.5}$, PM_{10} , nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and carbon monoxide (CO) concentrations during the study period were obtained from the National Air Pollution Monitoring System. The system fulfills the quality assurance and quality control mandates of the Chinese government through its ambient air-monitoring stations which, ranging in number from 4 to 15 per city, provide hourly air pollution data. The daily (24-h) mean concentrations of pollutants averaged across all the stations in a given city were used as the reading for that city on that day. To allow potential confounding effects of weather conditions on IHD, meteorological data (daily mean temperature [$^{\circ}\text{C}$] and relative humidity [%]) in each city were obtained from the Chinese Meteorological Bureau (Wang et al., 2018).

2.3. Study design

Associations between ambient PM concentrations and IHD were investigated using a time-stratified case-crossover study design. In this design, cases serve as their own controls by using exposure on the days before as well as after the case period, in the same city. For each case of

IHD, ambient PM exposure on the case day (the day of hospital admission) was compared with exposure on a series of referent days occurring on the same days of the week within the same month and year as the case day. This approach can control for the influence of day of the week, seasonal and long-term trends and also slowly varying individual-level risk factors.

2.4. Statistical analysis

Spearman's correlation tests were applied to examine the associations among exposure variables. Conditional logistic regression was applied to estimate the associations between PM and IHD, with adjustment for same-day average temperature, relative humidity, city and holiday. The results were reported as the odds ratio (OR) and 95% confidence interval (CI) in the daily IHD admissions per interquartile range (IQR) increase in PM concentration.

To examine the temporal association of PM concentration with IHD, we fitted the models with different lag structures from the current day (lag0) up to 5 lag days (lag5). Considering that single-day lag models may underestimate the effect of pollutants (Bell et al., 2004), we also estimated associations with 3-day (lag0–2) and 4-day (lag0–3) moving average PM concentrations.

In addition, 2-pollutant models were applied to examine the stability of the air pollutants' effects. The gaseous pollutants were only included for adjustment in 2-pollutant models, and not as primarily investigated exposures. We use stratified analyses to examine whether associations differed by geographical region (southern and northern China), gender, and age (≥ 65 years and < 65 years). Stratified models were compared using a Z-test (Altman and Bland, 2003).

The cities in this study were divided into two parts, south and north, along the Qinling Mountains-Huaihe River line.

All analyses were conducted using R programming language (V.3.2.2, R Core Team (2017)). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/> (R Core Team, 2017). All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

3. Results

Characteristics of the study subject summarized in Table 1. There were 720,261 hospital admissions for IHD. The mean age at admission for IHD was 63.5 ± 11.7 years. There were 63.5% male patients, 45.5% elderly patients (≥ 65 years old), and 72.6% of patients were from northern China.

3.1. Air pollution and meteorological variables

Summary statistics of air pollutants and meteorological variables in the 26 Chinese cities during the study period (2014–2015) are shown in Table 2. The means of air pollutants were $63.5 \pm 50.6 \mu\text{g/m}^3$ for

Table 1
Demographic characteristics of ischemic heart disease admissions.

Variable	Ischemic heart disease
Total	720,261
Gender	
Male (%)	457,582 (63.5)
Female (%)	262,679 (36.5)
Age (year) (mean $\pm$ SD)	63.5 $\pm$ 11.7
< 65 (%)	392,305 (54.5)
≥ 65 (%)	327,956 (45.5)
Geographic region	
Southern China (%)	197,250 (27.4)
Northern China (%)	523,011 (72.6)

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