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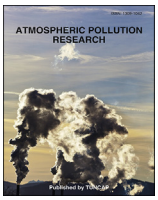

Emergency room visits for respiratory diseases associated with ambient fine particulate matter in Taiwan in 2012: A population-based study

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ABSTRACT

This population-based study explored the effects of ambient fine particulate matter ($PM_{2.5}$) on hospital emergency room visits (ERVs) for respiratory diseases (RDs) in Taiwan in 2012. Data on hospital ERVs for RDs and ambient $PM_{2.5}$ levels in 2012 were obtained from the National Health Insurance Research database and the Environmental Protection Administration, respectively. The lag structure of relative risks (RRs) of hospital ERVs for RDs was estimated using the Quasi-Poisson generalized additive model. During the study period, the average daily number of hospital ERVs for RDs, chronic obstructive pulmonary disease (COPD), acute exacerbation chronic obstructive pulmonary disease (AECOPD), asthma, and pneumonia were 17, 15, 17, 17, and 17, respectively, and the mean 24-h average $PM_{2.5}$ concentration was 27.8 μg/m^3. Increased hospital ERVs for RDs were significantly associated with $PM_{2.5}$; moreover, geographic variation in $PM_{2.5}$ hospital ERVs for RDs was observed. In terms of RRs for each 10 μg/m3 increase in $PM_{2.5}$, Kao−Ping air quality zone (with districts: Kaohsiung and Pingdong) had the largest RRs associated with $PM_{2.5}$; the RRs were 1.23 [95% confidence interval (CI) = 1.05−1.45] for AECOPD (at lag 0−1 days), 1.07 (95% CI = 1.01−1.13) for asthma (at lag 0−1 days), and 1.07 (95% CI = 1.01−1.13) for pneumonia (at lag 0−1 days). On hot season, the RRs were 1.05 (95% CI = 1.01−1.08) for AECOPD (at lag 0−3 days); moreover, on cold season, the RRs were 1.15 (95% CI = 1.03−1.28) for asthma (at lag 0−1 days) and 1.15 (95% CI = 1.03−1.28) for pneumonia (at lag 0−1 days). Overall, $PM_{2.5}$ exposure had lag effects on hospital ERVs for RDs; elevated RRs started at 2-day (lag 0−1 days), and larger RR estimates were observed at longer lags. In summary, this study revealed an association between $PM_{2.5}$ and hospital ERVs for RDs in Taiwan.

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1. Introduction

Particulate matter (PM) has been classified as carcinogenic to humans (Group 1) by the International Agency for Research on Cancer (IARC) in 2013 (IARC , 2014). Fine PM (aerodynamic diameter < 2.5 μm, $PM_{2.5}$) has been considered more harmful than PM_{10} (aerodynamic diameter < 10 μm) because it can penetrate the lung alveoli, causing lung inflammation and affecting the

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pulmonary immune function (Zhao et al., 2014). Epidemiological studies have consistently demonstrated that $PM_{2.5}$ exposure is associated with increased hospital admissions (HAs) and mortality for cardiovascular diseases and respiratory diseases (RDs) (Dominici et al., 2006; Halonen et al., 2009; Hwang et al., 2016; Kloog et al., 2012; Li et al., 2016; Lu et al., 2015; Peacock et al., 2011). Studies examining the effects of $PM_{2.5}$ on hospital emergency room visits (ERVs) for RDs are limited, but several studies have been conducted in the United States (Gleason and Fagliano, 2015; Rodopoulou et al., 2014, 2015). Rodopoulou et al. (2015) revealed that $PM_{2.5}$ was associated with cardiovascular and respiratory emergencies in Arkansas, USA, during the cold period. Rodopoulou et al. (2014) revealed that $PM_{2.5}$ had an effect on respiratory emergencies in New Mexico, USA. Gleason and Fagliano (2015) reported that $PM_{2.5}$ was not associated with pediatric emergency department visits for asthma in Newark, USA. Limited studies have been conducted in Europe (Halonen et al., 2008), China (Xu et al., 2013), and Taiwan (Wang and Lin, 2016). Halonen et al. (2008) indicated positive associations between $PM_{2.5}$ and pooled asthma–chronic obstructive pulmonary disease (COPD) emergency visits in Helsinki, Finland. Xu et al. (2013) reported statistically significant associations between $PM_{2.5}$ and the hospital ERVs for total RD and cause-specific diseases, including upper respiratory tract infection, lower respiratory tract infection, and acute exacerbation chronic obstructive pulmonary disease (AECOPD) in Beijing, China. A study conducted in Taipei, Taiwan, revealed that $PM_{2.5}$ was associated with the hospital ERVs for RDs (Wang and Lin, 2016).

Asian dust storm events originate from the deserts of Mongolia and northern China and form atmospheric particles that increase the $PM_{2.5}$ levels in East Asia, including in Taiwan (Chen et al., 2004). Taiwan is located on the lee side of the East-Asian winter and summer monsoons, sea–land breezes, and northeastern monsoon, which strongly influence $PM_{2.5}$ recirculation and accumulation in Taiwan (Tsai et al., 2008, 2011). The annual ambient $PM_{2.5}$ concentration in Taiwan (25.2 $\mu g/m^3$) exceeded the World Health Organization guideline limits (10 $\mu g/m^3$) in 2014 [Environmental Protection Administration (EPA), 2015]. A few studies have demonstrated the effects of ambient $PM_{2.5}$ on the mortality (Wang and Lin, 2016) or number of HAs due to cause-specific RDs, such as COPD, asthma, and pneumonia in Taiwan (Cheng et al., 2015; Hwang et al., 2016; Tsai et al., 2013, 2014); however, these studies have been limited to one or two metropolitan areas. Moreover, information regarding the effects of $PM_{2.5}$ on emergency HAs for RDs in Taiwan is limited. ERVs and HAs are indispensable factors for assessing the acute morbidity effects of air pollution; however, their demographic and diagnostic differences may affect their usefulness while interpreting the observed air pollution–health association (Winquist et al., 2012). Winquist et al. (2012) stated that ERV data is preferred for RD analyses because greater analytic power can be achieved using ERV data than HAs data. Therefore, to comprehensively assess the association between $PM_{2.5}$ and respiratory morbidity in Taiwan, we conducted a population-based study for exploring the effects of atmospheric $PM_{2.5}$ levels on hospital ERVs for RDs in Taiwan in 2012.

2. Methods

2.1. Hospital emergency room visits data

This study was approved by the Institutional Review Board (IRB) of Chang Gung Medical Foundation (IRB no. 103-1244C). This population-based study was conducted using the medical claims data from the National Health Insurance Research Database (NHIRD) obtained from Taiwan's National Health Insurance (NHI) program (registered number: NHIR-NHIRD-104-076). The NHI program has reimbursed nearly all medical services costs for Taiwanese inhabitants since 1995. Furthermore, by the end of 2010, this insurance program had covered approximately 99.89% of the total population in Taiwan (Bureau of National Health Insurance, 2002). The NHIRD is a valid resource for epidemiological research, providing high quality information on prescription use, diagnosis, and hospitalization (Cheng et al., 2011, 2014).

Daily counts of hospital ERVs in 2012 with a primary diagnosis of RD were obtained from the NHIRD. Disease diagnoses were based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). RD outcomes included COPD (ICD-9-CM 490-492 and 496), AECOPD (ICD-9-CM 49121), asthma (ICD-9-CM 493), and pneumonia (ICD-9-CM 480-486).

2.2. Outdoor $PM_{2.5}$ and meteorological data

The Taiwan Air Quality Monitoring Network (TAQMN), established by the Taiwan EPA in 1993, had 76 stationary monitoring stations distributed throughout the island in 2015 (EPA , 2015). Each monitoring station measures hourly concentrations of ambient air pollutants and meteorological variables. $PM_{2.5}$ concentrations in Taiwan are being measured continuously since 2006 (EPA , 2015). We obtained the hourly $PM_{2.5}$ and temperature monitoring records for 2012 from the TAQMN (EPA , 2015; Lin et al., 2008).

According to geographical characteristics and air quality conditions, the TAQMN divides Taiwan into seven air quality zones, including North (with four districts: Keelung, Taipei, New Taipei, and Taoyuan), Chu–Miao (with two districts: Hsinchu and Miaoli), Central (with three districts: Taichung, Jhanghua, and Nantou), Yun–Chia–Nan (with three districts: Yunlin, Chiayi, and Tainan), Kao–Ping (with districts: Kaohsiung and Pingdong), Yilan (with one district: Yilan) and Hua–Tung (with two districts: Hualian and Taidong) (EPA , 2015) (Fig. 1). The TAQMN monitoring stations measure and record hourly concentrations of ambient $PM_{2.5}$ and meteorological data, including temperature and relative humidity (RH). The hourly data were averaged to calculate the daily average data for $PM_{2.5}$ and meteorological variables at 76 monitoring

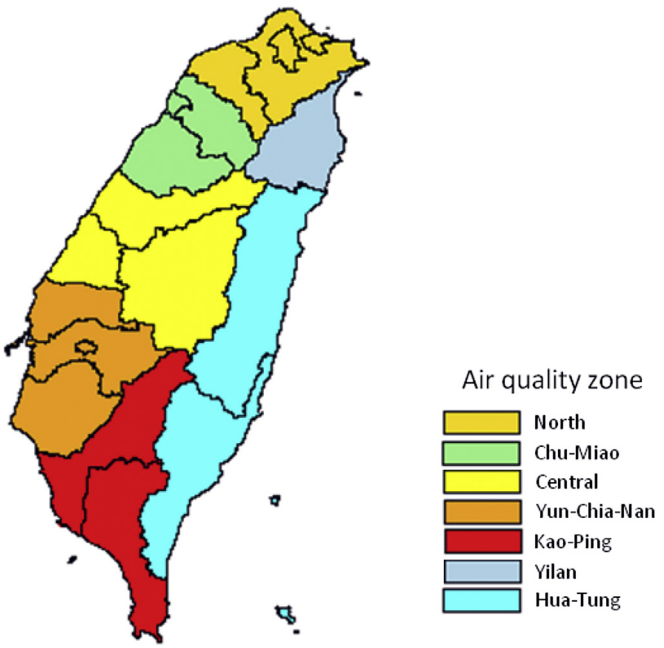

Fig. 1. Locations of air quality zones in Taiwan.

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