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Original Research Article

An evaluation of the relation between air quality and hospital presentations due to respiratory tract diseases: A cross-sectional study

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Air pollution is a major cause of respiratory tract diseases. The purpose of this study was to assess the relation between air quality levels and numbers of admissions to chest diseases clinics in Erzurum between July 2016 and July 2017. In this cross-sectional descriptive study, the mean 24 hour PM_{10}, $PM_{2.5}$ and SO_2 data were obtained from T.R. Ministry of Environment and Urban Planning, Air Quality Monitoring Stations Website for 1 July 2016-30 June 2017. The numbers of patients hospitalized at chest diseases clinics at Aziziye and Palandöken were obtained from the Provincial Health Directorate. The descriptive statistics of the data are presented as median, minimum (min)-maximum (max) values and percentage. The Kruskal Wallis and Spearman Correlation tests were used for the analyses and statistical significance was considered at $p<0.05$. Median measurement values were PM_{10} 54.1 (min: 28.9; max: 100.4), and SO_2 11.2 (min: 5.2; max: 21.1). $PM_{2.5}$ measurement was performed at only one station (Taşhan), with a median value of 61.6 (min:9, max: 546). Analysis of the relations between mean air pollution parameters in the four stations in Erzurum and examination of the numbers of hospitalizations and duration of hospital stay in the three chest clinics in the city center, revealed significant correlations between mean SO_2 and mean days of hospitalization (r= 0.69; p=0.01), and between Taşhan $PM_{2.5}$ values and numbers of patients hospitalized (r =0.64; p =0.02) and days of hospitalization (r= 0.58; p =0.54). Air quality in Erzurum is at levels that represent a severe health threat and affects presentations to chest diseases clinics

Key words: Air pollution, sulfur dioxide, particulate matter, respiratory tract diseases

INTRODUCTION

Air pollution is an important environmental risk factor and global threat to health. External environment air pollution is estimated to have caused 3 million premature deaths worldwide in 2012 (approximately 72% due to ischemic heart disease and stroke, 14% to chronic obstructive pulmonary disease (COPD) or acute respiratory tract infections, and 14% to lung cancer). There is significant inequality in exposure to air pollution, with 88% of these deaths occurring in low- or middle-income countries.

In addition to causing early mortality, air pollution also increases the burden of non-infectious disease by leading to stroke, heart disease, lung cancer, and both chronic and acute respiratory tract diseases such as asthma(WHO, 2018).

Numerous epidemiological studies investigating the effects of air pollution on hospital presentations in various different countries have shown that rises in$PM_{10}$and SO_2 levels result in increased hospital admissions associated with respiratory tract diseases (such as asthma, COPD, and pneumonia) (Atkinson et al., 2001; Medina-Ramón et al.,

Table 1. European (EU) countries, World Health Organization (WHO), and Turkey threshold values of SO_2, PM_{10} and $PM_{2,5}$

	Threshold values (Mean 24-hours)			
	EU countries [20]	Turkey (2017) [21]	WHO[22]	Number of times the limit is permitted to be exceeded (in a year)
SO_2 (sulfur dioxide)	125 μg/ m3	175 μg/m^3	20 μg/m^3	3
PM_{10} (particulate matter)	50 μg/ m3	70 μg/ m3	50μg/m3	35
$PM_{2.5}$ (particulate matter)	25 μg/m3		25μg/m3	-

2006; Wilson et al., 2005; Zanobetti et al., 2000). Studies from Switzerland in various years have shown that increases in PM_{10}, NO_2 and SO_2, which largely derive from fossil fuels, cause decreases in pulmonary functions, and bronchitis symptoms (Ackermann-Liebrich et al., 1997; Zempet al., 1999).

Air pollution episodes resulting from very elevated PM emissions and resulting in thousands of deaths in less than one month, such as in the Meuse Valley in Belgium in 1934, Donora in the Unites States in 1947, and in London in 1952, represent the starting points of air pollution for researcher (Filleul et al., 2003).

In order to reduce air pollution in Turkey, the Directive on Air Quality Control (DAQC) No. 2872, based on the Law on the Environment, was introduced in 1986, and air quality measurement stations were established in all the country's 81 provinces by the Ministry of the Environment and Urban Planning in 2005-2007(Ministry of Health, 2010). All data collected by these stations are forwarded to the Ministry of the Environment and Urban Planning Environmental Reference Laboratories Data Processing Centerfor analysis and are also published simultaneously on thewww.havaizleme.gov.tr web site.

Erzurum is the largest and most developed city in northeast Turkey. However, it is not an industrial city. Topographically, Erzurum is one of the highest altitude cities in Turkey, and winter temperatures can be as low as -40 °C. Air pollution in the city is mainly caused by heating and traffic (Karaca et al.,2013).

The purpose of our study was to evaluate changes in air pollution parameters in Erzurum between July 2016 and July 2017, and to determine the relations between rates at which Turkish, World Health Organization and European (EU) Union limits were exceeded and the levels of these parameters, and presentation to chest diseases clinics in Erzurum city.

METHODS

In this cross-sectional, descriptive study, data were obtained from the Erzurum, Aziziye, Palandöken and Taşhan stations (within the provincial center) using the Turkish Ministry of the Environment and Urban Planning Air Quality Monitoring Stations website between July1, 2016 and June 30, 2017.

Air quality measurement in the province of Erzurum is performed using fully automated devices installed by the Ministry of the Environment and Urban Planning. Particulate matter is measured using fully automated BAM 1020 devices, and sulfur dioxide with fully automatic Monitor Europe devices.

Mean 24-hourPM_{10}, $PM_{2.5}$ and SO_2 measurements were downloaded on the dates specified, and the data were compared with EU, World Health Organization (WHO), and Turkish domestic threshold values (Table 1).

All patients who were admitted between July 1, 2016 and June 30, 2017 to the chest diseases clinics of the hospitals in the province of Erzurum and approved hospitalization by the physician were included in our study. Numbers of patients hospitalized at chest diseases clinics at Aziziye and Palandöken were obtained from the Provincial Health Directorate. Diagnosis spectrum of the patients or ICD codes couldn't be obtained.

The dependent variable in this research was the monthly number of patients hospitalized in chest diseases, while the independent values were PM_{10}, $PM_{2.5}$ and SO_2 values. Seasonal and monthly changes in air pollution parameters were also examined. Winter was specified as the period from 1 October to 31 March, and summer as that from 1 April to 30 September.

Data were recorded and analyzed on Statistical Package for the Social Sciences (SPSS) 22.00 software. Normality of distribution of variables was examined using theKolmogorov-Smirnov test. Data not exhibiting normal distribution were expressed as median andminimum (min)-maximum (max) values and percentages for descriptive statistics. TheKruskal-Wallis and Spearman Correlation tests were used for analysis. p values <0.05 were regarded as statistically significant.

Approval for the study was obtained from the Atatürk University Medical Faculty Clinical Research ethical committee before commencement, and the research was conducted in line with ethical committee principles.

Table 2. Air pollution measurements between July 2016 and July 2017 and presentations to chest diseases clinics in the Erzurum city center

		Median	Minimum	Maximum
PM10 ($\mu gr/m^3$)	Erzurum	44	13	186
	Aziziye	74	11	271
	Palandöken	13	2	125
	Taşhan	57	16	400
PM2.5 ($\mu gr/m3$) (Taşhan)		61.6	16.6	174.0
SO2 **($\mu gr/m^3$)**	Erzurum	10	2	53
	Aziziye	10	1	89
	Palandöken	7	1	15
Number of examination		6883.1	4756	8958
Number of hospitalizations		443.2	327	552
Number of days of hospitalization		2554	1762	3762

RESULTS

Median measurement values obtained from the four stations in Erzurum between July 2017 and July 2017 were PM_{10} 54.1 (min: 28.9; max: 100.4), and SO_2 11.2(min: 5.2; max: 21.1). $PM_{2.5}$measurement was performed at only one station (Taşhan), on337 days(92.3%), with a median value of61.6 (min:9, max:546) (Table 2).

EU threshold levels for PM_{10} were exceeded on98 days (%26.8) in Erzurum, 199 (54.5%) in Aziziye, 9 (2.5%) inPalandöken, and 201 (55.1%) in Taşhan. Turkish national limits forPM_{10}were exceeded on 53 days (14.5%) in Erzurum, 138 (37.8%) inAziziye, 3 (0.8%) in Palandöken, and 131 (35.9%) in Taşhan.

In terms of SO_2, EU and Turkish limits were not exceeded on any days in Erzurum, but WHO limits were exceeded on 11 days (3.0%); in Aziziye, EU limits were exceeded on 1 day (0.3%), Turkish limits on no days, and WHO limits on92 days (25.2); while inPalandöken, no limits were exceeded on any days.

The median PM_{10} value at the Erzurum station was 49.5 (min:13, max:186), and the median SO_2 value was 10.5 (min:2, max:53); the median summer PM_{10} value was 29 (min:13, max:77), and the median SO_2 value was8 (min:3, max:19). The median winter PM_{10} value at Aziziye was 99 (min:18, max:271), and the median SO_2 value was 21.5 (min:2, max:89), while the median summer PM_{10} value was51 (min:11, max:138), and the median SO_2 value was 7 (min:1, max:16). The median winterPM_{10} level at the Palandöken station was 14 (min:4, max:125), and the median SO_2 value was 7 (min:1, max:15), while the median summer PM_{10} value was9 (min:2, max:59), and the median SO_2 value was 6 (min:2, max:14). The median winterPM_{10}at the Taşhan station was 95.5 (min:22, max:371), and the median $PM_{2.5}$ value was54.1 (min:13, max:373), while the median summer PM_{10} value was54 (min: 5, max:83), and the median $PM_{2.5}$ value was 23.7 (min:12, max:38).

When PM_{10} and SO_2 values were compared by seasons, significant differences were determined for all stations' PM_{10} and SO_2 values between winter and summer ($p<0.05$), with the exception of Palandöken PM_{10} ($p=0.87$).

Significant differences were determined at all stations between PM_{10} and SO_2values by months ($p<0.001$). Air pollution was highest at all stations in January.

Analysis of relations between mean air pollution parameters in the four stations in Erzurum and examination of numbers of hospitalizations and length of hospital stay in the three chest clinics in the city center revealedsignificant correlations between mean SO_2 and mean days of hospitalization ($r= 0.69$; $p=0.01$), and between Taşhan $PM_{2.5}$ values and numbers of patients hospitalized ($r= 0.64$; $p=0.02$) and days of hospitalization($r= 0.58$; $p=0.54$) (Table 3).

The month that the air temperature was lowest between July 2017 and July 2017 in Erzurum was December (mean: -7,67 ° C; min: -17 °C, max: 0 ° C). The highest air temperature was in August (average: 20.71 ° C; min: 17 ° C, max: 24 ° C). Analysis of relations between air temperature and mean PM_{10} (r: -0.88; p: 0.001); and between air temperature and mean SO2 (r: -0.89; p: <0.001) revealed significant negative relation at very high level. The relationship between air temperature and clinical data analysis revealed that there was a significant negative relation at moderate level between air temperature and the number of examinations (r: -0,59; p: -0,04), and there was a significant negative relation at high level between air temperature and the numbers of patients hospitalized (r: -0.70; p: 0.01) (Table 4).

DISCUSSION

Measurements performed in the Erzurum city center between June 2016 and June 2017 show that air pollution is

Table 3. Relations between air pollution parameters and presentations to chest clinics

		PM_{10}	$PM_{2.5}$ (Taşhan)	SO_2
Number of examinations	r*	0.52	0.55	0.43
	p**	0.08	0.06	0.15
Number of patients hospitalized	r*	0.48	0.64	0.51
	p**	0.11	0.02	0.08
Days of hospitalizations	r*	0.43	0.58	0.69
	p**	0.15	0.04	0.01

*r: correlation coefficient
**p: statistical significance

Table 4. Air temperature's relations with air pollution parameters and presentations to chest clinics

	Air temperature (°C)	
	r*	p**
PM_{10}	-0.88	0.001
SO_2	-0.77	0.003
$PM_{2,5}$	-0.89	<0.001
Number of examinations	-0.59	0.04
Number of patients hospitalized	-0.70	0.01
Days of hospitalizations	-0.53	0.07

*r: correlation coefficient
**p: statistical significance

a major problem, and that EU and WHO limits and Turkish national thresholds were exceeded at severe levels in both the short and long terms. According to Turalioğlu (2005) air pollution levels in Erzurum worsened increasingly in 2003-2004, this trend came to an end between 2003 and 2006, and that pollution parameters, and particularly SO_2, decreased significantly. In particular, short- and long-term season limits set out in the 2006 Directive on the Protection of Air Quality were not exceeded (Nazım, 2008).One study assessing air pollution in Erzurum in 1990-2008 reported an approximately 3.7-fold decrease in SO2 levels and a 4-fold decrease in particulate matter(Kopar and Zengin, 2009). Comparing the results of those studies with our own findings, the decrease in SO_2 values appears to have persisted, while PM_{10} values remained at approximately similar levels. We think that the use of natural gas, which has become increasingly common in the city since 2005, has played a major role in this. Similarly to all studies in Erzurum, a city with no industrial effects, the highest levels of air pollution were in winter, and especially in January. The effects of air pollution deriving from fossil fuels used for heating in this city, with its cold climate, are at life-threatening levels. Local administrations must increase supervision in order to improve air quality, and the requisite measures must be adopted.

The effects on health of air pollution have been revealed in previous studies(Raaschou-Nielsen et al.,2013). Research from the United States and Europe has shown that a 10 μgr/m3 increase in PM_{10} and SO_2 values causes increases in hospitalizations due to respiratory diseases of 1.0%-2.4% and 0.9%-1.1%, respectively, while a 10 μgr/m3 increase in $PM_{2.5}$ causes a 3.3% increase in hospitalizations(Burnett et al., 1999). In a study conducted between 2000 and 2004 in 25 hospitals in Hong Kong, a significant relationship was found between PM_{10}, $PM_{2.5}$ and SO_2 pollutants and hospital admissions for COPD (Ko et al., 2007). A study examined the relation of invasive pneumococcal disease to season and atmospheric conditions in Houston detected significant correlations between the occurrence of pneumococcal diseases and air pollution reported significant correlation between $PM_{2.5}$ and SO_2 values and number of days of hospitalization (Kim et al., 1996).Similar to the findings in the literature, a significant relationship was found between $PM_{2.5}$ and SO_2 values and the number of hospitalization days in our study.

The results of the studies clearly show that the frequency of respiratory diseases in adults is inversely proportional to the ambient temperature (Kim et al., 1996). In a study on air pollution and emergency room visits in Delhi, a negative correlation was found between air temperature and all air pollutant parameters and cardio-respiratory events similar to our study(Pande et al., 2002). In a study of air pollution and cardiovascular and respiratory diseases, air pollution parameters were higher in the cold months and increased pollution parameters and respiratory diseases were positively correlated (Liang et al., 2009).

Our finding of a correlation between presentations to chest diseases clinics and air pollution is important in terms of revealing the health impacts of air pollution, a preventable public health problem. However, the fact that out study examined relations between monthly presentations and air pollution parameters retrospectively, represents a limitation in terms of it being impossible to investigate patient-specific effects (such as asthma, COPD, and cancer). A prospectively planned study examining the impacts of air pollution on health in terms of characteristics such as causes of presentation, sex, and agewill be useful in determining cause-specific and effective factors. In addition, long-term evaluation of daily hospital data will be useful in showing the delay in emergence of air pollution-associated health effects.

CONCLUSION

Air quality in Erzurum is at levels that represent a severe health threat and affects presentations to chest diseases clinics.Local administrations must adopt the requisite measures to improve air polution, a preventable public health problem.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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