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Estimating the acute effects of fine and coarse particle pollution on stroke mortality of in six Chinese subtropical cities☆

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ABSTRACT

While increasing evidence suggested that $PM_{2.5}$ is the most harmful fraction of the particle pollutants, the health effects of coarse particles ($PM_{10-2.5}$) have been inconclusive, especially on cerebrovascular diseases, we thus evaluated the effects of PM_{10}, $PM_{2.5}$, and $PM_{10-2.5}$ on stroke mortality in six Chinese subtropical cities using generalized additive models. We also conducted random-effects meta-analyses to estimate the overall effects across the six cities. We found that PM_{10}, $PM_{2.5}$, and $PM_{10-2.5}$ were significantly associated with stroke mortality. Each 10 $\mu g/m^3$ increase of PM_{10}, $PM_{2.5}$ and $PM_{10-2.5}$ (lag03) was associated with an increase of 1.88% (95% CI: 1.37%, 2.39%), 3.07% (95% CI: 2.35%, 3.79%), and 5.72% (95% CI: 3.82%, 7.65%) in overall stroke mortality. Using the World Health Organization's guideline as reference concentration, we estimated that 3.21% (95% CI: 1.65%, 3.01%) of stroke mortality (corresponding to 1743 stroke mortalities, 95% CI: 896, 1633) were attributed to PM_{10}, 5.57% (95% CI: 0.50%, 1.23%) stroke mortality (3019, 95% CI: 2286, 3777) were attributed to $PM_{2.5}$, and 2.02% (95% CI: 1.85%, 3.08%) of stroke mortality (1097, 95% CI: 1005, 1673) could be attributed to $PM_{10-2.5}$. Our analysis indicates that both $PM_{2.5}$ and $PM_{10-2.5}$ are important risk factors of stroke mortality and should be considered in the prevention and control of stroke in the study area.

1. Introduction

Existing literature has shown a consistent increased risk in cardiovascular mortality resulting from acute exposure to ambient air pollution (Villeneuve et al., 2012; Zhang et al., 2017). The association with stroke, a common cause of mortality and disability (Bergström et al., 2017), has gained relatively limited attention (Chung et al., 2017; Lin et al., 2017a). Though, it is estimated that stroke accounted for over six million deaths globally in 2015, with more than half of those deaths occurring in developing countries (Collaborators, 2016; Foreman, 2015). In China, stroke was the leading cause of death in 2015, with approximately two million deaths attributed to stroke (Yang et al., 2013).

It has been well documented that particulate matter (PM) pollution is closely linked with occurrence of stroke (Liu et al., 2016, 2017). According to particle diameter, PM_{10} can be divided into fine particles ($PM_{2.5}$) and coarse particles ($PM_{10-2.5}$). Increasing evidence supported that $PM_{2.5}$ might be the most relevant size fraction for their detrimental health effects (Qiu et al., 2013), the effects of

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coarse particles have remained inconclusive.

However, this research question has not been well examined yet. This study was thus conducted with the aim to investigate the effects of different particle size fractions on stroke mortality in six Chinese cities.

2. Methods

2.1. Study area

China may have the most serious PM pollution situation in the world (Kan et al., 2012), and there are serious concerns about the harmful health effects of air pollution in heavily-polluted areas such as the Pearl River Delta region (PRD) (Jahn et al., 2011).

Six subtropical cities (Dongguan, Foshan, Guangzhou, Jiangmen, Shenzhen, and Zhuhai) were selected from this region (Fig. 1). Detailed descriptions of these six cities have been reported previously (Lin et al., 2017b). The six cities share similarities in geographical, meteorological, and cultural conditions.

2.2. Data collection

2.2.1. Stroke mortality data

The daily data on mortality due to stroke during February 2013 to June 2016 were obtained from the local health departments. We identified stroke mortality based on the principal death cause coded by ICD-10, specifically for overall stroke (ICD-10: (ICD-10 codes: I60–I66), ischemic stroke (ICD-10 codes: I63-I66), and hemorrhagic stroke (ICD-10 codes: I60-I62).

2.2.2. Air pollution data

The daily pollution data were obtained from municipal air monitoring system. Following the national regulations, these stations were established away from the vicinity of major traffic or industrial properties, so that representative measurements of background pollution can be monitored (Lin et al., 2016a).

We collected the daily 24-h mean concentrations of $PM_{10,}$ $PM_{2.5}$, ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). $PM_{10-2.5}$ concentrations were calculated as the difference of the concentrations of PM_{10} and $PM_{2.5}$ (Brunekreef and Forsberg, 2005). In each city, we used daily mean concentrations of each air pollutant across all monitoring stations as a surrogate for the population's daily exposure.

Daily weather data (mean temperature (°C) and relative humidity (%)) were obtained from the National Weather Data Sharing System.

2.3. Statistical analysis

We first examined the city-specific effects of daily PM_{10}, $PM_{2.5}$ and $PM_{10-2.5}$ on stroke mortality. Following previous similar air pollution epidemiology studies, we employed a quasi-Poisson time series model to quantify the associations (Zanobetti and Schwartz, 2008). In the model, we controlled for public holidays (PH) and day of the week (DOW) using binary variables. We also controlled for seasonal patterns, long-term trends, temperature, and relative humidity using penalized smoothing splines. We selected the model specifications and degrees of freedom (df) for the smoothers following previous air pollution epidemiology studies (Tian et al., 2013). Specifically, we selected 6 df per year for temporal trends, a df of 6 for moving average temperature of the current day and previous three days (Temp03), and a df of 3 for relative humidity (Humidity). The model construction for this type of analysis has been described previously (Tian et al., 2016). The core model is defined as:

$$\log[E(Y_t)] = \alpha + s(t, \cdot df = 6/year) + s(Temp03, \cdot df = 6) + s(Humidity, \cdot df = 3) + \beta_1 * \cdot DOW + \beta_2 \cdot * \cdot PH$$

where $E(Y_t)$ is the expected daily stroke mortality count on day t, α is the intercept, s() indicates a smoother according to penalized splines, df represents the degrees of freedom, t represents time for the purpose of adjusting for seasonality and long-term trends, Temp03 is the moving average of the current day and the temperature 3 days prior, and β_1 and β_2 are regression coefficients.

The effects of PM pollutants were estimated across different lag

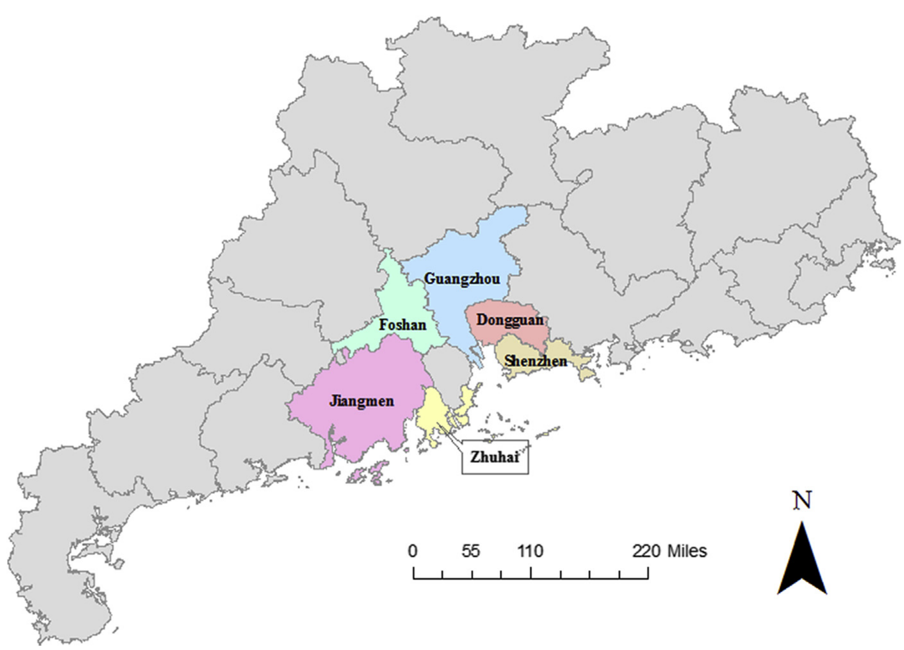

Fig. 1. The location of the six cities in Guangdong Province, China.