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Ambient Air Quality and Respiratory Problems in Turkey

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Rapid development in Turkey, especially over the last 25 years, has provided better living standards for its residents, yet the quality of the environment has not been taken into account seriously. Air pollution monitoring in many centres has been into operation since early 1990's in Turkey. 50 Province center are known to have impaired outdoor air quality in the country. On the contrary, some cities have transformed their residential heating system by relying on imported natural gas, while some others have relatively better air due to their year-round warmer temperatures. In this study, the number of cases of upper respiratory sickness, sinusitis, bronchitis, tonsillitis, laryngitis and pharyngitis, together with various some factors, namely outdoor air sulphur dioxide, vehicle density, wind rate and mean ambient air temperature and population density were investigated by multi regression to establish whether they were linked or not. It was determined that population density is the most important factor in the cases of the examined health problems.

Key Words: Respiratory system diseases, Turkey, Air pollution.

INTRODUCTION

Turkey has been undergoing a remarkable growth in population, industrialization and urbanization despite the fact that the environmental quality of the country has not been investigated sufficiently. It was noted that air quality in relatively clean air cities and outdoor air impaired cities have different morbidities of upper respiratory system diseases, sinusitis, pharyngitis, laryngitis, tonsillitis and bronchitis[1].

Countrywide, the mean urbanization is nearly 65 % and the three large metropolitan centres (Istanbul, Ankara and Izmir) are inhabited by more than 22 % of the total population[2]. According to Baldasano *et al.*[3] report, these metro-cities had notably impaired air quality between the late 1970's and 1995. Zaim[4] reported approximately 15 million residents of the country under impaired air stress. The ambient air quality has not been a specific concern in some cities, such as Ankara, since they established

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natural gas distribution systems to provide safer and cleaner energy for their residents[5]. On the other hand, many provinces in the country are still generally dependent on sulphur-rich fossil fuels[6] and there are several coal-powered energy production plants near to some of the provincial centres, *i.e.* Kütahya and Kahramanmaras. Local coal mines supply raw quality fuel for heating purposes yet countrywide, coal quality is not at the desired level[7-11] due to the fact that the energy policy of Turkey critically depends on its own resources.

In this study, average outdoor temperature, wind condition, traffic and population patterns and an important air pollution indicator (SO_2) during winters in Turkish cities between 1995 and 2003; together with health-related data, specifically upper respiratory disease, sinusitis, bronchitis, laryngitis, pharynigitis and tonsillitis cases between the years of 2002 and 2004 were collected and analyzed in order to show the connection between urban air quality and air quality related diseases. Ambient air quality and population, as well as health related data sets, were used in this study because polluted urban air is a major cause in diseases, such as asthma[12] coughing and pneumonia[13], even death[14]. Cities close to coal-fired power production stations were reported as air impaired ones[15]. Furthermore, traffic is known to be a notable air polluting source that affects people working outdoors such as policemen, building and road construction workers and so on, who were investigated by Karita *et al.*[16] even though studying the effects of air contaminants on humans is a notably difficult task[17]. Despite a general slight improvement in urban air quality in Turkey over the last decade, the ambient air quality still needs to be recovered specifically in winters since the upper respiratory disease incidence rate is high as well as being notably elevated for sinusitis and bronchitis.

EXPERIMENTAL

To compute the most important factor in public health, the health-related data were collected on the following from the TRMH (reflecting 2002, 2003 and 2004)[18-20]; winter term mean SO_2 concentrations between 1995 and 2004; province total populations according to 2000 Census; and related meteorological data were obtained from Turkish Statistical Institute[21], Ministry of Environment and Forestry[2] and General Directorate of State Meteorological Works[22]. Since Turkey is a moderately large country and topographic features vary province by province, it is relatively complicated to analyze air quality data covering the whole state. Hence, 60 Turkish provinces (out of a total of 81) were taken into account for this study. Fifty province centers that are air-quality-impaired cities with high SO_2 concentrations in their urban atmospheres were taken into account. Current status of ten cities, which reported to have relatively clean air, were assessed the exhibit effects of air quality improvement. Statistical analyses were completed using SPSS® 10.0 program. Multi-regression equations were developed for both impaired ambient-air provinces (n = 50) and relatively clean-air cities (n = 10).

RESULTS AND DISCUSSION

According to the air quality between 1995 and 2004 in the provincial centres[21], many cities were found to have high annual SO_2 concentrations (higher than 60 μg m^{-3}) in the winter months between 1995 and 2004. Long-term standards recommended by the World Health Organization are currently 50 μg m^{-3} for SO_2 despite the fact that Turkish Air Pollution standards for SO_2 and particulate matter are restricted to 150 μg m^{-3} in the long-term. Table-1 summarizes the fundamental properties of the provincial groups (impaired outdoor air and relatively clean-air) examined. Table-2 recapitulates upper respiratory system symptoms, sinusitis, bronchitis, tonsillitis, bronchitis and laryngitis cases[18-20] in both ambient air quality impaired cities and relatively clean air province centers.

TABLE-1
FUNDAMENTAL PROPERTIES OF THE PROVINCES EXAMINED

Data category	Meteorological data		Demographic	Economic	Average SO_2 level (μg m^{-3})	n
	Mean air temperature (ºC)	Mean wind velocity (m s^{-1})	Population density (capita km^{-2})	Traffic density (vehicle $capita^{-1}$)		
Impaired	6.7	2.31	118 (270)	0.103 (0.05)	112 (44)	50
Clean-air	8.1	2.27	103 (84)	0.098 (0.06)	45 (12)	10

Numbers in parentheses indicate standard deviations.

TABLE-2
NUMBERS OF REPORTED CASES OF THE EXAMINED SYMPTOMS (MEAN OF 2002, 2003 AND 2004)

Category	Examined health problems					
	URSD	Sinusitis	Pharyngitis	Tonsillitis	Bronchitis	Laryngitis
Impaired	119,408	11,501	12,931	26,983	19,411	1,806
SD	128,303	12,391	16,181	29,921	24,123	2,987
Clean-air	109,079	12,069	10,364	25,477	16,245	2,175
SD	14,729	16,531	12,130	31,038	19,034	2,300

SD = Standard deviation.

Local coal mines with high emission values of major air pollutants, *e.g.* in Canakkale, Kutahya and Erzurum, are largely responsible for the reduced air quality in some of the cities. Additionally, some provinces, *e.g.* Mugla and Kutahya, have important coal-fired electric generation plants. It was noted that coal-fired power generation plants emit nitrogen, carbon, particulate matter, sulphur oxides and toxic elements into the atmosphere[15]. In Istanbul, traffic and industry are possibly the most important factors responsible for urban air impairment despite the fact that some clean air transportation vehicles (*e.g.* natural gas powered public buses), *albeit* a minority compared to diesel-powered buses, have been serving in the metropolitans since the early 1990's. Like Istanbul, both Kocaeli and Izmir, which were reported

to have high sulphur dioxide concentrations in their urban atmospheres, are remarkably industrialized cities. Whilst Ankara, a relatively clean air city, contributes only a low 4.3 % gross production to the country's total, Istanbul supplies 42.4 % of the total gross national production[4]. Furthermore, only 11.4 % of all roadway vehicles are registered in the state capital, Ankara, while 15.7 % of all roadway vehicles are registered in Istanbul[23]. As a general indication, the ratio of the number of cars to the total national is approximately 21 % in Ankara, 16 % in Izmir and Eskisehir, 14 % in Bursa, 12 % in Istanbul, 11 % in Kocaeli (province centre: Izmit) and on average 10 % for the other provinces listed in Table-3[2,23]. Among the above-mentioned provinces only Ankara is a relatively clean air city. However, in terms of the number of vehicles, Istanbul has approximately 16 % of the total number of vehicles in Turkey[23]. It is therefore not surprising, because of population, vehicles, life style, *etc*., that unexpectedly high respiratory sickness incidence was reported in 2001 in Istanbul and it should be stated that the air-quality related sickness cases are notably high even though Istanbul is not in the top 10 worst air quality cities' list after 2000.

TABLE-3
CORRELATION MATRIX OF THE EXAMINED SYMPTOMPS FOR IMPAIRED (n = 50) AND CLEAN (n =10) OUTDOOR AIR PROVINCES

Symptom	URSD	Sinusitis	Pharyngitis	Tonsillitis	Bronchitis	Laryngitis
URSD	1					
Sinusitis	**0.7378**	1				
Pharyngitis	**0.7197**	**0.7961**	1			
Tonsillitis	**0.8160**	**0.8504**	**0.8245**	1		
Bronchitis	**0.7163**	**0.6051**	**0.7299**	**0.8265**	1	
Laryngitis	0.1034	**0.3331**	0.2791	0.2734	0.1587	1
Clean air						
Sinusitis	0.5022	1				
Pharyngitis	0.5693	**0.7812**	1			
Tonsillitis	0.5149	**0.9069**	**0.9224**	1		
Bronchitis	0.3822	**0.6971**	**0.9156**	**0.8722**	1	
Laryngitis	-0.1027	0.5996	0.7040	0.6927	0.6751	1

Numbers in bold indicate significant correlations at 99 % confidence level.

$$URSD = -49012 + \mathbf{10969\ T} + 14933\ W + \mathbf{260\ PD} + 425175\ TD - 125\ SO_2 \quad (1)$$

$$Sinusitis = 1327 + 411\ T + 305\ W + \mathbf{28.4\ PD} + 42257\ TD - 8.7\ SO_2 \quad (2)$$

$$Pharyngitis = -5739 + 554\ T + 1323\ W + \mathbf{39.7\ PD} + \mathbf{75718\ TD} - 5\ SO_2 \quad (3)$$

$$Tonsillitis = -2745 + 1277\ T + 820\ W + \mathbf{77.4\ PD} + 99056\ TD - 0.3\ SO_2 \quad (4)$$

$$Bronchitis = -7077 + 1391\ T + 850\ W + \mathbf{64.2\ PD} + 67455\ TD + 6.3\ SO_2 \quad (5)$$

$$Laryngitis = 124 - 186\ T + 135\ W + \mathbf{6.44\ PD} + 9982\ TD + 7.41\ SO_2 \quad (6)$$

where, T = winter mean ambient temperature (ºC), W = mean wind rate (m s^{-1}), PD = population density in the province (capita km^{-2}), TD = traffic density (vehicle $capita^{-1}$), SO_2 = mean annual ambient sulfur dioxide concentration (µg m^{-3}).

The most important parameters at play in the symptoms are written in bold in above the equations. Interestingly, of all symptoms examined only population density was found to be the most important single parameter that determines morbidity rates. All regression equations given above, with the exception of laryngitis, given above were found to be statistically significant at least 99.9 % confidence level. For laryngitis, the regression equation was determined to be significant to 99.8 % confidence level. For pharyngitis, along with population density, traffic was found to be the second most important factor that determines symptom's morbidity rate (at 96.4 % confidence level). For URSD, along with population density, ambient air temperature was determined to be the second most important factor (at 95 % confidence level). For the equations numbered from 1 to 6 above, regression and adjusted regression coefficients are 58.6 and 53.9 % for URSD; 50.5 and 44.8 % for sinusitis; 62.4 and 58.1 % for pharyngitis; 63.1 and 58.9 % tonsillitis; 68.5 and 64.9 % for bronchitis and 33.5 and 25.9 % for laryngitis.

Alternatively, there is a strong logarithmic relationship between population density and cases of URSD, tonsillitis, bronchitis, sinusitis and pharyngitis. However, no statistically significant relationship was determined between population density and laryngitis in impaired ambient air cities, as illustrated in Fig. 1. Table-3 summarizes correlations between the symptoms examined in ambient air problematic cities and relatively clean air cities respectively.

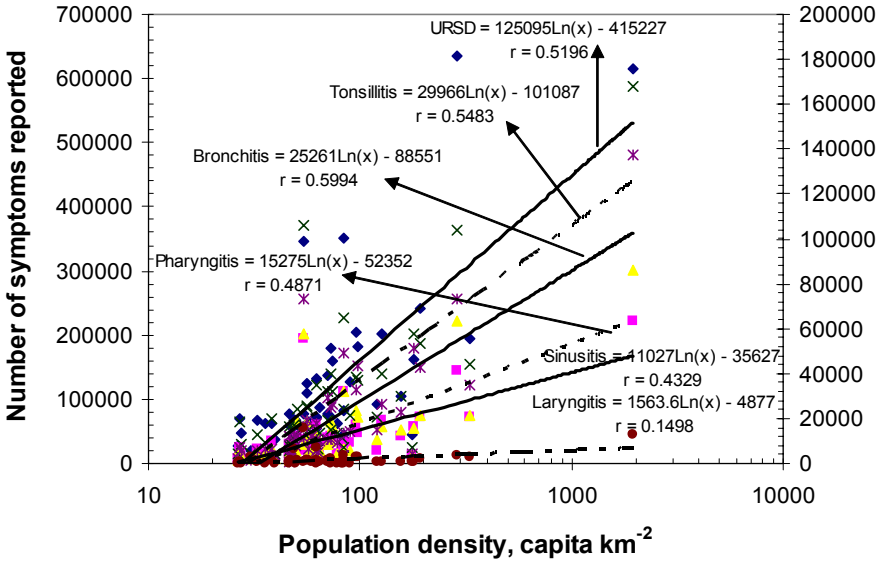

Fig. 1. Relationship between population density and examined symptoms in ambient air quality impaired provinces in Turkey (URSD belongs to left-hand side (primary) y axis. Other symptoms belong to right-hand side (secondary) y axis

However, there is no relationship between any of the parameters taken as independent variables and the symptoms examined in relatively clean air provinces. Such an outcome signifies that there is a significant difference between relatively clean-air cities and ambient air quality impaired cities. For all insignificant relationships between the independent parameters and examined symptoms, the equation regression coefficients were found to be less than 41.5 %.

According to Tanritanir[24] in some European Union countries (Austria, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Spain, England), bronchitis, emphysema and asthma cases are the 8th largest cause of death, followed by pneumonia-related deaths, which are responsible for 27,465 deaths in the countries mentioned, that is, the 10th most important reason; whereas in Turkey respiratory diseases other than bronchitis, emphysema and asthma and pneumonia are included in the list and are the 6th largest cause of death, followed by pneumonia cases as the 7th and bronchitis, emphysema and asthma cases as the 10th.

If a decrease in ambient air pollution in 50 Turkish provinces can be realized in future years after a successful implementation of better combusted fuels, *i.e.* natural gas and increase in heating system performances. A reduction in URSD, pharyngitis, tonsillitis and bronchitis cases are most probably be expected. If we deduct examined symptoms in relatively clean-air provinces from impaired-air provinces, we could easily see a significant-lessening in the cases for each symptom. Data summarized in Table-2 was used for this analysis. A reduction of 17,568 cases of URSD, pharygitis, tonsillitis and bronchitis was projected if ambient air quality impaired provinces can improve their air quality. However, slight increases in both sinusitis (total 568) and laryngitis (total 369) were computed based on the same projection method mentioned above.

Conclusion

It should be noted that Turkey has been experiencing notable outdoor air pollution in many of its provincial centres. A total of 50 provinces, with nearly 49 million people living in these provinces, that use low quality fuels, coal and lignite, for residential heating and industrial operations, are especially an urban air pollution hazard. Some provinces include coal powered electric generation plants with insufficient environmental treatment technologies within their borders. The total population living in these provincial centres is more than 22 million. This figure is larger than the figure given by Zaim[4], who noted 15 million (1997). There is an urgent need for coal-powered electric generation plants to be equipped with fuel quality improvement systems, such as desulphurization and/or smokestack gas treatment units, to minimize their suspended particulate matter and SO_2 and smoke emissions. In spite of the fact that some Turkish cities have been using imported natural gas in homes and industries since the early 1990's, many cities are still waiting for completion of natural gas pipelines to reach them. Consequently, if an improvement in ambient air quality in Turkish cities can efficiently be realized, the number of people suffering

from symptoms related to ambient air pollution will decline substantially. This decline relies upon the measures indicated and their effects would be seen in a short time. With an effective reduction in air pollution, an 8.7 % decrease in URSD, 19.9 % decline in pharyngitis, 5.6 % reduction in tonsillitis and 25.2 % drop in bronchitis in currently ambient air quality problematic provinces is anticipated. According to the multi-regression approach, the population density was found to be the most important factor that determined the air-pollution related symptom cases examined. A balanced and optimal urbanization and industrialization and better air quality *via* strict air pollution control throughout the country are therefore strongly recommended.

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