Available online at www.sciencedirect.com
ScienceDirect
Science of the Total Environment 385 (2007) 28–36
Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Humankind
www.elsevier.com/locate/scitotenv

The adverse effects of fine particle air pollution on respiratory function in the elderly

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Received 6 April 2007; received in revised form 28 June 2007; accepted 2 July 2007
Available online 10 August 2007

Abstract

There is increasing concern that airborne particles are critical risk factors for adverse health conditions in susceptible populations. The objective of this panel study is to investigate an association between particulate matter and the peak expiratory flow rate (PEFR) in the elderly and to compare estimated risks using PM_{10} or $PM_{2.5}$ levels as a measure of exposure. During a 2-year longitudinal follow-up study, we contacted subjects living in an asylum for the elderly, provided them with a mini-Wright peak flow meter, and instructed to record all the flow readings, any respiratory symptoms, passive smoking activity, and hours spent outdoors for that given day. Daily levels of particulate matter were measured by two separate mini-volume air samplers (for PM_{10} and $PM_{2.5}$) placed on the rooftop of the two-story residence asylum building. In our statistical models, we assumed that the expected response varied linearly for each participant with a slope and intercept that depended on fixed or time-varying covariates using a mixed linear model. The daily mean levels of PM_{10} and $PM_{2.5}$ were 78 $\mu g/m^3$ and 56 $\mu g/m^3$, respectively. For every 10 $\mu g/m^3$ increase in PM_{10} and $PM_{2.5}$ levels, there was an estimated PEFR change of −0.39 l/min (95% CI, −0.63, −0.14) and −0.54 l/min (95% CI, −0.89, −0.19), respectively. These data also suggest that fine particles have a more adverse respiratory health impact for sensitive individuals such as the elderly and that more research and control strategies should focus on the smaller particles associated with air pollution.

Keywords: Air pollution; Fine particle; PEFR; The elderly; Mixed linear model

1. Introduction

A growing body of literature has demonstrated an association between day-to-day fluctuations in air pollution and daily morbidity or mortality changes. In recent years, a number of epidemiologic studies in Korea have reported that air pollution has an effect on human health conditions, including mortality (Lee and Schwartz, 1999; Lee et al., 1999) and asthma-related emergency room visits (Lee et al., 2002). A few Korean studies have also looked at the relationship between ambient air pollution and pulmonary function as an indicator of respiratory health (Yu et al., 2004).

There is increasing concern that airborne particles may be a critical risk factor for adverse health conditions and for populations susceptible to the adverse health effects of air pollution. Epidemiologic evidence suggests that exposure to short-term ambient levels of particulate matter is associated with adverse health effects, including an increase in hospital admissions (Lee et al., 2002; Schwartz, 1994) and respiratory symptoms (Hoek and Brunekreef, 1993), a decrease in pulmonary

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doi:10.1016/j.scitotenv.2007.07.005

function (Koenig et al., 1993; Lee and Shy, 1999) and an excess of daily mortalities (Lee and Schwartz, 1999; Lee et al., 1999). Smaller particulate matter is known to be more risky since it consists of more toxic components and penetrates more deeply into lung airways. Fine particles are deposited in the alveolar region more often than coarse particles. A few studies have demonstrated the effects of air particulate size on mortality (Schwartz et al., 1996, 1999) and hospital admission (Anderson et al., 2001). Most existing studies on particulates and their association with human health outcomes have used the total suspended particulate (TSP) or PM_{10} (particles less than 10 μm in aerodynamic diameter) as the measurement for PM exposure, and little data exist using $PM_{2.5}$ (particles less than 2.5 μm in aerodynamic diameter) as the exposure measure. People with asthma or cardiac conditions, children and the elderly are considered to be particularly sensitive to the effects of air pollutants. Several panel studies have shown consistent negative associations between an increase in air particulate levels and decreased pulmonary function in children (Hoek and Brunekreef, 1993; Koenig et al., 1993). Only a few air pollution studies have looked at the relationship between particular matter and respiratory function in the elderly, even though they are regarded as a group sensitive to air pollution effects.

Repeated measures of lung function in panels of subjects have also been used to evaluate the effect of episodes of particulate air pollution. Air contaminants may affect airways, lung parenchyma, bronchial responsiveness, and may cause acute transient bronchoconstriction. To monitor the short-term effects of air pollution, we can record the peak expiratory flow, which may be reduced by airway narrowing or factors that limit maximal inspiration. Peak flow measurements have been widely used as a simple, inexpensive indicator of acute changes in lung function among asthmatic patients.

We conducted a panel study of the elderly living in an asylum to assess the impact of exposure to ambient particulates on respiratory function as measured by the peak expiratory flow rate (PEFR). This study also enabled us to investigate ambient PM_{10}, $PM_{2.5}$ and PEFR in the elderly under relatively low air pollution conditions. Our other objective was to compare the estimated risks associated with levels of PM_{10} and $PM_{2.5}$ exposure.

2. Methods

2.1. Study participants

This study used a longitudinal component from a panel study conducted during 2000 and 2001. During the study period, we conducted three panel surveys, with each survey lasting 4 consecutive weeks. We chose a dense area located close to a major traffic road in South-Western Seoul Metropolitan. This area was a well-known industrial complex in the 1970s. In the 1980s, most companies moved to a designated location in the outer block of Seoul. At present, exhaustive gas emitted from automobiles is considered to be the major source of air pollution in the area. The subject population included individuals at a private asylum for the elderly.

During the introductory meeting, every participant signed an informed consent form and completed a questionnaire describing the subjects' demographics, medical history, daily activity patterns and occupational history.

At the introductory meeting, we provided a mini-Wright peak flow meter (Vitalograph Inc., Lenexa, Kansas) and demonstrated how to measure and record PEFR. Each participant also received a package of preformatted health diaries with verbal and written instructions for completion. Participants were instructed to perform the peak flow test three times daily in the standing position (in the morning, afternoon, and evening) and record all the readings along with any lower respiratory symptoms (cough, wheeze, and cold), any passive smoking activity, and hours spent outdoors on that day.

2.2. Air pollution exposure

Ambient air concentrations of PM_{10} and $PM_{2.5}$ were measured with two separate mini-volume air samplers (Airmetrics™, Eugene, Oregon). These samplers were placed on the rooftop of the two-story asylum residence building. The air flow of the samplers was fixed to 5 l/min. In order to measure particle mass, we exchanged the filter (Teflon Quartz Filter with 0.2 μm pore size and 47 mm diameter) every 24 h during the same lung function measurement period because our lung function measurement was done on a daily basis.

2.3. Analysis

The analysis of these longitudinal data relied on the combined data collected from the daily diaries of each participant and the PM_{10}/$PM_{2.5}$ levels as the measure of outdoor air quality parameter, provided by rooftop samplers. The frequency distribution of each variable was checked to find missing and unreasonable data values (e.g., if a daily PEFR was not between 100 and 800 l/min, the value was checked for clerical error, and corrected or treated as an error). We also excluded the records of the PEFR trials from the first week, because