



Association between short-term exposure to fine particulate matter and daily emergency room visits at a cardiovascular hospital in Dhaka, Bangladesh

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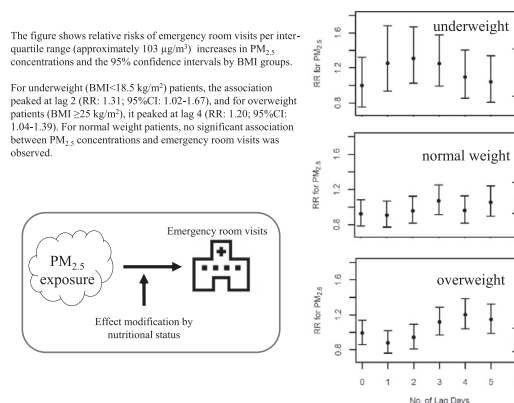
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HIGHLIGHTS

- We examined cardiovascular health effects of PM_{2.5} exposure in Dhaka, Bangladesh.
- The daily number of emergency room visits at a cardiovascular hospital was used.
- PM_{2.5} was not associated with number of emergency room visits on the same day.
- A significant effect of PM_{2.5} was observed 2–4 days after the exposure.
- The extent of delay was different according to the nutritional status of patients.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: It has been suggested that exposure to fine particulate matter (PM_{2.5}) adversely affects cardiovascular health. However, the effect modifications by individual characteristics and season have been less studied in developing countries where PM_{2.5} levels are high.

Objectives: To estimate the risks of cardiovascular emergency room visits in relation to daily concentrations of PM_{2.5} and to assess how these associations can be modified by age, sex, and nutritional status of patients and by season.

Methods: The analytic sample was 6774 adults who visited the emergency room at a cardiovascular disease (CVD) hospital in Dhaka throughout one year (n = 364 days). A time-stratified case-crossover design with conditional Poisson regression analysis was used to estimate the relative risks (RRs) and 95% confidence intervals (CIs) of visits while adjusting for temperature. Stratification was performed by gender, age (<65 and

Abbreviations: CAMS, continuous air monitoring station; CI, confidence interval; CVD, cardiovascular disease; IQR, interquartile range; NO₂, nitrogen dioxide; OR, odds ratio; PPB, parts per billion; RR, relative risk; SO₂, sulfur dioxide; WHO, World Health Organization.

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Season

≥65 years), BMI (underweight, normal weight, overweight), and season (dry summer: February to April; wet summer: May to October; dry winter: November to January).

Results: The mean concentration of PM_{2.5} was 86.1 µg/m³. An IQR increase (103 µg/m³) in PM_{2.5} at lag 3 was significantly associated with a 12% (RR: 1.12; 95% CI: 1.01–1.23) increase in CVD emergency room visits. No evidence of association was found for the other lags. Underweight and overweight patients showed evidence of increased risk at lag 2 (RR: 1.31; 95% CI: 1.02–1.67) and lag 4 (RR: 1.20; 95% CI: 1.04–1.39), respectively.

Conclusion: Increases in the daily concentrations of PM_{2.5} may lead to more cardiovascular emergency room visits in Dhaka, Bangladesh. Response times from ambient exposure to CVD emergency visits may differ by season and the nutritional status of susceptible individuals, necessitating further research.

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1. Introduction

In the past several decades, ambient air pollution has become a serious health problem in both developed and developing countries (Landrigan et al., 2017). According to the World Health Organization (WHO), in 2014, 92% of the world population was living in an environment in which the WHO recommended standards for outdoor air quality were not met (World Health Organization, 2016). In 2015, ambient particulate matter (PM) pollution was responsible for 4.2 million deaths globally; among these, 1.36 million deaths occurred in South Asian countries (Forouzanfar et al., 2016). Age-standardized mortality rates (per 100,000 people) attributable to PM were >7 times higher in Pakistan (136.3), India (133.5) and Bangladesh (133.2) compared to those of Japan (16.8) and the USA (18.5) (Cohen et al., 2017). The mean concentration for PM_{2.5} was 135 µg/m³ in Dhaka and 169 µg/m³ in Delhi, whereas the mean concentration ranged from 11 to 20 µg/m³ in several US cities (Krzyzanowski et al., 2014).

Short-term exposure to PM_{2.5} has been linked to increased mortality (Fajersztajn et al., 2017; Laden et al., 2006), increased numbers of hospital admissions (Dominici et al., 2006; Peters et al., 2001; Pope et al., 2006) and increased risks of emergency room visits for cardiovascular diseases (CVD) (Guo et al., 2009; Liu et al., 2013; Metzger et al., 2004). While the acute adverse health effects of PM_{2.5} exposure have been reported across countries, the effect estimates are heterogeneous (Atkinson et al., 2010). The causes of such heterogeneity in effect estimates are largely unknown. Variations in PM concentration and composition observed in different locations (Mues et al., 2013) may play a role because the health effects of PM vary depending on its composition (Valavanidis et al., 2008). Additionally, effect modification by individual characteristics and/or by season may also contribute to the observed heterogeneity (Bell et al., 2013; Huang et al., 2012; Linn et al., 2000; Qin et al., 2015; Zhang et al., 2016; Zhao et al., 2013).

Elderly populations, females and patients with existing medical conditions such as diabetes or hypertension are likely to be more susceptible to the adverse health effects of PM as previous research has suggested (Bell et al., 2013; Huang et al., 2012; Linn et al., 2000; Zhang et al., 2016). More recently, evidence has emerged that overweight/obesity may modify the association between long-term exposure to PM and CVD (Qin et al., 2015; Zhao et al., 2013). A study in China (Qin et al., 2015) reported that the negative impact of annual PM₁₀ exposure on CVD was stronger among obese subjects (odds ratio (OR) ranged 1.33–1.59 per 19 µg/m³ increase in annual PM₁₀ concentration) compared with normal weight subjects (OR ranged from 0.93–1.15 per 19 µg/m³ increase in annual PM₁₀ concentration). It was hypothesized that since obesity is associated with decreased oxidant defense and PM_{2.5} is associated with increased oxidative stress, obesity may modify the PM-induced CVD-related health effects (Weichenthal et al., 2014). On the other hand, evidence on the impact of being underweight in association with PM and CVD is scarce. Although developing countries are experiencing a nutritional transition from underweight to overweight populations (Popkin et al., 2012), the problem of poor nutritional status remains in those countries. In fact, among Bangladeshi adults, both underweight (30.4%) and overweight (18.9%) are prevalent

(Biswas et al., 2017). Considering that Bangladesh is experiencing an epidemiological transition from infectious diseases to non-communicable diseases (Karar et al., 2009), understanding the relationship between acute PM exposure and CVD in the context of nutritional status is important in this country.

While the seasonal variations of the health effects of PM have also been evaluated in previous epidemiological studies, findings remain inconsistent (Hsu et al., 2017; Peng et al., 2005; Qian et al., 2010). Moreover, there is a lack of research in regions with a subtropical monsoon climate, especially in areas where the concentration of PM fluctuates throughout the year. For example, in Bangladesh, the mean PM_{2.5} concentration in the dry season is much higher (171 µg/m³) than in the wet season (39.5 µg/m³) (Rana et al., 2016). Therefore, studies on the seasonal variations in the health effects of PM are important to provide evidence on how local climate affects the seasonality of PM-induced health risk, as well as behavioral changes that might alter exposure patterns in the region.

The objectives of the current study were (1) to investigate the association between short-term exposure to PM_{2.5} and daily emergency room visits for CVD in Dhaka, Bangladesh and (2) to determine if this association varied by age, sex, BMI and season.

2. Material and methods

2.1. Emergency room visit data

Bangladesh has a subtropical monsoon climate and is characterized by a moderately warm temperature, wide seasonal variations in rainfall, and high humidity (National Environmental Agency of Singapore, 2018). The study was conducted at the National Institute of Cardiovascular Diseases (NICVD) in its capital city Dhaka. The total area of the Dhaka district is 1464 km², and the total population was 12,043,977 in 2011 (Bangladesh Bureau of Statistics, 2013). Patients from all over the country come to this hospital from various socioeconomic backgrounds given the low cost and medical specialties. The hospital has an ordinary outpatient department and emergency room service. Patients with severe cardiac complications, chest pain or who were unconsciousness are referred to the emergency room, while those with mild cardiac problems go to the ordinary outpatient department for consultations. Admission to the emergency room is based on medical assessment by doctors independent of the preference of patient or family members.

The present study was conducted from February 2, 2014 to January 31, 2015 (n = 364 days). The data on daily emergency room visits were recorded manually throughout the study period, except on public holidays (n = 16 days) and Fridays (n = 52 days, designated non-working days), by data collectors specially employed for our research. There were additional 20 days without information on emergency room visits, resulting in a total of 88 days of non-consecutive missing health outcome data. One or more data collectors stayed at the hospital for 24 h by working in three 8-hour shifts. These collectors were provided detailed instructions on the data recording procedure before starting their work. A one-page questionnaire was used to collect

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