Effects of Atmospheric Sulphur Dioxide and Particulate Matter Concentrations on Emergency Room Admissions Due to Asthma in Ankara#

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SUMMARY

Recent studies have associated short-term exposure to respirable particulate matter (PM_{10}) and sulphur dioxide (SO_2) with peak flow decrements, increased symptoms of respiratory irritation, increased use of asthma medications, and increased admission and hospitalization for asthma. To further delineate the association between SO_2, PM_{10} exposure and asthmatic response, we compiled daily records of asthma emergency room visits from our hospital and data of meteorological conditions, SO_2 and PM_{10} concentrations in Ankara area. Weekly averages of daily counts of emergency room visits for asthma were significantly associated with average weekly SO_2 and PM_{10} exposure on previous week (r= 0.328, p= 0.017 and r= 0.355, p= 0.009 respectively). Admission to emergency room for asthma count was also negatively correlated with ambient temperature (r= -0.496, p= 0.0001) and strong wind existence (X^2= 3.930, p= 0.047) on previous days. It was also positively correlated with ambient relative humidity (r= 0.531, p= 0.0001). We observed that numbers of emergency visits due to asthma were higher in winter months, April and September. In winter and early spring period there was concordance between asthma emergency admissions with air pollutants levels. During this period ambient temperatures were low as well. There were two discordance points in monthly variation of air pollution and asthma visits. We thought that first asthma visits peak was related to allergic pollens during April and second peak was due to opening of schools and increasing of respiratory infections for this reason during September. The general pattern of our results confirms that even low levels of air pollution encountered in Ankara are linked to short-term increases in the number of people visiting emergency department for asthma.

Key Words: *Asthma, sulphur dioxide, particulate matter, air pollution.*

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ÖZET

Ankara'da, Atmosferik Sülfür Dioksit ve Partiküler Madde Konsantrasyonlarının Astım Nedenli Acil Servis Başvurularına Etkisi

Son çalışmalar; solunabilir partiküler madde (PM_{10}) ve sülfür dioksit (SO_2) maruziyeti ile zirve akım hızı azalması, solunum irritasyonuna bağlı yakınmalarda artış, astım ilacı kullanımında artış ve astım nedeniyle başvuru ve hastaneye yatış sıklığı arasında ilişki olduğunu göstermiştir. SO_2 ve PM_{10} maruziyeti ile astmatik yanıt arasındaki ilişkiyi daha fazla aydınlatmak amacıyla hastanemize, astım nedeniyle olan günlük acil servis başvuruları ve Ankara bölgesinde meteorolojik şartlarla, SO_2 ve PM_{10} konsantrasyonlarına ilişkin veri topladık. Astım nedeniyle günlük acil servis başvurularının haftalık ortalaması ile önceki haftanın SO_2 ve PM_{10} konsantrasyonları ortalaması arasında istatistiksel anlamlı ilişki saptadık (sırasıylala, r= 0.328, p= 0.017 ve r= 0.355, p= 0.009). Ayrıca, astım nedeniyle acil servise başvuru sayısı ile hava sıcaklığı (r= -0.496, p= 0.0001) ve güçlü rüzgar varlığı (X^2= 3.930, p= 0.047) arasında negatif ilişki bulunuyordu. Havanın göreceli nemliliği ise pozitif yönde ilişkiliydi (r= 0.531, p= 0.0001). Astıma bağlı acil servis başvurularının kış aylarıyla, Nisan ve Eylül aylarında arttığını gözledik. Kış ve ilkbahar başında acil servise astım nedenli başvuru sıklığı ile hava kirliliği düzeyleri arasında uyum izleniyordu. Bu dönemde aynı zamanda hava sıcaklığı da düşük seyretmişti. Ancak hava kirliliği ve astım başvurularının aylık değişimleri arasında iki noktada uyumsuzluk bulunuyordu. Bunlardan birincisinin Nisan ayındaki allerjik polen artışına, ikincisinin ise Eylül ayında okulların açılması ile solunum yolu infeksiyonlarındaki artışa bağlı olduğunu düşünüyoruz. Sonuçlarımız; Ankara'daki düşük seviyeli hava kirliliğine kısa süreli maruziyetin bile, astım nedeniyle acil servis başvurularını arttırdığını göstermektedir.

Anahtar Kelimeler: *Astım, sülfür dioksit, partiküler madde, hava kirliliği.*

Bu çalışma, "European Respiratory Society 12th Annual Congress, Stockholm, Sweden, at 14th-8th September, 2002" de sunulmuştur.

There is evidence that air pollution may cause, induce, or aggravate functional changes, morbidity, and mortality with some effects being closely related to daily changes in air pollution (short-term effects) whereas others should be considered the effects of long-term exposure (1). The concentration levels of sulfur dioxide (SO_2) and particulate matter (PM) have frequently been used as indicators especially for the winter air pollution episode mixture. The concentration levels of PM have been expressed in variety of ways, including total suspended PM, black smoke, and coefficient of haze (2). More recently, the use of PM_{10} (PM with an aerodynamic diameter equal to or less than an nominal 10 µm) as an indicator of particulate pollution has been suggested (3).

As a lower respiratory illness, it is natural to hypothesize that there is a relationship between asthma and air pollution. For 20 years numerous epidemiological studies in the field of air pollution have been carried out, but only few deal with asthma. Panel studies have found relationships between peaks in air pollutants and the frequency of asthmatic symptoms collected on daily diaries, or of emergency hospital admissions (4-6). But a number of studies from United States of America (USA) and Europe have examined emergency room admissions, predominantly for asthma, with no consistent results emerging (7). So to further delineate the association between meteorological variables, SO_2, PM_{10} exposure and asthmatic response, we examined the association between our hospital emergency room visits for asthma and meteorological conditions, SO_2 and PM_{10} concentrations in Ankara area.

MATERIALS and METHODS

In dates between 01 January 1998 and 31 December 1998, 10.985 persons admitted to emergency department of Atatürk Chest Diseases and Chest Surgery Education and Research Hospital. We retrospectively evaluated registered data for persons who followed with previously diagnosed asthma, or asthma attack diagnosed by physician based on findings on the day of emergency admission and asthma diagnosis supported with following tests after hospitalization or outpatient evaluation. We have found 666 (280 male and 386 female and age range is 24-59) adult patients with these criteria's.

Data of meteorological conditions in Ankara area for 1998 were obtained from The Directorate of Ankara area of Turkish State Meteorolo-

gical Service. These data have included mainly, daily average amount of rain, actual pressure, relative humidity, the velocity, duration and direction of wind, and minimum, average and maximum daily temperature. As previous studies we used ambient pressure, humidity, strong wind (speed over 10.8 m/sec) and minimum daily temperature parameters (8).

Air pollution measures for Ankara area in 1998 were obtained from The Air Pollution Control and Research Laboratories of Environmental Health Research Directorate. We could utilize only SO_2 and PM_{10} measures for some technical reasons. However, it has been suggested that SO_2 could be a sensitive surrogate for other pollutants (9). These measures had been monitored and analyzed from seven separate stations in Ankara area. In these stations Atmospheric pollution analyzer GRH-76M (DKK Corp. Japan) was used to collect data. Locations of our hospital, seven air pollution stations and meteorological service are shown in Figure 1.

Statistical Package for Social Sciences (SPSS Inc.) software was used in statistical analysis. Variables were 24 hours average concentrations of SO_2 and PM_{10}, daily atmospheric pressure, relative humidity, minimum daily temperature, and daily number of visits to emergency room. The selection of representations of these variables was primarily based on findings in previous studies (8). Like these studies same day, one and two days before and the average of lag 0-6 days (a week before) were analyzed. Pearson and Spearman correlation tests and Chi-square test were used to demonstrate statistical associations. Linear regression scatter plot and line graphics were used for visual presentations. Mean and standard deviation were given for distribution measures. Two way p value < 0.05 was accepted as a statistically significant.

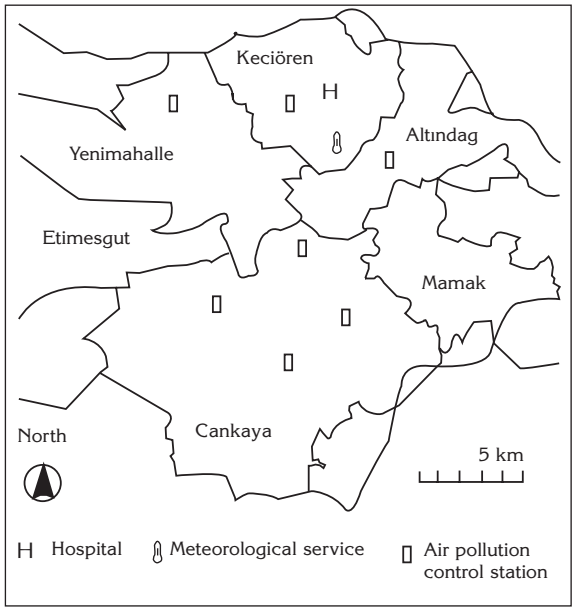

Figure 1. Locations of our hospital, seven air pollution stations and meteorological service.

RESULTS

Seasonal variation of meteorological data, air pollutants concentrations and asthma related emergency admissions are shown in Table 1. The smallest number of admission was observed in the summer (p= 0.004). We detected that minimum air temperature was the highest and humidity was the lowest in summer months.

An association between monthly total number of emergency visits and average monthly SO_2 and PM_{10} concentrations are presented in Figure 2. There was a good agreement in period of November through March but significant discordance was found in April and September. When the speed of wind is between 10.8-17.1 m/sec it is called as strong wind according to meteorological terms. We have found statistically significant negative association between asthma related admissions and strong wind existence in same day (X^2= 3.930, p= 0.047). There were also statistically significant association between strong wind existence on previous day and SO_2 and PM_{10} concentrations (r= -0.237 and -0.252 respectively, p= 0.0001). For this reason we think that strong winds throws away air pollution and makes it's effect on asthma admissions indirectly.

The association between meteorological variables, SO_2, PM_{10} exposure and asthmatic response was presented in Figure 3. There were statistically significant negative correlation between average weekly minimum temperature and mean weekly asthma emergency visit number (r_s= -0.496, p= 0.0001). Counts of emergency

Table 1. Seasonal variation of meterological data, air pollutants concentrations and asthma related emergency admissions

Seasons	*t*min* C°	Humidity (%)	Air pressure (mb)	SO_2 (µg/m^3)	PM_{10} (µg/m^3)	Asthma visits
Spring	6.1 ± 5.9	68.3 ± 13.0	911.3 ± 4.7	28.7 ± 23.9	37.0 ± 27.4	186
	(-7.1-15)	(45-95)	(896-921)	(7-141)	(11-150)	
Summer	16.3 ± 3.0	54.5 ± 11.0	911.9 ± 2.9	25.5 ± 9.1	25.7 ± 9.0	122
	(9.4-22.6)	(30-84)	(902-918)	(12-64)	(13-59)	
Autumn	8.8 ± 4.4	61.7 ± 14.3	914.6 ± 4.1	29.2 ± 10.7	53.4 ± 27.9	147
	(-2.1-19.2)	(32-87)	(907-925)	(14-68)	(14-167)	
Winter	-0.1 ± 3.5	73.0 ± 8.7	915.9 ± 4.7	62.4 ± 35.8	78.8 ± 53.4	211
	(-11-8)	(48-93)	(906-926)	(13-169)	(18-269)	

Mean ± standart deviation (range) are given for meterological and air pollution variables and total number of person are given for admissions.
* *t*min= Minimum temperature.

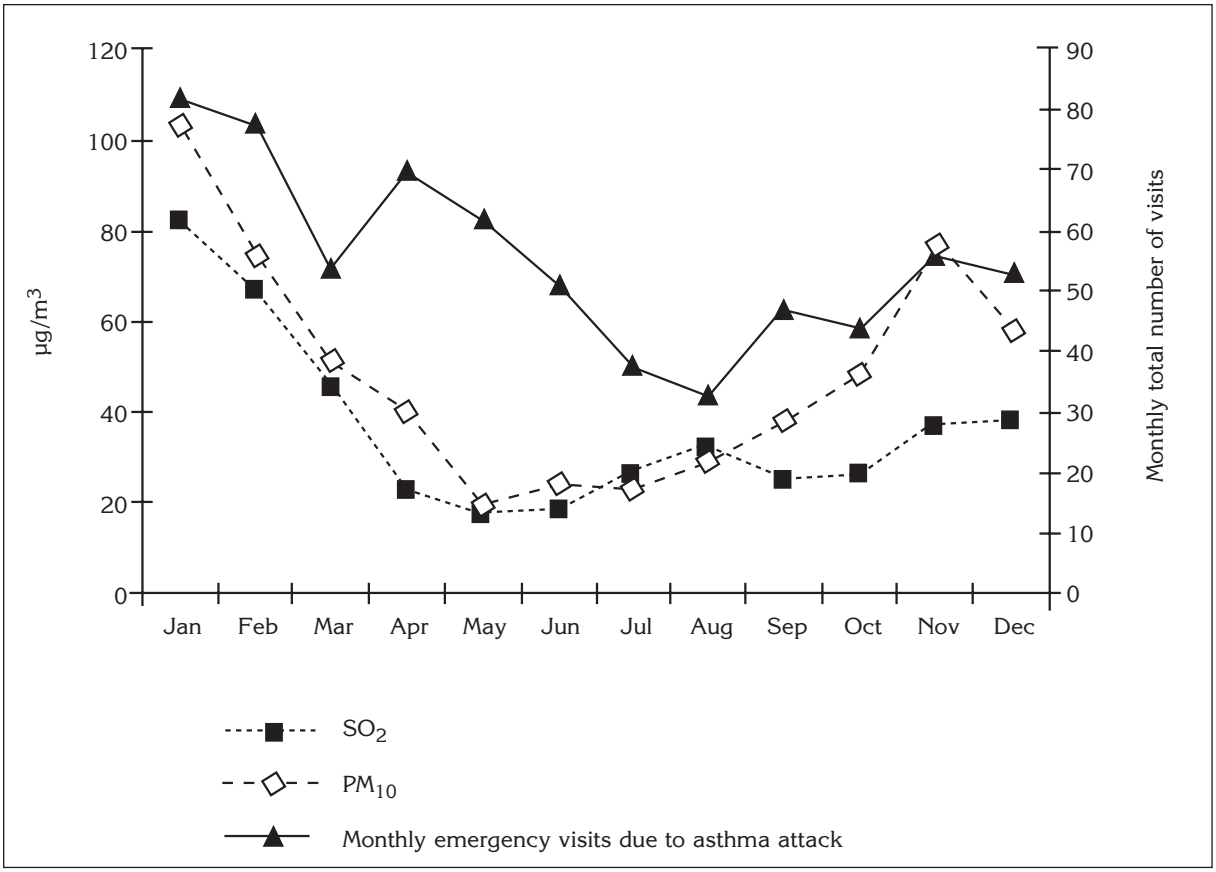

Figure 2. Relationship between air pollution levels and monthly emergency visits due to asthma attack. There were good correlations in period of November through March but discordances were found in April and September.

admission were higher in cold weeks. The relative humidity of ambient air was positively correlated with asthma admissions (r_s= 0.531, p= 0.0001). Humidity levels were lowest in summer. Statistically significant association was not found between air pressure and asthma. Although indirectly effect of air pressure observed for the reason of statistically significant correlation

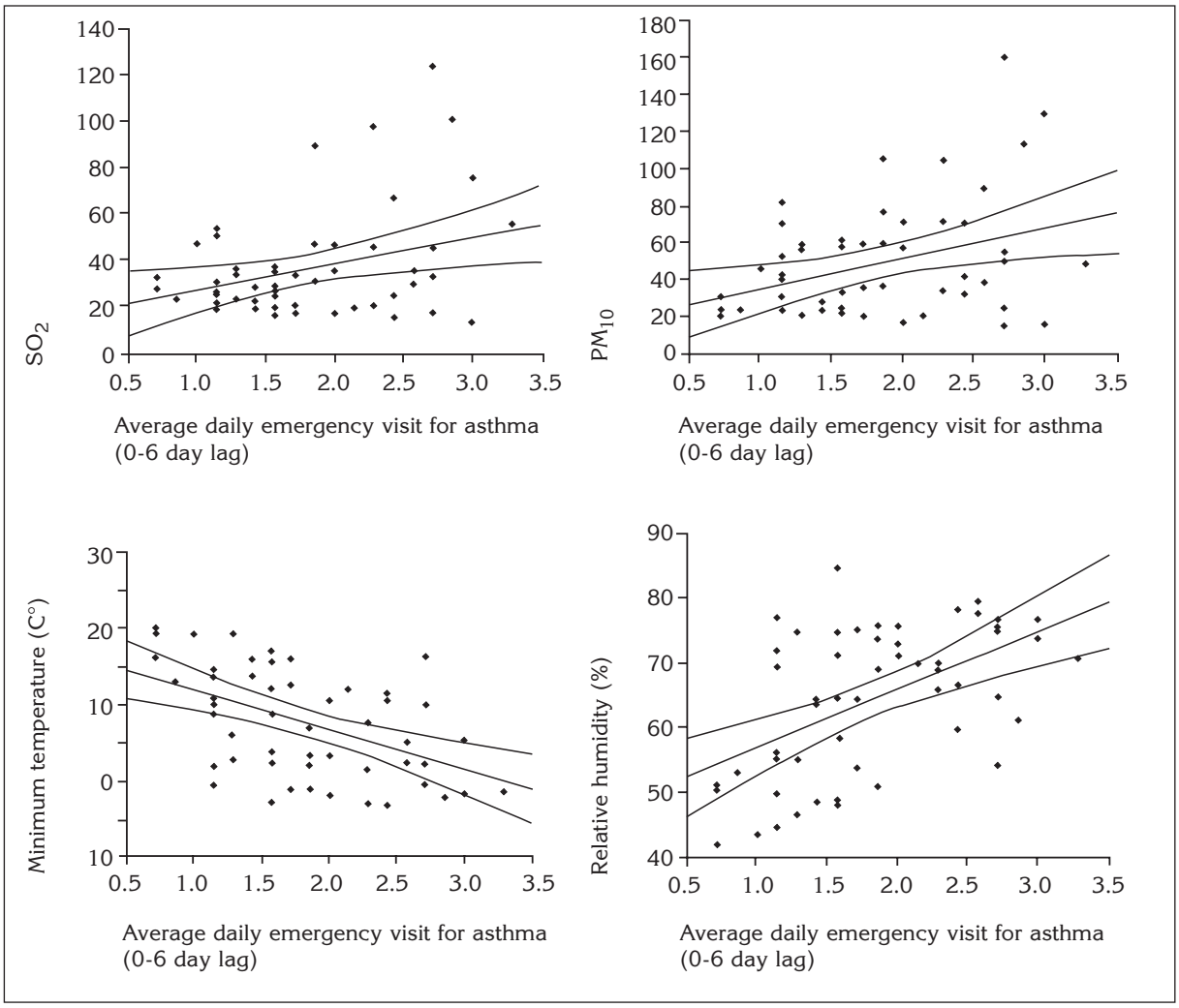

Figure 3. Associations between mean weekly SO_2, PM_{10} concentrations, minimum temperature and relative humidity and emergency visit due to asthma attack (scatter plots with regression line and 95% confidence bands).

was exist between air pressure and air pollutants concentrations (r= 0.524, p= 0.0001 for SO_2 and r= 0.595, p= 0.0001 for PM_{10}).

We have found statistically significant correlation between average weekly SO_2 concentrations and asthma related emergency visits (r_s= 0.328, p= 0.017). There was more strong correlation between ambient air PM_{10} concentrations and asthma related emergency visits (r_s= 0.355, p= 0.009).

DISCUSSION

We observed that numbers of emergency visits due to asthma were higher in winter months, April and September. Air pollutants concentrations were increasing in September and continuing until March also. In winter and early spring period there was concordance between asthma emergency admissions with air pollutants levels. But during the period with the highest air pollution concentrations, ambient temperatures were low as well. Cold air can be cause of respiratory symptoms and pulmonary function decrements in asthmatic subjects. Also frequent respiratory infections associated with cold weather may also have affected the observed increase in emergency department visits (2). The meteorological influence has been studied by several authors in its association with respiratory symptoms, with controversial findings (4,5). There was a strong

peak in asthma emergency visits in September and it did not appear to be related to air pollution. This pattern was reported in many other studies (10). Dales and colleagues reported that respiratory infection is the major identifiable risk factor for the large autumnal increase in asthma admissions (11). We thought that the opening of schools was caused the increasing of respiratory infections during September.

Pollens also may have caused increase in asthma admissions in spring period. Pollen season begins in February and March in Ankara and mostly includes Platanus, Artemisa, Populus like grass and tree pollens (12,13). Evidence suggests that pollutants may enhance the allergenicity of pollen grain proteins and that synergistic effects operate between aeroallergens and certain pollutants. Air pollutants do exert effects, not only on pollen morphology, but also on the abundance and characteristics of the pollen proteins (14,15).

The number of emergency visits was lower on days that strong wind exists. It's natural because most air pollution incidents are not due to an increase in pollution emissions, but rather to meteorological factors that do not allow pollutants to disperse (16). But unusual environmental conditions like thunderstorm can adversely affect people with respiratory diseases (7).

There have been a number of epidemiological studies of emergency room admissions and air pollution. They address a variety of pollutants, age ranges and time periods as well as utilizing a range of statistical methods. No consistent picture emerges from their results. Statistically significant associations with visit for asthma and O_3, SO_2, NO_2, PM_{10} and black smoke are all reported.

"The Pollution Effects on Asthmatic Children in Europe (PEACE)" study investigated the acute health effects of short-term changes in air pollution on children with chronic respiratory symptoms. The study was conducted in the winter of 1993-1994 following a standardized protocol by 14 research centers in Europe (8). In conclusion of this study, overall, no clear association between changes in incidence or prevalence of respiratory symptoms and changes in air pollution could be detected. In some of the locations, air pollutions levels may have been too low to result in demonstrable (17). In fact, in some of the zones, significant correlations of increasing pollution with decreasing peak expiratory flow have been found, together with effects on prevalence or incidence of symptoms and use of bronchodilators (18).

"The Swiss Study on Air Pollution and Lung Disease in Adults (SAPALDIA)" study published a 3.14% decrement in mean FVC for a 10 $\mu g/m^3$ increase in the long-term levels of ambient PM_{10} and they stated that this effect may be considered small (19). Although Kunzli and colleagues have demonstrated that the currently suggested way of presenting the impact of air pollution on lung function at the population level rather than at the individual level of relative risks shows that a small change in the population mean of a quantitative measure can have considerable impact on the number of subjects with relevant impairment (20).

"Pollution Atmosphérique et Affections Respiratoires Chroniques (PAARCH)" study conducted in 24 areas of seven French towns during 1974-1976. Data were reanalyzed in 1998 and a geographical correlation between asthma and annual mean level of SO_2 was found in adults (21). As a European project "Air Pollution and Health, a European Approach (APHEA)" data from six major cities of Europe were analyzed with a purpose of to investigate the short-term effects of air pollution on hospital admission for chronic obstructive pulmonary disease (COPD). The results of study confirmed that air pollution is associated with daily admissions for COPD in European cities with widely varying climates (22,23). Castellsague and colleagues studied an association between air pollution and asthma emergency visits in Barcelona in 1985-1989 period and they found that relative risk (RR) for black smoke was 1.08 and for NO_2 was 1.05 (24). Segala and colleagues have shown an association between winter air pollution and increase in report and duration of asthma attacks in asthmatic children, morning PEF level and dura-

tion of supplementary ß$_2$-agonist use. The strongest association was the risk of asthma attack for an increase of 50 µg/m^3 of SO_2 (odds ratio= 2.86) (25). Also many other epidemiological studies have shown positive short-term associations between indices of health and the relatively low levels of outdoor air pollution (7,26-28). Hiltermann and colleagues reported that the air pollution can effect all asthma patients and severity of asthma is not an indicator for the sensitivity to air pollution (29).

Ünsal and colleagues studied association between daily values of air pollution and emergency visits due to respiratory and cardiovascular diseases in 1996-1997 periods in Eskisehir, Turkey. They reported that the admissions due to upper and lower respiratory infection, COPD and cor pulmonale increased with an increase in SO_2 and smoke values (30). Daglı and colleagues have showed that asthmatic symptoms increase dramatically with air pollution around Istanbul (31).

The use of stationary air pollution monitoring data to represent personal exposure is a weak point of our study, shared by most panel studies. Most of people's time is spent indoors in winter. Nevertheless, studies comparing indoor and outdoor particulate concentrations have reported an average indoor/outdoor ratio of at least 0.5 and some authors found that indoor pollutants correlated highly with outdoor pollutants level suggesting that outdoor pollution measurement is a reasonable proxy for personal exposure (32,33). Another limiting point may be to use single hospital emergency registrations. We have analyzed air pollution data for average daily concentrations for whole Ankara region not each of monitoring stations. So we think that there is no reason to think of possible variation by hospital related to air pollution levels. Our hospital has 780 bed for respiratory diseases and emergency visits number was big enough to make statistical inferences in 1998.

In Ankara, average annual SO_2 concentration decreased from 54 µg/m^3 in 1994 to 36 µg/m^3 in 1998, and average annual PM_{10} concentration decreased from 61 µg/m^3 in 1994 to 49 µg/m^3 in 1998. These values are under than permitted long-term exposure limit (mean annual concentration < 150 µg/m^3) by WHO. Ankara was not in the 10 most polluted cities list in 1998. There were not daily mean SO_2 and PM_{10} concentration of any day above short-term limit (400 µg/m^3 for SO_2 and 300 µg/m^3 for PM_{10} according to Environment Ministry direction for air quality prevention (34)), and above first level of warning (700 µg/m^3) in Ankara (for all seven monitoring stations) through 1998 (35). Against this low level of air pollution, we could demonstrate a positive association between emergency room visits for asthma and SO_2 and PM_{10} levels. This association was obtain in the strongest level with weekly average lag as in previous studies (8). We also observed that cold and wet meteorological conditions are adversely affecting asthma patients.

The general pattern of our results confirms that even low levels of air pollution encountered in Ankara are linked to short-term increases in the number of people visiting emergency department for asthma.

ACKNOWLEDGEMENTS

The authors greatly appreciate the assistance of Mrs. Songül BOZAT, Mrs. Canan YEŞİLYURT (Chief of The Air Pollution Control and Research Laboratories of Environmental Health Research Directorate) and Mr. Mahmut AKKAŞ (Director of Statistics and Publication Department of Directorate of Ankara Area of Turkish State Meteorological Service) for obtaining of data.

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