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Effects of air pollution on respiratory hospital admissions in İstanbul, Turkey, 2013 to 2015

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HIGHLIGHTS

- İstanbul has PM_{10}, $PM_{2.5}$ and NO_2 pollution.
- Short-term exposure to PM_{10}, $PM_{2.5}$ and NO_2 is positively associated with increased respiratory hospital admissions in İstanbul.
- $PM_{2.5}$ has the strongest impact.
- Women and elderly people were more sensitive to respiratory risk of air pollution.
- The first air pollution and respiratory hospital admission study using GLM in İstanbul.

GRAPHICAL ABSTRACT

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ABSTRACT

We examined the associations between the daily variations of air pollutants and hospital admissions for respiratory diseases in İstanbul, the largest city of Turkey. A time series analysis of counts of daily hospital admissions and outdoor air pollutants was performed using single-pollutant Poisson generalized linear model (GLM) while controlling for time trends and meteorological factors over a 3-year period (2013–2015) at different time lags (0–9 days). Effects of the pollutants (Excess Risk, ER) on current-day (lag 0) hospital admissions to the first ten days (lag 9) were determined. Data on hospital admissions, daily mean concentrations of air pollutants of PM_{10}, $PM_{2.5}$ and NO_2 and daily mean concentrations of temperature and humidity of İstanbul were used in the study. The analysis was conducted among people of all ages, but also focused on different sexes and different age groups including children (0–14 years), adults (35–44 years) and elderly (≥65 years). We found significant associations between air pollution and respiratory related hospital admissions in the city. Our findings showed that the relative magnitude of risks for an association of the pollutants with the total respiratory hospital admissions was in the order of: $PM_{2.5}$, NO_2, and PM_{10}. The highest association of each pollutant with total hospital admission was observed with $PM_{2.5}$ at lag 4 (ER = 1.50; 95% CI = 1.09–1.99), NO_2 at lag 4 (ER = 1.27; 95% CI = 1.02–1.53) and PM_{10} at lag 0 (ER = 0.61; 95% CI = 0.33–0.89) for an increase of 10 μg/m3 in concentrations of the pollutants. In conclusion, our study showed that short-term exposure to air pollution was positively associated with increased respiratory hospital admissions in İstanbul during 2013–2015. As the first air pollution hospital admission study using GLM in İstanbul, these findings may have implications for local environmental and social policies.

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1. Introduction

Air pollution has become one of the most serious environmental concerns for urban areas throughout the world over the past several decades. Various epidemiological studies in recent years reported associations between elevated air pollution levels and increased death and hospitalization rates due to respiratory and cardiovascular diseases (Samet et al., 2000; Atkinson et al., 2001; Katsouyanni et al., 2001; Chen et al., 2004; Pope and Dockery, 2006; Dominici et al., 2006; Samoli et al., 2008; Mahiyuddin et al., 2013; Li et al., 2016). Some epidemiological studies showed that air pollution affects human health even air pollutant concentrations are below the air quality standards (Peters et al., 2001; Pope et al., 2002; Peng et al., 2006).

In Turkey, many studies have been published about air pollution and some of them linked air pollution to adverse population health in cities based on data that were collected in the 1990s and 2000s (Keles and Ilıcalı, 1998; Savaş et al., 2002; Hapçıoglu et al., 2005, Tomaç et al., 2005; Tecer et al., 2008; Toros et al., 2013; Ozcan and Cubukcu, 2015, Çapraz et al., 2015). For İzmir, it was reported that there is a statistically significant relation between the number of asthma cases and the level of air pollution urban air pollution in the six core districts in Izmir between the years 2007 and 2010 (Özcan and Çubukcu, 2015). The findings indicate that high levels of sulfur dioxide (SO_2) and particulate matter (PM_{10}) were significant causes of asthma. In a study undertaken in İstanbul, significant associations between air pollution and daily mortality from cardiovascular disease, respiratory diseases, and total non-accidental causes were found over a 6-year period (2007–2012). An increase of 10 μg/m3 in concentrations of PM_{10}, SO_2 and NO_2 over 10 days of lag corresponded to RR = 1.0018 (95% CI = 0.9569–1.0489), RR = 1.2116 (95% CI = 0.9727–1.5091) and RR = 1.0253 (95% CI = 0.9829–1.0694) increase of respiratory mortality, respectively (Çapraz et al., 2015).

Air pollution is an important risk factor for respiratory health effects. Respiratory diseases and the related mortality have been increasingly associated with exposure to air pollutants. Sensitive and vulnerable groups such as pregnant women, children, the elderly and those already suffering from respiratory and other serious illnesses or from low income groups are especially affected from air pollution. Studies have shown that the number of respiratory diseases in children and elderly increases due to the higher air pollution concentrations (Braga et al., 1999, 2001; Viegi et al., 2009). According to these studies, children are more susceptible because they need twice the amount of air inhaled by adults and the elderly are more affected due to their weak immune and respiratory systems and they have been exposed to a great amount of air pollution throughout their lives.

In the current study which is the first air pollution and respiratory hospital admission study using GLM in Turkey, we conducted a time-series study of the relationship between daily mean levels of air pollutants (PM_{10}, $PM_{2.5}$ and NO_2) and daily hospital admissions for respiratory conditions in İstanbul, using Poisson regression in generalized linear model (GLM) while controlling for time trends and meteorological factors. The analysis was conducted among people of all ages, but also focused on different sexes and subjects in the range 0–14 years, 35–44 years and ≥65 years.

2. Methodology

2.1. Study area

İstanbul (29° N and 41° E) is located in the northwestern part of Turkey, separated as Asian and European parts by Bosporus strait which is approximately 30 km in length. It is the most populated and industrialized city in Turkey, with an area of 5400 km^2. The city also forms one of the largest urban settlements in Europe with a population of 14.1 million. The climate is moderate in İstanbul. The average temperature is 22.7 °C in summer and 6.5 °C in winter (Unal et al., 2011). The temperatures can drop below zero in winter season.

Today, İstanbul has especially particulate matter and NO_2 pollution depending on different emission sources (İncecik and İm, 2012; Özdemir et al., 2014). Since the mid-1990's, SO_2 concentrations are gradually decreased to very low levels in the city due to the widespread use of natural gas in heating and industry (İncecik and İm, 2012). The major emission sources in the city are motor vehicles, industrial processes, construction activities, residential heating and ship emissions. Traffic emissions in İstanbul have been increased due to the rapid increase in car numbers since 1990s. According to Turkish Statistical Institute, the number of registered vehicles was 3.000.000 in January 2016 in İstanbul (Turkish Statistical Institute, 2016). People are exposed daily to continuous particulate matter and NO_2 pollution due to the frequent traffic jams in the city. PM_{10} concentrations show a seasonal pattern with higher concentrations in winter and lower concentrations in summer. Shallow mixing height and adverse weather conditions (high pressure systems and lower wind speeds) lead to elevated air pollution levels in winter season (Unal et al., 2011). Long-range transportation of air pollutants is another factor affecting the air quality of the city. İstanbul is in a common route for air parcels, where air pollutants are carried over European continent crossing over the city to the Asian and Mediterranean regions. Air masses arriving to İstanbul are seasonally dependent and include air pollution originating in European and Black Sea countries during winter, and desert dust loaded air originating in Northern Mediterranean (Saharan) and Middle-Eastern countries during spring (Karaca et al., 2009). Particulate matter concentrations occasionally can reach very high values during the desert dust transportation events.

2.2. Data

The data of daily respiratory hospital admission counts of residents living in İstanbul from March 1, 2013 to March 31, 2015 (761 days) was obtained from the database of Republic of Turkey Ministry of Health. The selection was made according to the International Classification of Disease, Tenth Revision (ICD-10) by the World Health Organization. Daily hospital admission counts from respiratory diseases (ICD-10: J00-J98) among residents of all ages were considered. In addition, hospital admissions for different sexes and different age groups (children, adults and elderly) were also separately analyzed.

Hourly air pollution data, including PM_{10}, $PM_{2.5}$ and NO_2, were obtained from the database of Ministry of Environment and Urbanization, the government agency in charge of collection of air pollution data in Turkey. The daily concentrations for each pollutant were averaged from the available monitoring results of 11 fixed-site stations of Air Quality Monitoring Network in İstanbul (Başakşehir, Mecidiyeköy, Silivri, Şirinevler, Ümraniye, Üsküdar, Kağıthane, Esenyurt, Sultanbeyli, Sultangazi and Esenler) under Republic of Turkey Ministry of Environment and Urbanization (Fig. 1). To allow adjustment for the effect of weather on hospital admissions, hourly meteorological data (temperature and relative humidity) were obtained from the Air Quality Monitoring Stations where meteorological measurements are also made. We have used daily means of the pollutants and weather variables calculated from the hourly data to represent the daily reading for Istanbul. The percentage of data for each pollutant was: PM_{10} (99.9%), $PM_{2.5}$ (99.9%) and NO2 (99.4%).