Evaluation of Air Pollution Effects on Asthma Disease: The case of Izmir

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Abstract

Urban air pollution is undoubtedly a significant risk factor for human health and has been increasing due to increasing population, population density, rapid urbanization, industrialization, traffic density, since the 1950s. The aim of the study is to test the relation between the number of asthma cases and the levels of air pollutants (sulfur dioxide (SO₂) and particulate matter (PM₁₀)). The data are collected for six districts in Izmir for the years between 2007 and 2010. The results from the regression show that there is a statistically significant relation between the number of asthma cases and the level of urban air pollution.

Keywords: Urban air pollution; quality of life; Izmir; asthma

1. Introduction

The air pollution problem is one of the most significant reasons in the causation of respiratory diseases, beside other factors (socio-economic status, inadequate health care, life and work conditions, etc.) in developing countries, metropolitan areas, and in city centers (Tağlı and Menteşe, 2012). Since 2005, approximately 35 million people worldwide have died because of chronic lung diseases, such as asthma, chronic obstructive pulmonary disease (COPD), etc. In the next 10 years, the number of people who will loose their lives due to these chronic diseases is

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expected to increase by 17%. In Turkey, 305,367 people (about 71% of the total deaths) died due to the chronic diseases, and 34,211 people (about 8% of the total deaths) lost their lives owing to the chronic lung diseases (asthma, COPD, etc.) in the year 2000 (Ministry of Health, 2009). Asthma is defined as a disease of the respiratory system caused by narrowing of the airways, causing attacks triggered by a wide variety of stimuli. The causes of asthma in the literature include respiratory infections, humidity and temperature changes, seasonal changes, gas and particles that cause the ambient air pollution. In epidemiological studies, it is mentioned that air pollution cause an increase in total mortality, morbidity of respiratory diseases in adults and respiratory symptoms in children. It has been shown that the intensity of air pollutants including, sulfur dioxide (SO2) and particulate matter (PM10) affects asthma cases increase significantly (Sheppard et al., 1999; Koç et al., 2002). Urban air pollution is an inevitable component of the modern life in built environments. It has become a public health problem, and it has been affecting the quality of life, especially in large and densely populated cities, due of the intensive use of energy. Air pollution is unquestionably a significant risk factor for human health and a threat to the quality of life. In other words, if the level of air pollutant increases, the quality of life is affected negatively. “Better Life Index” that is implemented in the year 2011 and constituted by OECD (The Organisation for Economic Co-operation and Development) suggests significant criteria for the reduction of air pollution to increase the air quality under the heading of “Environmental Conditions” to provide better living conditions (Akar, 2014). The aim of the study is to test the relation between the number of asthma cases and the level of urban air pollution. Two common air polluters are considered in the study: (1) sulfur dioxide (SO2) and (2) particulate matter (PM10). The data are collected for six districts in Izmir, Turkey, including Konak, Bornova, Buca, Karsiyaka, Cigli, and Balcova, for the years between 2007 and 2010. A total of 42,950 asthma cases is in the dataset. The total population in these six districts is 2,856,430 for the year 2010. The results show that there is a statistically significant relationship between urban air pollution and observed asthma cases.

2. Background

The particulate matter in the atmosphere (TAP, PM2.5, PM10), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3) and carbon monoxide (CO) lead to an increase in the level of air pollution with the increasing traffic congestion and population density in urban areas (Bayram, 2008; İncecik, 1994). Air pollution in urban areas, caused by dense population and motor vehicle, affects the incidence rate of respiratory system related diseases (asthma, chronic obstructive pulmonary disease, upper respiratory tract infections, bronchitis, etc.). In the literature, there exists a sizable amount of studies on air quality and respiratory system related diseases. These studies focus on different types of diseases (Tağıl and Menteşe, 2012; Darcan, 2013). Sheppard et al. (1999), Çelikoğlu (1999), Koç et al. (2002) and Bektas and Birkan (2003) focus on chronic obstructive pulmonary disease (COPD) and bronchial asthma. Most of these studies deal with the relationship between respiratory diseases and a single air pollutant. For example, Sheppard et al. (1999) and Çelikoğlu (1999) focus on particulate matter (TAP). The particulate matter (PM10) is also another important urban air pollutant that cause chronic airway diseases (asthma, COPD, etc.), the upper and lower respiratory system diseases and lung or heart problems (Babin et al., 2008). Similarly, sulphur dioxide (SO2), which is a substantial and widespread pollutant, precipitates chronic respiratory diseases, chronic obstructive pulmonary disease (COPD) and other lung diseases (Ünsal and Yetkin, 2005). Some studies examine the relationship between the deaths and hospital references depend on the level of air quality and the respiratory system problems (Holland et al., 1979). A number of studies examine the relationship between the level of air pollutant and asthma morbidity and total mortality. Şahin (2000) observes a significant relationship between the levels of particulate matter (PM10) measured on a daily basis and asthma morbidity and total mortality and Bebek (1996) suggest a significant relationship between the level of particulate matter (PM10) and hospital references due to acute respiratory tract disease. Similarly, a significant relationship between the particulate matter concentration and hospitalization due to asthma attacks connected with humidity is observed (Çelikoğlu, 1999). It is shown that the level of life quality for asthma patients decrease with increasing air pollution. Wilson and Spengler (1996) suggest that air pollution cause an increase in total mortality, morbidity of respiratory diseases in adults and respiratory symptoms in children and the intensity of air pollutants sulfur dioxide (SO2) and particulate matter (PM10) affect asthma cases increase. Especially during the winter, it is proved that there is positive relationship between the level of air pollution and hospitalization depends on chronic airway diseases and the number of asthma cases about children in 0-2 years of age (Olgun,
Especially during the winters, the concentration of sulfur dioxide (SO$_2$) and particulate matter (PM$_{10}$) increase, and these changes trigger asthma attacks (Berktaş and Bircan, 2003).

3. Data

The city of Izmir is the third largest city in Turkey with a total population of 4,061,074 by the year 2013. The city is located at the west of the Anatolian Peninsula and on the east coast of the Aegean Sea. It is surrounded by the three provinces, Balıkesir, Manisa and Aydın. The north part of Izmir has been mostly developed as industrial zones, the eastern part has been largely characterized by agriculture, and the west and the south parts have tourism and residential areas. The study area includes six core districts of the city of Izmir including, Konak, Bornova, Buca, Karsiyaka, Cigli and Balcova. The study area is represented in Figure 1. The population data are available from the Turkish Statistical Institute.

The number of asthma cases and the levels of PM$_{10}$ and SO$_2$ data are available for the years between 2007 and 2010. The data for the number of asthma cases are obtained from the Statistics Unit in Public Health Directorate within of the Ministry of Health. The total recorded number of asthma cases in these six districts is 5,212 in 2007, and 42,950 in 2010. The descriptive statistics for the number of asthma cases at the district are presented in Table 1. Data for the level of air quality (PM$_{10}$ and SO$_2$) at the daily basis are available from the Environmental Health Unit within of the Izmir Metropolitan Municipality. The descriptive statistics at the district level as daily averages for PM$_{10}$ and SO$_2$ are presented in Table 2 and Table 3. Finally, the descriptive statistics for population at the district level are shown in Table 4. The data is available for six districts for the years 2007, 2008, 2009 and 2010. Thus, there are 24 observations in the data set.
Source: Ozcan and Cubukcu (2014)

Table 3. The descriptive statistics of average daily SO$_2$($\mu$g/m$^3$) levels at the district level (n=24).

| Year | Minimum | Maximum | Mean | Std. Deviation |
|------|---------|---------|------|----------------|
| 2007 | 6.2     | 36.0    | 16.1 | 11.0           |
| 2008 | 8.7     | 41.3    | 20.1 | 12.3           |
| 2009 | 10.5    | 26.0    | 14.8 | 5.7            |
| 2010 | 6.5     | 17.8    | 13.6 | 4.1            |

Source: Ozcan and Cubukcu (2014)

Table 4. The descriptive statistics of population at the district level (n=24).

| Year | Minimum | Maximum | Mean   | Std. Deviation |
|------|---------|---------|--------|----------------|
| 2007 | 74,837  | 847,409 | 407,180| 279,447        |
| 2008 | 76,219  | 903,375 | 463,942| 346,450        |
| 2009 | 77,915  | 917,074 | 470,739| 350,179        |
| 2010 | 77,767  | 925,586 | 476,072| 352,020        |

Source: Ozcan and Cubukcu (2014)

Fig. 2. The spatial distribution of the number of asthma cases at the district level (2007-2010) (n=6).

Source: Ozcan and Cubukcu (2014)
Fig. 3. The spatial distribution of PM$_{10}$ levels at the district level (2007-2010) (n=6).

Source: Ozcan and Cubukcu (2014)
Fig. 4. The spatial distribution of SO$_2$ levels at the district level (2007-2010) (n=6).

Source: Ozcan and Cubukcu (2014)

Fig. 5. The spatial distribution of population at the district level (2007-2010) (n=6).

Source: Ozcan and Cubukcu (2014)
The number of asthma cases varies between 92 and 1,915 people, with a mean of 868.7 people in 2007. As seen in Table 1 and Fig. 2, a continuous increase in the numbers of recorded asthma cases is observed through the years between 2007 and 2010 (Table 1). As seen in Figure 2, this increase in the number of asthma cases is significant especially in Buca, Bornova, and Konak districts. The daily average PM$_{10}$ at the annual basis values vary between 14.2 μg/m³ and 72.2 μg/m³, with a mean of 47.2 μg/m³ in 2007. They vary between 35.8 μg/m³ and 50.8 μg/m³, with a mean of 43.6 μg/m³ in 2010 (Table 2, Figure 3). The daily average SO$_2$ values vary between 6.2 μg/m³ and 36.0 μg/m³, with a mean of 16.1 μg/m³ in 2007. They vary between 6.5 μg/m³ and 17.8 μg/m³, with a mean of 13.6 μg/m³ in 2010 (Table 3, Figure 4). The total population of the districts varies between 74,837 and 847,409 people, with a mean of 407,180 people in 2007. It varies between 77,767 and 925,586 people, with a mean of 476,072 people in 2010 (Table 4, Figure 5).

4. Estimation and results

Multivariate linear regression is used to examine the possible effects of the urban air pollutants sulphur dioxide (SO$_2$) and particulate matter (PM$_{10}$) on the number of asthma cases at the district level in Izmir between the years 2007 and 2010, taking into account the effect of the total population. The selected model is a no-intercept model. The selected model explains 88% (R$^2$=0.88) proportion of the variability in the recorded asthma cases. Remark that the selected model has no constant, so the R$^2$ cannot be compared with the models with a constant. Dummy variables are used to detect the effect of the district and the year but these variables did not yield statistically significant results. The parameter estimates are presented in Table 5.

Table 5. Parameter estimates for the selected model (dependent variable: number of asthma cases in ln form) (n=24).

| Variable | Unstandardized Coefficient | Standardized Coefficient | t-statistics | Significance |
|----------|-----------------------------|--------------------------|--------------|--------------|
| SO2      | 0.1020                      | 0.2710                   | 1.6310       | 0.1180       |
| PM10     | 0.0660                      | 0.4400                   | 3.5240       | 0.0020       |
| Population | 0.000000371               | 0.2970                   | 1.8590       | 0.0770       |

Source: Ozcan and Cubukcu (2014)

The parameter estimates show that the recorded number of asthma cases increase with the level of the urban air pollutants sulphur dioxide (SO$_2$) and particulate matter (PM$_{10}$). A one μg/m³ increase in the level of sulphur dioxide (SO$_2$) causes approximately the number of asthma cases by 44.2, when all other variables are at their sample means. On the other hand, a one μg/m³ increase in the level of particulate matter (PM$_{10}$) causes approximately the number of asthma cases by 28.2, when all other variables are at their sample means. Among the explanatory variables, particulate matter (PM$_{10}$) is statistically significant at the 0.002 level, sulphur dioxide (SO$_2$) at the 0.112 level, and population at the 0.077 level (Table 5).

5. Conclusions

This study aims to examine the relation between the number of asthma cases and the level of urban air pollution using multivariate linear regression. Urban air pollution is measured through the level of two common air polluters: (1) sulphur dioxide (SO$_2$) and (2) particulate matter (PM$_{10}$). The results from the regression shows 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. The findings indicate that high levels of sulphur dioxide (SO$_2$) and particulate matter (PM$_{10}$)are significant causes of asthma, taking into account the effect of population. This study has one important drawback. The data used in the study pertains to a limited number of districts and a limited urban area. A more comprehensive study should consider a larger urban area with a more diverse urban setting. Nonetheless, the results of the current study reveal that the levels of these two pollutions
should be monitored and controlled for improving the quality of life especially in dense urban areas. Further studies may focus on the effects of planning decisions on the levels of urban pollutants.

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