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The association between fine particulate air pollution and hospital emergency room visits for cardiovascular diseases in Beijing, China

Yuming Guo [a,*], Yuping Jia [a], Xiaochuan Pan [a,*], Liqun Liu [b], H.-Erich Wichmann [b]

[a] Department of Occupational and Environmental Health, Peking University School of Public Health, No 38, Xueyuan Road, Haidian District, Beijing 100191, China
[b] Institute of Epidemiology, German Research Center for Environmental Health, Munich, Germany

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ABSTRACT

Background: Because epidemiological studies have yielded different results, the association between exposure to fine particulate matter less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$) and acute events of cardiovascular diseases (CVD) is unknown. Additionally, no research has been conducted to explore the association between $PM_{2.5}$ and hospital emergency room (ER) visits of cardiovascular diseases in Beijing, China.

Objective: To explore the association between $PM_{2.5}$ and the hospital ER visits in Beijing, China for CVD {(International Classification of Diseases, 10th vision (ICD-10): I00~I99)}.

Methods: We collected data for daily hospital ER visits for CVD from the Peking University Third Hospital, daily ambient $PM_{2.5}$ data from a fixed monitor site at Peking University, and data on the daily level of gaseous air pollutants {sulfur dioxide (SO_2) and nitrogen dioxide (NO_2)} from the Beijing Municipal Environmental Monitoring Center between June 1, 2004 and December 31, 2006. A time-stratified case–crossover design was used to evaluate associations between CVD health outcomes and ambient air pollutants.

Results: 8377 hospital ER visits of CVD were collected in our study. After adjusting the temperature and the relative humidity, the associations for 10 $\mu g/m^3$ increases in levels of $PM_{2.5}$, SO_2, or NO_2 and hospital ER visits for cardiovascular diseases were statistically significant with odds ratios (ORs) of 1.005{95% confidence interval (CI): 1.001–1.009}, 1.014(95% CI: 1.004–1.024), and 1.016(95% CI: 1.003–1.029), respectively.

Conclusion: These findings suggest that elevated levels of ambient air pollutants are associated with the increase in hospital ER visits for CVD in Beijing, China.

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1. Introduction

In recent years, the results of many epidemiologic studies have suggested an association between ambient air pollution and morbidity and mortality of cardiovascular diseases (CVD) (Kan et al., 2008; Le Tertre et al., 2002; Wang et al., 2002). Researches have found the associations between short-term changes in ambient air pollution levels and hospital admission for CVD (Dominici et al., 2006; Zanobetti and Schwartz, 2005). There were also studies focusing on the association between air pollution and hospital emergency room (ER) visits for CVD (Peel et al., 2007; Szyszkowicz, 2008). Some studies conducted in the United States and European countries found that the increase of particulate matter less than 10 μm in aerodynamic diameter (PM_{10}) could induce the increase of myocardial infarction in the exposed population (Braga et al., 2001a; Mann et al., 2002).

Different results have been found for the association of fine particulate matter less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$) and acute events of CVD thus a conclusion based on epidemiological evidences cannot be made. For example, while Peters et al. (2001) found that elevated risk of myocardial infarction was associated with higher concentration of $PM_{2.5}$ in the 1 to 3 h period just before the myocardial infarction in a hospital-based study, a study by Levy et al. (2001) did not find the association between daily $PM_{2.5}$ concentration and out of hospital cardiac arrest.

Some studies conducted in China have statistically significant results for the association of ambient PM_{10} levels are with the mortality for CVD or respiratory diseases (Ren et al., 2007; Zhang et al., 2007), but there has been little research using hospital admissions, outpatient visits or hospital ER visits as the health outcomes, which may be more sensitive indicators for the effects of PM pollution. Especially there is no research on the association between $PM_{2.5}$ and ER visits for CVD. The aim of our study was to quantitatively analyze

Abbreviations: $PM_{2.5}$, fine particulate matter less than 2.5 μm in aerodynamic diameter; PM_{10}, particulate matter less than 10 μm in aerodynamic diameter; SO_2, sulfur dioxide; NO_2, nitrogen dioxide; OR, odds ratios; ICD-10, International Classification of Diseases, 10th vision; ER, emergency room; CVD, cardiovascular diseases; CI, confidence interval; SD, standard deviation; Lag 0 day, exposure on the day of hospital emergency room visit; lag 1 day, exposure on the day before hospital emergency room visit; lag 2 days, exposure on the 2 days before hospital emergency room visit; lag 3 days, exposure on the 3 days before hospital emergency room visit.

* Corresponding authors. Department of Occupational and Environmental Health, Peking University School of Public Health, No 38, Xueyuan Road, Haidian District, Beijing 100191, China. Pan is to be contacted at Tel./fax: +86 10 82802530. Guo, Tel.: +86 10 82805130; fax: +86 10 82802530.

E-mail addresses: guoyuming@yahoo.cn (Y. Guo), xcpan@hsc.pku.edu.cn (X. Pan).

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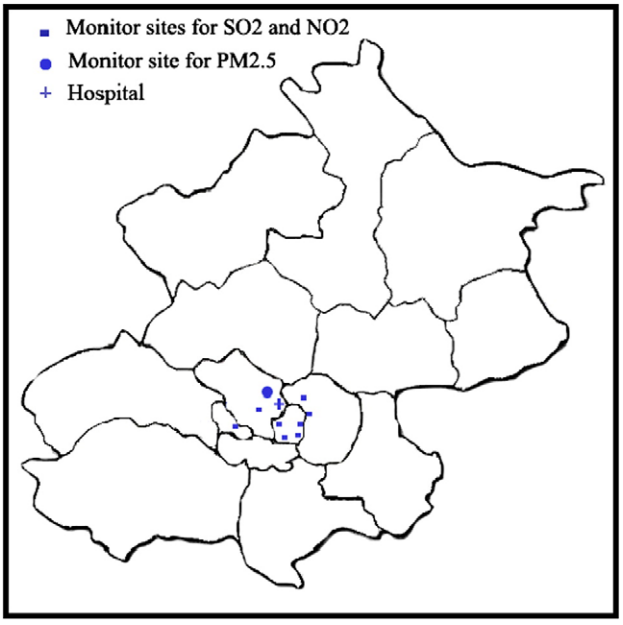

Fig. 1. The locations of monitor sites of air pollutants and Peking University Third Hospital in Beijing city.

the effects of short-term exposure to $PM_{2.5}$ on cardiovascular events in the exposed population. These health records have been stored in the databases of the medical record department in the Peking University Third Hospital. To explore the effect of short-term exposure of air pollution on the CVD, the case–crossover design was conducted in Beijing, China.

2. Materials and methods

2.1. Data collection for the hospital emergency room visits

Data on hospital ER visits were collected from the Peking University Third Hospital, which is located in northwest part of urban city of Beijing (Fig. 1). It is one of the top-level hospitals in Beijing, even in all China. Relevant information for each case of daily ER visits in the Emergency Department of the Hospital were collected, i.e. age, gender, identification number, occupation, diagnostic code, living address and primary diagnosis. We coded the data of daily ER visits according to the International Classification of Disease, 10th revision (ICD10) for CVD (ICD10: I00~I99) from June 1, 2004 to December 31, 2006. Based on the living address of the cases of the ER visits for CVD, we collected the cases had lived in the resident areas around the hospital or in urban area in Beijing.

2.2. Data collection of air pollution and weather condition

The concentration of ambient $PM_{2.5}$ was measured by TEOM(R) RP1400a air sampler, located in the campus of the Peking University (Fig. 1) which is about 4.0 km away from Peking University Third Hospital. For $PM_{2.5}$, 24 h values were recorded, and we computed the daily average concentration for data analysis. There were 136 missing values for $PM_{2.5}$ data, so that imputation of missing data was done using EM (expectation and maximization) theory (Zhang, 2002) based on the other pollutants' values. We also collected daily data on ambient sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) from the Beijing Municipal Environmental Monitoring Center, which had eight fixed monitoring sites and distributed in different part of the urban area (Fig. 1). Firstly the daily average concentration of air pollutants the eight fixed monitoring stations was counted by the same regulation, then the daily average concentration of air pollutants utilized in this study was computed from the eight fixed monitoring stations between June 1, 2004 and December 31, 2006. If the data of air pollutants were missed for a particular monitoring station on a given day, the average concentration was counted by the values from the remaining monitors. The air pollution data was representative to analyze the exposure of local population.

Mean daily temperature and relative humidity were collected from the regular monitoring data of the monitoring station of Institute of Atmospheric Physics, Chinese Academy of Science between June 1, 2004 and December 31, 2006. This station is located approximately 2 km away from the Peking University Third Hospital.

2.3. Data analysis

The case–crossover design with the time-stratified approach first introduced by Maclure (1991) has been utilized to research short exposure on the acute health effect. Case–crossover design is a relatively novel case–control study, in which each case can be looked as its own control. Recently, the case–crossover design has been applied in many studies of air pollution and health (Barnett et al., 2006; Ren et al., 2007).

The main intention of this study was to compare each subject's exposure experienced just before hospital visit with that at other times when the subject was not hospitalized. Because the case and the control are the same person, confounders related to individual factors are successfully controlled, such as: age, sex, smoking, and nutrition conditions, and so on. Each subject is their own control, all time invariant or slowly varying risk factors are controlled by design. Simulation analysis has shown that this approach can give unbiased estimates in the presence of strong seasonal confounding (Bateson and Schwartz, 1999; Lee and Schwartz, 1999).

The case–crossover design was used in our study to analyze the association of air pollution with the hospital ER visits for the CVD. The conditional logistic regression model was applied to calculate the odds ratio (OR) of exposures for subject during the case time and the control time, respectively. Cox regression model of the SPSS 13.0 software (Zhang, 2002) was utilized to fit the conditional Logistic Regression model to analyze the ORs of the air pollution level and ER visits for CVD.

To examine the hazard period of air pollution for CVD, we used the distributed lag model to evaluate the effect of air pollutants. The hazard period was defined as the same day, previous day up to the 3rd day prior to the hospital visit; the same day of last week for the hospital visit was used as control, for example, if the subject went to hospital ER on Monday, the last Monday would be used as control, therefore the concentrations of air pollutants in the hazard period were compared with the control period. The relevant daily data of air temperature and relative humidity were put into the models as confounding factors (Braga et al., 2001b; Schwartz, 2005). At the same time, single and multiple pollutants models were used to analyze the interactions among the other air pollutants and weather conditions.

Table 1
Summary of air pollutants and weather condition between study period.

	Frequency distribution			Minimum	Maximum	Mean ± SD
	25	50	75			
Air pollution						
$PM_{2.5}$(μg/m^3)	57.71	101.60	158.40	0.72	517.69	121.58 ± 88.05
SO_2 (μg/m^3)	17.00	30.32	62.11	5.00	293.00	49.32 ± 49.17
NO_2 (μg/m^3)	52.32	64.00	79.34	14.40	214.4	68.25 ± 25.52
Weather condition						
Temperature (°C)	5.80	14.50	22.90	−8.70	32.90	14.08 ± 10.12
Relative humidity (%)	35.00	47.00	62.00	0.00	100.00	49.01 ± 18.91
CVD visits	6	9	11	0	26	8.87 ± 3.80

Abbreviations: $PM_{2.5}$: fine particulate matter with an aerodynamic diameter of <2.5 μm; SO_2: sulfur dioxide; NO_2: nitrogen dioxide; SD: standard deviation.

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