Available online at www.sciencedirect.com
ScienceDirect
Science of the Total Environment 382 (2007) 43–51
Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Humankind
www.elsevier.com/locate/scitotenv

Effects of personal particulate matter on peak expiratory flow rate of asthmatic children

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Received 2 December 2006; received in revised form 31 March 2007; accepted 10 April 2007
Available online 22 May 2007

Abstract

Many researches have shown that the particulate matter (PM) of air pollution could affect the pulmonary functions, especially for susceptible groups such as asthmatic children, where PM might decrease the lung function to different extents. To assess the effects of PM on health, most studies use data from ambient air monitoring sites to represent personal exposure levels. However, the data gathered from these fixed sites might introduce certain statistical uncertainties. The objectives of this study are to evaluate the effects of various size ranges of PM on peak expiratory flow rate (PEFR) of asthmatic children, and to compare the model performance of using different PM measurements (personal exposures versus fixed-site monitoring) in evaluation. Thirty asthmatic children, aged 6 to 12 years, who live near the fixed monitoring site in Sin-Chung City, Taipei County, Taiwan, were recruited for the study. Personal exposures to PM_1, $PM_{2.5}$, and PM_{10} were measured continuously using a portable particle monitor (GRIMM Mode 1.108, Germany). In addition, an activity diary and questionnaires were used to investigate possible confounding factors in their home environments. The peak expiratory flow rate of each participant was monitored daily in the morning and in the evening for two weeks. Results showed several trends, although not necessarily statistically significant, between personal PM exposures and PEFR measurements in asthmatic children. In general, notable findings tend to implicate that not only fine particles ($PM_{2.5}$) but also coarse particles ($PM_{2.5-10}$) are likely to contribute to the exacerbation of asthmatic conditions. Stronger lagged effect and cumulative effect of PM on the decrements in morning PEFR were also found in the study. Finally, results of linear mixed-effect model analysis suggested that personal PM data was more suitable for the assessment of change in children's PEFR than ambient monitoring data.

Keywords: Particulate matter; Coarse particle; Peak expiratory flow rate; Personal exposures; Asthmatic children

1. Introduction

Numerous epidemiological researches have shown that respiratory morbidity and mortality and declines in lung function are associated with current levels of particulate pollution in urban air (Dockery et al., 1993; Pope et al., 1995; Vedal et al., 1998; Schwartz and Neas, 2000; Penttinen et al., 2001; Brunekreef and Holgate,

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doi:10.1016/j.scitotenv.2007.04.016

2002). In these studies, particulate matter (PM) has usually been measured as the mass of particles smaller than 10 μm (PM_{10}) or 2.5 μm ($PM_{2.5}$) in diameter, with a central monitoring site serving as a surrogate for personal exposures. The relationship between particulate pollution and lung function, principally peak expiratory flow rate (PEFR), is mostly consistent, despite differences in definitions of outcome measurements and statistical methods used to model the relationship between air pollution and health (Neas et al., 1995; Gielen et al., 1997; Trenga et al., 2006; Bourotte et al., 2007).

Asthma is a priority regarding child health care in Taiwan. While the mortality rate related to asthma in Taiwan has slowly decreased over the past two decades, the prevalence of asthma under children has increased from 1.3% in 1974 to 10.8% in 1994 (Hsieh and Shen, 1988; Kuo et al., 2003; Jan et al., 2004). A recent study further suggested a slight increase in asthma prevalence for elementary school children in Taiwan, compared to the results reported 10 years ago (Chang et al., 2006). Not only has asthma become an important issue in public health, but uncontrolled asthma, which could result in higher demands on emergency services and hospitalization, is also a significant financial burden on health care systems (Barnes et al., 1996).

Despite the progress that has been made to date, comparatively few studies have directly assessed the relative contributions of different particle sizes to the deterioration of lung functions in asthmatic children. This is due, in part, to the difficulty of conducting short-term monitoring for personal exposures (Howard-Reed et al., 2000). To address this issue, we investigated the effects of particulate air pollution on peak expiratory flow rate in a group of children with asthma. The relationships between particles of different sizes (1 to 10 μm) and PEFR were examined. In addition, results of model performance using personal monitoring for particulate exposures were compared to those using data from a central ambient monitoring site.

2. Methods

2.1. Study design

This panel study was conducted to monitor changes in personal PM exposures and PEFR simultaneously for the subjects during December 2003 to February 2005. Thirty asthmatic children in Taipei County were recruited, all of whom were enrolled in the same elementary school and live within 2 km from a stationary monitoring site (Taiwan Particle Supersite), which is operated by Taiwan Environmental Protection Administration (Taiwan EPA). In each 2-week session, each subject completed both the continuous PM exposure assessment in the first five days and the PEFR monitoring procedure throughout the 14 session days. Asthma was diagnosed by a physician and was thus defined according to the criteria of the American Thoracic Society. At the beginning of each sampling session, field staff obtained data from each subject, including sex, age, height, weight, symptoms in the past 12 months, and medical history. Furthermore, household information such as presence of cockroaches, dust mites, mold, furry pets, carpeting, plants inside the house, home dampness, environmental tobacco smoke (ETS), gas cooking appliances, mosquito repellant, and incense burning were collected through walk-through survey by a technician. Field staff also collected information regarding environmental factors of physical nature such as whether the house contained an air cleaner or air conditioner, as well as the presence of outdoor traffic, industries, and temple pollution. The review board of the Environmental Protection Bureau of Taipei County approved the research protocol, and a written consent was obtained from each participant's parents before the study was launched.

2.2. PEFR monitoring

During the study, each subject performed PEFR maneuvers in the morning after awaking and in the evening near bedtime every day of the 2-week session. The subjects were instructed to take the measurements before taking any medication. The highest of three values from consecutive PEFR maneuvers in the morning, as well as in the evening, were retained for further analysis. Subjects were trained by field staff to handle the electronic PEFR monitor (Asthma Monitor PF-100, Microlife, Taiwan) properly and were given a standard operation procedure for self-measuring. PEFR measurements were recorded in the monitor automatically and were later downloaded by field staff.

2.3. PM monitoring

Personal exposures to different sizes of particles were measured continuously using a portable particle monitor (DUSTcheck Portable Dust Monitor, model 1.108, GRIMM Labortechnik Ltd., Germany). Mass concentrations of PM_1, $PM_{2.5}$, and PM_{10}, as well as ambient temperature and relative humidity, were measured and recorded for one-minute periods. The raw data were then summarized to one-hour segments for statistical analysis. Mass concentrations of $PM_{2.5-10}$ were obtained by subtracting the $PM_{2.5}$ fraction from the concurrent PM_{10} levels. A similar approach was applied to derive the data