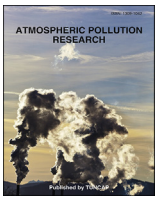
Atmospheric Pollution Research 7 (2016) 147–154

HOSTED BY

Contents lists available at ScienceDirect

Atmospheric Pollution Research

journal homepage: http://www.journals.elsevier.com/locate/apr



Original article

Study on the association between air pollution and mortality in İstanbul, 2007–2012

Özkan Çapraz [a], Bahtiyar Efe [b, *], Ali Deniz [b]

[a] Marmara Clean Air Center, Şişli, İstanbul, Turkey
[b] İstanbul Technical University, Faculty of Aeronautics and Astronautics, Department of Meteorology, Maslak, 34469, İstanbul, Turkey

ARTICLE INFO

Article history:
Received 28 October 2014
Received in revised form
15 August 2015
Accepted 15 August 2015
Available online 12 October 2015

Keywords:
Air pollution
Daily mortality
Generalized linear model (GLM)
İstanbul

ABSTRACT

We examined the associations between the daily variations of air pollutants and mortality in the population of İstanbul, Turkey, using generalized linear models while controlling for time trends and meteorological factors over a 6-year period (2007–2012) at different time lags (0–10 days). Effects of the pollutants (Relative Risk (RR) on current-day (lag 0) mortality to the first ten days (lag 10) were determined. Data on daily mortality, daily mean concentrations of air pollutants of PM_{10}, SO_2 and NO_2 and daily mean concentrations of temperature and humidity for İstanbul were used in the study. We found significant associations between air pollution and daily mortality from cardiovascular disease, respiratory diseases, and total non-accidental causes in İstanbul. An increase of 10 $\mu g/m^3$ in concentrations of PM_{10}, SO_2 and NO_2 over 10 days of lag corresponds to RR = 1.0222 (95% Confidence Interval (CI) = 0.9957–1.0494), RR = 1.1639 (95% CI = 1.0279–1.3177) and RR = 1.0327 (95% CI = 1.0105–1.0554) increase of cardiovascular mortality, respectively. The associations for total non-accidental and respiratory mortality were also positive. Among the three air pollutants, SO_2 was associated with the largest RR for deaths from cardiovascular disease, respiratory disease and total mortality. In conclusion, our study showed that short-term exposure to air pollution was associated with increased cardiovascular, respiratory and total non-accidental mortality in the city during 2007–2012. These findings may have implications for local environmental and social policies.

1. Introduction

Air pollution and its impact on people's health and the environment have attracted attention globally during the last 50 years. Adverse health effects of air pollution include a broad range of acute and chronic health effects causing increased hospital admissions (Chen et al., 2004), increased emergency room visits (Li et al., 2011) and, most importantly, increased mortality (Dockery et al., 1993). According to the estimation of World Health Organization, ambient (outdoor) air pollution in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012 (WHO, 2014). Epidemiological studies have shown short-term and long-term associations between the levels of ambient air pollutants with respiratory and cardiovascular mortalities in different parts of the world (Pope and Dockery, 2006; Samoli et al., 2008; Liang et al., 2009; Wong et al., 2010; Zhang et al., 2011; Yu et al., 2012; Mahiyuddin et al., 2013). Various studies show that all types of air pollution, at high concentration, can affect the airways. Symptoms such as nose and throat irritation, followed by bronchoconstriction and dyspnoea, especially in asthmatic individuals, are usually experienced after exposure to increased levels of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). In patients with lung lesions or lung diseases, pollutant-initiated inflammation will worsen their condition. Major concerns for human health also occur from exposure to PM_{10} including death from respiratory and cardiovascular causes, damage to lung tissue, cancer, stroke, increased numbers of heart attacks and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to the effects of particulate matter. On the other hand, similar effects are also observed with long-term exposure to lower pollutant concentrations. Even within

* Corresponding author. Tel./fax: +90 (212) 285 31 22.
E-mail addresses: caprazozkan@gmail.com (Ö. Çapraz), efeba@itu.edu.tr (B. Efe), denizali@itu.edu.tr (A. Deniz).

Peer review under responsibility of Turkish National Committee for Air Pollution Research and Control.

http://dx.doi.org/10.1016/j.apr.2015.08.006

the limits of the current air quality standards, the negative health effect of air pollutants can still be observed (Vedal et al., 2003).

Located between Europe and Asia, Turkey as a developing and recently industrialized country, has experienced serious air quality problems in the past. İstanbul, one of the mega cities in the world and the biggest city of Turkey, has experienced significant particulate matter (PM) and sulphur dioxide (SO_2) episodes due to the poor quality fossil fuel burning for domestic heating and industry in the late 1980s and beginning of 1990s (Unal et al., 2011). In the mid-1990s, following the natural gas project (switching of fuel oil and lignite to natural gas), emission sources have shown significant changes over time, total suspended particle and SO_2 levels were gradually decreased (İncecik and İm, 2012). However, due to the rapid increase in the number of cars, industry and population since 1990s, air pollutant emissions in the city have been increased (İBB, 2007; Doğan, 2013). Today, traffic, industrial processes, domestic heating, long-range transportation of pollutants and ship emissions are the most significant emission sources in İstanbul. The city is facing especially secondary particulate matter and nitrogen dioxide (NO_2) problems depending on fixed point-source (houses, industrial facilities, etc.) as well as motor vehicle-related air pollution (İncecik and İm, 2012).

In Turkey, there are several epidemiological studies indicating significant relationship between high air pollution levels and the number of patients who are admitted to the medical units in Turkey (Keles and Ilıcalı, 1998; Savas et al., 2002; Hapcioglu et al., 2005; Tomaç et al., 2005; Tecer et al., 2008). However, only a limited number of studies have been conducted about the relation of air pollution with mortality (Şahin, 2000; Doğru et al., 2008). According to Sahin, there was a significant correlation between daily mortality data and total suspended particle. Doğru et al. found that, there is a correlation between total suspended particle and mortality but there wasn't a correlation between SO_2 and mortality. These studies were limited due to a lack of integration with local environmental and epidemiological data. Beside of that, as far as we know, no study has ever used generalized linear model (GLM) using a Poisson distribution to assess the effects of air pollution on mortality yet. Our study aims to estimate short-term health effects of pollutants on mortality in İstanbul by adopting a generalized linear model (GLM) using a Poisson distribution.

In this study, we conducted a time-series study of the relationship between air pollution and mortality in İstanbul, using Poisson regression in generalized linear model (GLM) while controlling for time trends and meteorological factors. Our study aims to estimate short-term health effects of pollutants on mortality in İstanbul over a 6-year period, 2007–2012.

2. Methodology

2.1. Study area

Located between Black Sea and Sea of Marmara, İstanbul is the largest urban area of Turkey with 5400 km^2 area. With a population of 14.1 million, the city forms one of the largest urban agglomerations in Europe. İstanbul is separated as Asian and European parts by Bosphorus strait which is approximately 30 km in length. The city has a Mediterranean climate. While the summer months are relatively dry and hot, the winter months are mild and rainy in İstanbul. The daily mean winter and summer temperatures are about 6.5 °C and 22.7 °C, respectively. Rainfall mostly occurs in the winter and fall seasons with an average 344 mm and 309 mm, respectively (Unal et al., 2011). The prevailing wind directions are north-easterly and south-westerly in winter, and northerly in summer (Unal et al., 2000). Meteorological factors have considerable influence on air pollution. Wind carries air pollutants away from their source, causing them to disperse. In general, the higher the wind speed, the more pollutants are dispersed and their concentrations are lowered. However, high wind can also transport dust from long range distances.

Within İstanbul, different areas are exposed to different weather patterns and different levels of air quality. For example, coastal areas in the region are exposed to consistent winds, which help disperse pollutants. In inland areas of the city, air pollutants can build up when there is little or no wind. And also, cold winter months had greater exposure risk to pollutants as air pollutants often trapped in the lower layers of atmosphere resulting in high concentrations.

Nowadays, İstanbul is facing especially PM and NO_2 pollution depending on the emission sources (İncecik and İm, 2012). The major emission sources in the city are motor vehicles, industrial processes, residential heating and the ship emissions (Unal et al., 2011). Additionally, the trans-boundary pollutant transport significantly affects the air quality of İstanbul. According to the sensitivity analysis results, the response of İstanbul background PM_{10} concentrations can be as much as 26%, when anthropogenic emissions throughout Europe are changed by 50% (Kindap et al., 2006). İstanbul also experiences dust transport especially in the spring months coming mainly from the Sahara (Karaca et al., 2009).

2.2. Mortality, air quality and meteorological data

Daily mortality records of İstanbul Okmeydanı Education and Research Hospital, Ümraniye Education and Research Hospital, Haydarpaşa Numune Education and Research Hospital and İstanbul Şişli Etfal Education and Research Hospital were obtained from İstanbul Provincial Health Directorate from January 1, 2007 to December 31, 2012 (Table 1). The selection was made according to the International Classification of Disease, Tenth Revision (ICD-10) by the World Health Organization. Deaths from all non-accidental causes (ICD-10: A00-R99), cardiovascular disease (ICD-10: I00-I99) and respiratory disease (ICD-10: J00-J98) were considered.

Air quality indicators in our study include PM with aerodynamic diameter of $\leq$10 μm (PM_{10}), SO_2 and NO_2. We obtained hourly air quality data from the ten air quality stations of İstanbul Metropolitan Municipality (Table 1). Six of the ten stations are at the European side (Aksaray, Alibeykoy, Besiktas, Esenler, Sariyer, and Yenibosna) and four of them are at the Asian side of the city (Kadikoy, Kartal, Uskudar, and Umraniye) (Table 1).

Table 1
Air quality and meteorological stations with hospitals. The underlined numbers represent air quality stations, italic numbers represent meteorological stations and classic numbers represent hospitals in Fig. 1.

Type	No	Name	Place
Air quality	1	Esenler	Europe
Air quality	2	Alibeyköy	Europe
Air quality	3	Aksaray	Europe
Air quality	4	Beşiktaş	Europe
Air quality	5	Sarıyer	Europe
Air quality	6	Yenibosna	Europe
Air quality	7	Üsküdar	Asia
Air quality	8	Kadıköy	Asia
Air quality	9	Ümraniye	Asia
Air quality	10	Kartal	Asia
Meteorology	*1*	Sarıyer	Europe
Meteorology	*2*	Florya	Europe
Meteorology	*3*	Göztepe	Asia
Hospital	1	Okmeydanı	Europe
Hospital	2	Şişli Etfal	Europe
Hospital	3	Numune	Asia
Hospital	4	Ümraniye	Asia