



Short-term exposure to ambient particulate matter and emergency ambulance dispatch for acute illness in Japan



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HIGHLIGHTS

- Examined the association between short-term exposure to ambient suspended particulate matter and emergency ambulance dispatches for acute illness, a relatively new indicator for evaluating the health effects of air pollution.
- Using ambulance dispatch data, the present study demonstrated an increased risk of dispatches for acute illness associated with short-term exposure to suspended particulate matter.
- There was the significant effect modification in this association by the type of medical condition, with the effects being stronger for less severe medical conditions.

GRAPHICAL ABSTRACT

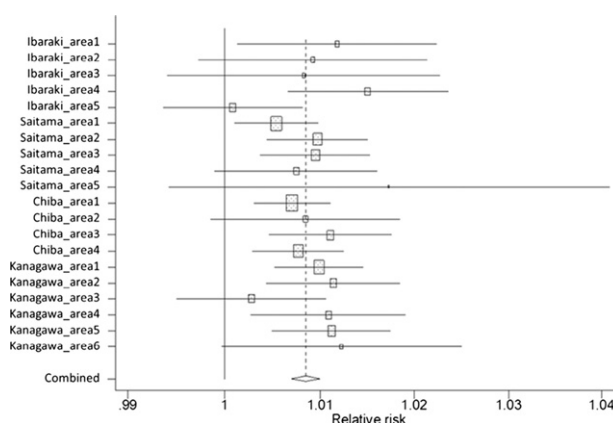


Figure shows area-specific and combined relative risk (RR) and 95% CIs of emergency ambulance dispatch for acute illness associated with a $10 \mu\text{g}/\text{m}^3$ increase in suspended particulate matter (SPM) at lag 0–1

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ABSTRACT

Short-term exposure to air pollution may be linked to negative health outcomes that require an emergency medical response. However, few studies have been undertaken on this phenomenon to date. The aim of this study therefore was to examine the association between short-term exposure to ambient suspended particulate matter (SPM) and emergency ambulance dispatches (EADs) for acute illness in Japan.

Daily EAD data, daily mean SPM and meteorological data were obtained for four prefectures in the Kanto region of Japan for the period from 2007 to 2011. The area-specific association between daily EAD for acute illness and SPM was explored using generalized linear models while controlling for ambient temperature, relative humidity, seasonality, long-term trends, day of the week and public holidays. Stratified analyses were conducted to evaluate the modifying effects of age, sex and medical conditions. Area-specific estimates were combined using meta-analyses.

Abbreviations: WHO, World Health Organization; PM, particulate matter; EAD, emergency ambulance dispatch; SPM, suspended particulate matter; PM_{10} , particulate matter with diameter $< 10 \mu\text{m}$; FDMA, Japanese Fire and Disaster Management Agency; O_3 , photochemical oxidants; NO_2 , nitrogen dioxide; SO_2 , sulfur dioxide; GLM, generalized linear models; PACF, partial autocorrelation function; DOW, day of the week; df , degree of freedom; RR, relative risk; CI, confidence interval; PAF, population attributable fraction.

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For the total study period the mean level of SPM was $23.7 \mu\text{g}/\text{m}^3$. In general, higher SPM was associated with a significant increase in EAD for acute illness [estimated pooled relative risk (RR): 1.008, 95% CI: 1.007 to 1.010 per $10 \mu\text{g}/\text{m}^3$ increase in SPM at lag 0–1]. The effects of SPM on EAD for acute illness were significantly greater for moderate/mild medical conditions (e.g. cases that resulted in <3 weeks hospitalization or no hospitalization) when compared to severe medical conditions (e.g. critical cases, and cases that led to >3 weeks hospitalization or which resulted in death).

Using EAD data, this study has shown the adverse health effects of ambient air pollution. This highlights the importance of reducing the level of air pollution in order to maintain population health and well-being.

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1. Introduction

According to the World Health Organization (WHO), air pollution has become the world's single biggest environmental health risk. An estimated 3.7 million deaths occurred worldwide due to ambient air pollution in 2012 (Bell et al., 2013). Among the air pollutants, particulate matter (PM) affects more people than any other pollutant. The adverse effects of short-term exposure to both coarse and fine PM are well documented in epidemiological studies and stretch across a range of health outcomes including mortality (Adar et al., 2014; Atkinson et al., 2014).

The majority of the studies that have found an association between ambient PM and adverse health outcomes have been conducted in North America and Europe (Atkinson et al., 2014; Peters et al., 2000) with fewer studies occurring in Asia (Lee et al., 2015). This may be an important gap in the research as the chemical composition of PM can vary with regard to its major emission sources and atmospheric conditions (Arruti et al., 2011; Mues et al., 2013). Indeed, epidemiological studies have shown that the levels and composition of PM vary significantly across regions and that these differences in composition are directly linked to variations in the adverse effects on human health (Levy et al., 2012; Samoli et al., 2005), making regional assessment of this association essential.

Studies showing the adverse health outcomes resulting from short-term exposure to ambient PM have mostly used mortality data (Peters et al., 2000; Samoli et al., 2013) or hospital-based data, such as hospital admissions or emergency room visits for non-fatal health outcomes (Qiu et al., 2014; Stafoggia et al., 2013; Zheng et al., 2015). Some studies have also made use of alternative data sources such as telephone calls for asthma (Laurent et al., 2008), doctors' house calls (Chardon et al., 2007), and information on doctor consultations (Hajat et al., 2002). In addition, more recently, emergency ambulance dispatch (EAD) data has begun to be used as a proxy for acute health outcomes. It has been suggested that these data may serve as a particularly useful resource to examine the health effects of environmental exposures (Alessandrini et al., 2011; Ueda et al., 2012). Moreover, very recent epidemiological studies have shown that short-term exposure to both fine and coarse PM is associated with an increase in EADs (Michikawa et al., 2015a; Michikawa et al., 2015b).

However, as yet, research using EAD data is still comparatively limited. For example, although previous studies that have used EAD data have focused on different indices of PM exposure such as coarse PM (Michikawa et al., 2015b) and fine PM (Michikawa et al., 2015a) as well as PM with a diameter $<10 \mu\text{m}$ (PM_{10}) (Sajani et al., 2014), not all indices of PM have been investigated. This is important as previous toxicological studies have shown that PM-induced toxic effects are often dependent upon the specific characteristics of PM, including its size and composition (Mirowsky et al., 2013). In Japan, for instance, although suspended particulate matter (SPM), i.e. particles with a diameter of less than approximately $7 \mu\text{m}$, have been monitored under the Japanese Air Quality Standard since 1972 (Japanese Ministry of Environment, 2009), up until now, no studies have examined the association between short-term exposure to SPM and EAD.

Given this, the aim of the present study was to examine the effect of short-term exposure to SPM on EAD for acute illness in four prefectures in central Japan. We further investigated whether age, sex and severity of medical condition could modify the effect of short-term exposure to SPM on EAD for acute illness in this setting.

2. Methods

2.1. Setting

The present study was conducted in 20 areas across four prefectures (Ibaraki, Saitama, Chiba and Kanagawa) in the Kanto region, located in the largest island of Japan, covering an area of approximately $17,466 \text{ km}^2$ (Fig. 1). The capital city, Tokyo, is located in the Kanto region and this region is the most highly developed, urbanized, and industrialized part of Japan, while the prefectures included in this study are those that surround Tokyo. The weather in this region is generally mild and characterized by a humid subtropical climate with four distinct seasons. There were about 25.4 million residents in these four prefectures according to the 2010 census. Among the prefectures, Kanagawa has the largest population with 9 million people, followed by Saitama with 7.2 million people, Chiba with 6.2 million people, while Ibaraki has a population of approximately 3 million people. Each prefecture is divided into several areas by its prefectural office based on climate and various socioeconomic characteristics. In this study, in order to examine the relationship between SPM and EAD for acute illness with as much precision and accuracy as possible, area-level analyses were performed within each prefecture.

2.2. Outcome data

The outcome variable in this study was the daily number of EADs for acute illness. EAD daily data for the period from 1 January 2007 to 31 December 2011 were obtained from the Japanese Fire and Disaster Management Agency (FDMA) for individual areas across the study region. Ambulance services for emergency purposes are provided free of charge by all local governmental fire defense headquarters throughout Japan and anyone can summon an ambulance by making an emergency telephone call (dial 119) (Tanigawa and Tanaka, 2006). Anonymous ambulance dispatch data for the four study prefectures were extracted from the FDMA dataset. For each record, information on the cause of the dispatch, date and time of the event, medical condition, primary diagnosis and basic information regarding the person requiring the dispatch, such as age and sex was available. In this study, only ambulance dispatches for acute illness were extracted from the total record. The medical condition of those transported to hospital was determined by an emergency medical doctor upon their arrival at the hospital. Five categories were used to describe the medical condition of the patients in the FDMA database: dead, critical (for patients with a condition where death is imminent), serious (for patients who were likely to require hospitalization for >3 weeks), moderate (for patients who would require hospitalization for <3 weeks) and mild (for patients who required no hospitalization) (Japanese Fire and Disaster Management Agency,

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