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# Association between particulate matter concentration and symptoms of atopic dermatitis in children living in an industrial urban area of South Korea

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ABSTRACT

*Introduction:* Increased exposure to particulate matter (PM) appears to increase the development of atopic diseases and allergic sensitization. This study evaluated the association between daily levels of PM with diameters less than 10 μm (PM10) and PM2.5 and symptoms of atopic dermatitis (AD) in children living in an industrial urban area.

*Methods:* Indoor PM10 and PM2.5 concentrations were measured with an optical particle counter in two preschools near large industrial complexes in Ulsan, South Korea during two 6-month periods (May–October of 2012 and 2013). Twenty-one children with AD from these preschools were enrolled and observed daily for AD symptoms during the same periods. Indoor and outdoor PM concentrations were used to estimate PM exposure based on time activity patterns.

*Results:* Analysis of PM10 and PM2.5 concentrations showed that indoor and outdoor PM10 levels varied similarly throughout each 6-month period. In addition, indoor concentration of PM2.5 had high correlation with ambient outdoor concentration of PM10. Correlation analysis also indicated a significant positive correlation between the exacerbation of AD symptoms and daily mean exposure to PM10 and PM2.5. Based on a generalized linear mixed model (GLMM), PM exposure was significantly associated with the exacerbation of AD symptoms, with a maximum adjusted odds ratio (aOR) of 1.399 for a 10 $\mu g/m^3$ increase of PM2.5 (95% CI: 1.216–1.610).

*Discussion:* Our findings suggest that short-term exposure to PM can exacerbate AD in young children living in an industrial urban area. PM2.5 had a stronger effect than PM10 on exacerbation of AD symptoms.

## 1. Introduction

Particulate matter (PM) is an environmentally ubiquitous air pollutant that is a growing public health concern. Many epidemiological and toxicological studies have found associations between ambient PM concentrations and adverse health outcomes (Kappos et al., 2004; Lippmann et al., 2003; Pope, 2000; Schwarze et al., 2006). PM can increase allergic sensitization and exacerbate symptoms of asthma (De Haar et al., 2006) and may also increase the development and exacerbation of atopic dermatitis (AD), one of the most common allergic disorders in children. Although there are still controversies regarding the health effects of PM, it can clearly induce oxidative stress in the skin, which leads to skin barrier dysfunction or immune dysregulation (Ahn, 2014). Several recent studies showed that exposure to PM can exacerbate the symptoms of AD in school children (Kim et al., 2013; Song et al., 2011; Morgenstern et al., 2008), but there is only limited direct evidence supporting this association. Further studies are needed to clarify the relationship between PM exposure and AD development, because AD is clearly associated with decreased quality-of-life.

There is growing concern in many countries about the effects of PM on AD in areas with high air pollution due to increases in urbanization and industrialization. High PM concentrations increase PM exposure, and this could increase health problems associated with PM, such as allergic diseases. Hence, it is necessary to investigate the effects of PM

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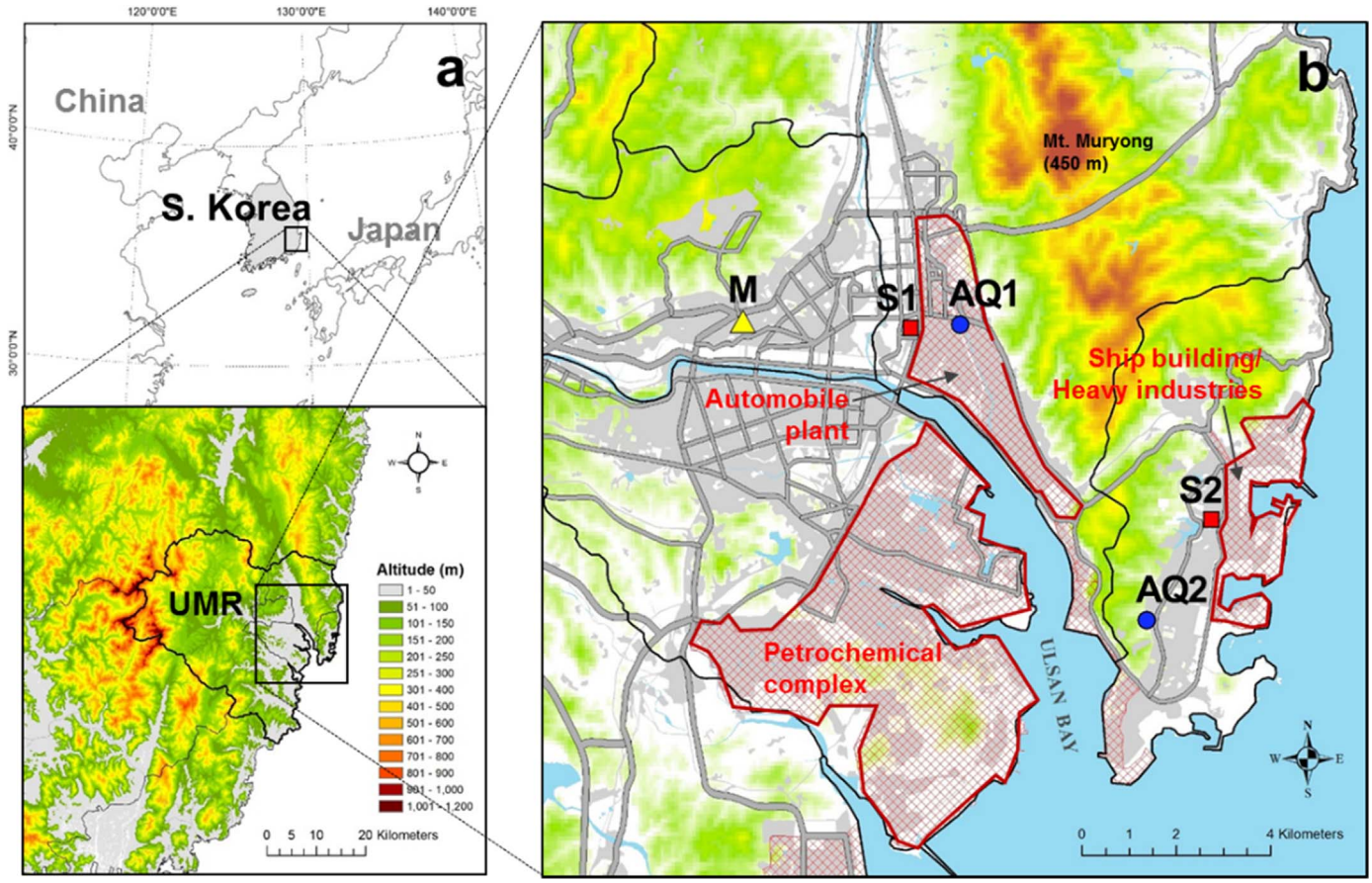


**Fig. 1.** Map showing (a) location of the UMR in South Korea and (b) urban environments and measurement sites: indoor measurement sites at two preschools (S1 and S2), air quality monitoring sites (AQ1 and AQ2) and meteorological sites (M). Red shaded regions and gray lines indicate industrial areas and main roads, respectively. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

on AD, especially in areas with high levels of PM. More specifically, identification of an association between short-term elevations of PM (which is common in many polluted cities) with symptoms of AD is needed to establish a better strategy for prevention and management of AD. However, few studies have examined the quantitative effects of short-term exposure to PM on AD in areas with high pollution, especially urban areas that are near large industrial complexes.

This study used long-term daily monitoring data to evaluate the association between PM exposure and AD symptoms in preschool children who live in industrial urban area of South Korea

## 2. Material and methods

### 2.1. Study area

The Ulsan metropolitan region (UMR) is located on the coast of southeastern Korea (Fig. 1). It has a population of 1.2 million, contains a central urban area with high traffic density, and large industrial complexes, including the world's largest automobile assembly plant and a petrochemical complex on the coast. Air pollution in the UMR is mainly due to emissions from these urban transportation and industrial facilities. We selected two preschools (S1 and S2, Fig. 1b) that are near these large industrial complexes for measurements of daily AD symptoms, PM concentrations, and their relationships. Several industrial plants, which are potential PM sources, are close to these preschools and residential areas, and these industrial emissions could have significant effects on indoor and outdoor PM pollution. Two air quality monitoring sites (AQ1 and AQ2, Fig. 1b) that are near the schools and operated by the Korea Ministry of Environment, were selected to obtain ambient outdoor concentrations of PM with diameters less than 10 μm (PM10).

### 2.2. Indoor PM measurements

Indoor concentrations of PM10 and PM2.5 were continuously measured with the Grimm Series 1.108 Aerosol Spectrometer (Grimm Tech., Inc., Douglasville, GA,USA), a portable optical particle counter, in two preschools (S1 and S2) from May to October of 2012 and 2013, respectively. The spectrometer sensitivity is 1 particle/L or 1 $\mu g/m^3$, and instrument reproducibility is ± 2%. Ambient air is drawn into the unit *via* an internal volume-controlled pump at a rate of 1.2 L/min. Previous publications provided detailed descriptions of this instrument (Cheng and Lin, 2010; Labortechnik Ltd., 1996). Monitoring was performed inside the classroom on the first floor of each building. The instrument was placed 1.5 m above the floor, and more than 2 m from doors and windows. The logging interval was set as 1 min. All children performed their normal activities and most of windows of the classroom normally remained closed during the entire sampling period. Several windows in each preschool were typically opened for ventilation and doors were frequently opened by entry and exit of persons. The indoor monitoring was not available for a specific period including summer vacation (19% and 11% of 6 months for S1 and S2, respectively).

### 2.3. Exposure assessment

Individual's total exposure to PM were estimated using indoor and outdoor PM concentrations based on time activities. The daily PM exposure estimates were from the average of indoor concentrations in the