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Differentiating the effects of fine and coarse particles on daily mortality in Shanghai, China

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Abstract

The findings on health effects of ambient fine particles ($PM_{2.5}$) and coarse particles ($PM_{10-2.5}$) remain inconsistent. In China, $PM_{2.5}$ and $PM_{10-2.5}$ are not the criteria air pollutants, and their monitoring data are scarce. There have been no epidemiological studies of health effects of $PM_{2.5}$ and $PM_{10-2.5}$ simultaneously in China. We conducted a time series study to examine the acute effects of $PM_{2.5}$ and $PM_{10-2.5}$ on daily mortality in Shanghai, China from Mar. 4, 2004 to Dec. 31, 2005. We used the generalized additive model (GAM) with penalized splines to analyze the mortality, air pollution and covariate data. The average concentrations of $PM_{2.5}$ and $PM_{10-2.5}$ were 56.4 μg/m^3 and 52.3 μg/m^3 in our study period, and $PM_{2.5}$ constituted around 53.0% of the PM_{10} mass. Compared with the Global Air Quality Guidelines set by World Health Organization (10 μg/m^3 for annual mean) and U.S. National Ambient Air Quality Standards (15 μg/m^3 for annual mean), the $PM_{2.5}$ level in Shanghai was much higher. We found that $PM_{2.5}$ was associated with the death rates from all causes and from cardiorespiratory diseases in Shanghai. We did not find a significant effect of $PM_{10-2.5}$ on mortality outcomes. A10 μg/m^3 increase in the 2-day moving average (lag01) concentration of $PM_{2.5}$ corresponded to 0.36% (95% CI 0.11%, 0.61%), 0.41% (95% CI 0.01%, 0.82%) and 0.95% (95% CI 0.16%, 1.73%) increase of total, cardiovascular and respiratory mortality. For $PM_{10-2.5}$, the effects were attenuated and less precise. Our analyses provide the first statistically significant evidence in China that $PM_{2.5}$ has an adverse effect on population health and strengthen the rationale for further limiting levels of $PM_{2.5}$ in outdoor air in Shanghai.

Keywords

Air pollution; Fine particles; Coarse particles; $PM_{2.5}$; Mortality

1. Introduction

Numerous epidemiological studies during the past 20 years have confirmed that short-term exposure to outdoor air pollution contributes to increased cardiorespiratory mortality and morbidity (Brunekreef and Holgate, 2002). Among the pollutants in the ambient mix, particulate matter (PM) has the most consistent association with mortality (Bell et al., 2004a and Bell et al., 2004b). PM consists of discrete particles that are categorized by sizes spanning several orders of magnitude: PM_{10}, or inhalable particles (defined as particulate matter less than 10 μm in aerodynamic diameter); $PM_{2.5}$, or fine particles (defined as those particles less than 2.5 μm in aerodynamic diameter); $PM_{10-2.5}$, also known as coarse particles (defined as those particles between 10 and 2.5 μm in aerodynamic diameter); and ultrafine particles (UFPs) (defined as those less than 0.1 μm). Most prior studies have used PM_{10} and $PM_{2.5}$ as particle measurements.

While many epidemiological studies have reported associations of mortality and morbidity with ambient $PM_{2.5}$ or PM_{10} (Pope and Dockery, 2006), fewer studies have evaluated associations with $PM_{10-2.5}$, which is largely due to lack of monitoring data. Not