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AN ANALOGY ON ASSESSMENT OF URBAN AIR POLLUTION IN TURKEY OVER THE TURN OF THE MILLENNIUM (1992–2001)

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Abstract. Rapid industrialization and urbanization in Turkey, especially over the last twenty five years, has provided better living standards to its residents, but it also caused a decrease in environmental quality. In late 1970's, air quality monitoring activities were started in some major cities by individual researchers in Turkey. It was just around the 1990's that a countrywide program on continuous air pollution monitoring in major province centers and selected large towns was launched. The impact of air pollution on people depend on various factors, such as existence and magnitude of coal powered energy generation plants, type of urban heating and their efficiency, and the numbers and specifications of vehicles. In this study, current Turkish urban air quality over the turn of the Millennium (1992–2001) is studied in the light of the country's worst cities in terms of outdoor air quality, the number of upper respiratory diseases, sinusitis, bronchitis, and pneumonia cases in these provinces reported by the state medical treatment facilities in 2001. The population that is under outdoor urban air pollution hazard was computed. A comparative analysis between the provinces that use natural gas and others that use fossil fuels was also completed in order to project monetary gains if the studied provinces will transform their indoor heating and industrial operations to be run by natural gas or other cleaner energy sources. If natural gas use in air polluted urban centers could be realized in the near future, approximately 212 to 350 million US dollars per annum could to be saved just by reducing health related problems caused by outdoor air pollution.

Keywords: air quality related diseases, air quality improvement, sinusitis, bronchitis, pneumonia, economic gain, Turkish urban air

1. Introduction

Despite the fact that Turkey has been one of the fastest developing countries in the world, its high population growth rate, unplanned and environmentally risky businesses, ignorance on environmental quality throughout the country and many such other elements are the major factors that have led to diminishing values of the country's environmental profile. Countrywide, average urbanization is approximately 65% and the three largest metropolitans, namely İstanbul, Ankara and İzmir province centers, are resided by more than 22% of the country's total population (DİE, 2002a,b). As Baldasano *et al.* (2003) reported, these metro-cities had notably impaired air quality between late 1970's and 1995 and Zaim (1997) reported approximately 15 million residents of the country are under polluted air stress despite the fact that the outdoor air quality has not been seen as a specific concern in Ankara and İstanbul since late 1990's. This is because of the fact that they have put forward their natural gas distribution systems to provide safer and cleaner energy to their residents in late 1988 and early 1992, respectively (BOTAŞ, 2003a). Having completed this transformation, although not fully completed, in the aforementioned two largest mega-centers (Ankara and İstanbul), these provinces in addition to Bursa, Eskişehir and Kocaeli (Province center: İzmit) (BOTAŞ, 2003b) later reported to have healthier (compared to the previous years) air quality in their urban atmospheres. However, many provinces in the country are still dependent on fossil fuels (Kaygusuz, 2003) for home heating and industrial processes. There are a number of coal fired power stations nearby some of them, such as Kütahya and Kahramanmaraş. Local coal mines are an especially important energy source for home heating purposes. The countrywide coal quality is neither at the desired level in terms of contaminant emissions when burnt nor could be in ignorable quantity (DPT, 2000, 2001a,b; Ekinci *et al.*, 1997; Toros *et al*, 1997) due to the fact that the energy policy of Turkey is critically dependant on its own resources, except for petroleum and natural gas.

In this analogy, population patterns, air pollution indicators (SO_2 and total suspended particulate matter (TSP)) in Turkish cities between 1992 and 2001, and health related data, specifically respiratory diseases, sinusitis, bronchitis, and pneumonia cases in the year 2001 have been collected and analyzed in order to show connections between urban air quality and air quality related diseases. Air quality and population data as well as health related data sets were used in this study since polluted outdoor urban air is a major cause for disease, such as asthma (Elsom, 1996) coughing and pneumonia (El-Fadel and Massoud, 2000), even death (Murray *et al.*, 2001). It was found that cities close to coal fired energy production plants are air impaired centers (Mishra, 2004). Moreover, traffic is considered to be a remarkable air pollution source and this has been found to affect people working outdoors, such as policemen, building and roadway workers, etc. (Karita *et al.*, 2004) despite the fact that studying the effects of air contaminants on humans is a notably difficult task (Selgrade, 2000). In this study, a group of forecasting efforts was attempted to show possible monetary gain if selected cities of the country will have cleaner air than that present currently. Even though there has been an overall slight decrease in urban air pollution in Turkey over the last ten years, the air quality still needs improving because of the fact that the respiratory disease incidence rate is high as well as notably elevated cases of sinusitis, bronchitis, upper respiratory diseases, and pneumonia.

2. Material and Methods

The health related data in terms of respiratory disease incidence in Turkish provinces, annual upper respiratory disease case numbers, sinusitis, bronchitis, and pneumonia diagnoses reported by the state hospitals in 2001; annual mean SO_2 and TSP concentrations between 1992 and 2001 and province total and province center populations in 2000 in the cities and provinces were obtained from Turkish Ministry of Health (TCSB), State Statistical Institution (DİE) and Turkish State Planning Organization (DPT) in order to project future monetary gains if urban air pollution could be reduced. Since Turkey is a moderately large country with varying topographic features by province locations, it is relatively complicated to analyze the air quality data covering the whole country. Consequently, the major air quality impaired cities were selected and only the top 27 cities with high SO_2 and TSP matter concentrations in their urban atmosphere between the years 1992 and 2001 were taken into account for this analogy. Finally, current air quality in the cities, which have been using natural gas for house heating since early 1990's, was also examined to exhibit effects of air quality improvement in these limited number of urban centers. Four projections were made to show the possible monetary gain in 27 cities with impaired air quality if outdoor air pollution related sicknesses were to be reduced to better air quality by using natural gas primarily for house heating and secondarily for industrial processes.

Statistical analyses were completed using the SPSS® program. First, homogeneity of air-pollution related diseases in the examined cities was tested to see whether sickness cases in clean-air province centers and polluted-air province centers are comparable. The numbers of disease cases belong to each province were divided by the province population. Since the data set was not found to be homogeneous, arcsine transformation was completed to perform one-way ANOVA in order to reveal whether the air pollution related sicknesses differ between air-polluted cities and relatively clean-air urban centers.

3. Results and Discussion

There were found to be a total of 27 province centers, which form the cities with the worst outdoor air quality in terms of mean annual SO_2 and TSP concentrations between 1992 and 2001, in Turkey (DİE, 1997a, 2002c). Figure 1 illustrates the locations of the cities with highest mean annual SO_2 and total (suspended) particulate matter (TSP) concentrations. The illustration shows 19 urban areas with the highest mean annual SO_2 and TSP concentrations together, for each area, between 1992 and 2001 (DİE, 1997b, 2002d).

Local coal mines, e.g. in Çanakkale, Kütahya and Erzurum, with low environmental quality could partly be responsible for polluted air in some of the cities shown in Figure 1. Additionally, some provinces, e.g. Muğla and Kütahya, have important coal-fired electric power generation plants within province borders. It is noted by Mishra (2004) that coal-fired power generation plants emit nitrogen, carbon, particulate matter, sulfur oxides, and toxic elements into the atmosphere. Eleven cities (İstanbul, Kütahya, Çorum, Sivas, Erzurum, Adıyaman, Kahramanmaraş, Denizli,

Figure 1. Turkish cities with the notably high both SO_2 and total suspended concentrations (written in bold); SO_2 concentrations (indicated with italic) and total suspended particulate concentrations (underlined) (NASA, 2002).

Kayseri, Diyarbakır and Gaziantep) are listed in the worst annual concentrations for both SO_2 and TSP between 1992 and 2001. It is an interesting point that there are five coastal cities with high TSP in their urban atmospheres (İstanbul, Zonguldak, Rize, İzmir, and Antalya). In İstanbul, traffic and industry are probable reasons for urban air impairment despite the fact that some clean air transportation vehicles (e.g. natural gas powered public busses) have been serving in the metropolis since the early 1990's. Similar to İstanbul, both Kocaeli and İzmir are remarkably industrialized cities. In the following sections, the factors that play important roles in urban air pollution, diseases caused by urban air pollution and monetary savings if cities with outdoor air pollution could improve their air quality are discussed in detail.

3.1. Air quality of Turkish cities in 1992–2001

According to the air quality in the province centers compiled by the State Statistical Institute (DİE, 1997a,b; 2002c,d), many cities were found to have high annual SO_2 concentrations (higher than 95 μg m^{-3}) and many cities' air quality was found to be impaired with high mean annual TSP (higher than 60 μg m^{-3}) between the years of 1992 and 2001. Long-term standards tailored by World Health Organization (WHO) are currently 50 μg m^{-3} for SO_2 and 70 μg m^{-3} for particulate matter (PM_{10}) in spite of the fact that the Turkish Air Pollution standards for SO_2 and particulate matter are both restricted with 150 μg m^{-3} for long-terms. Notable differences

TABLE I
SO_2 concentrations in selected Turkish cities between 1992 and 2001 (Bold ones indicate the city has both SO_2 and TSP pollution in outdoor air)

Province	Total province population	Province Center population	No. of years in top 10 air polluted cities' list	Max SO_2 conc., $\mu g\ m^{-3}$ and year	Mean annual SO_2 conc., $\mu g\ m^{-3}$	Respiratory disease incidence in 2001,%
Kütahya	656,903	166,665	10	228 (1993)	169	6.5
Kırıkkale	383,508	205,078	10	188 (1994)	118	9.2
Sivas	755,091	251,776	10	229 (1993)	113	8.7
Yozgat	682,919	73,930	10	193 (1998)	107	13.7
Konya	2,192,166	742,690	10	150 (1993)	97	5.0
Çanakkale	464,975	75,810	10	141 (1997)	96	5.9
Balıkesir	1,076,347	215,436	9	161 (1993)	115	5.0
Çorum	597,065	161,321	9	250 (1993)	114	5.1
Kayseri	1,060,432	536,392	9	149 (1992)	104	9.2
Edirne	402,606	119,298	9	130 (1999)	102	12.5
Kırşehir	253,239	88,105	9	124 (1995)	96	3.7
İstanbul	10,018,735	8,803,468	8	247 (1992)	129	10.5
Kahramanmaraş	1,002,384	326,198	8	207 (1993)	122	5.2
Diyarbakır	1,362,708	545,983	8	182 (1992)	102	14.1
Denizli	850,029	275,480	8	105 (2000)	95	4.2
Erzurum	937,389	361,235	7	276 (1993)	166	11.5
Adıyaman	623,811	178,538	7	152 (1993)	104	8.1
Gaziantep	1,285,249	853,513	6	140 (1994)	110	7.4
Muğla	715,328	43,845	2	141 (1998)	127	7.5
SUM	25,320,884	14,024,761	–	–	–	–
MEAN	1,332,678	738,145	8	179	115	8.05

between WHO and Turkish Air Pollution standards would be expected to drop in the future years since the Republic of Turkey is considering the rearrangement of its current air pollution limits in order to improve its overall environmental quality.

Based on the standards established by WHO, all of the cities included in Table I are in violation in terms of long term SO_2 concentration in outdoor air. On the other hand, almost one third of the cities listed in Table II include unimpaired outdoor urban air cities when WHO standards for long term total particulate matter are taken into account. Kütahya seems likely to have impaired air quality according to its 10 year average SO_2 concentration based only upon Turkish air pollution guidelines. Two important coal-fired power plants (Seyitömer (20 km from the city center) and Tunçbilek (35 km from the city center)) are close to the city center and they have no lignite pretreatment or emission control measures. Furthermore, there

TABLE II

TSP and health data in selected Turkish cities (1992–2001) (Bold ones indicate the city has both SO_2 and TSP pollution in outdoor air)

Province	Total province population	Province Center population	No. of years in top 10 air polluted cities' list	Max TSP conc., μg m^{-3} and year	Mean annual TSP conc., μg m^{-3}	Respiratory disease incidence in 2001,%
Zonguldak	615,599	104,276	10	137 (1992)	96	8.1
Sivas	755,091	251,776	10	156 (1993)	94	8.7
Kütahya	656,903	166,665	10	101 (2000)	72	6.5
Antalya	1,719,751	603,190	10	89 (1993)	66	6.0
Afyon	812,416	128,516	9	98 (1994)	80	9.9
Kayseri	1,060,432	536,392	9	96 (1999)	73	9.2
İzmir	3,370,866	2,232,265	9	149 (1992)	70	9.9
Diyarbakır	1,362,708	545,983	8	160 (1992)	100	14.1
Denizli	850,029	275,480	8	95 (1995)	86	4.2
Rize	365,938	78,144	8	112 (1994)	85	9.3
Kahramanmaraş	1,002,384	326,198	8	118 (1993)	79	5.2
İstanbul	10,018,735	8,803,468	8	92 (1992)	70	10.5
Çorum	597,065	161,321	8	86 (2000)	60	5.1
Erzurum	937,389	361,235	7	159 (1993)	96	11.5
Adıyaman	623,811	178,538	7	102 (1993)	72	8.1
Gaziantep	1,285,249	853,513	6	83 (1994)	65	7.4
Muş	453,654	67,927	4	82 (1994)	62	4.7
Ağrı	528,744	79,764	3	68 (1998)	59	2.3
Mardin	705,098	65,072	2	71 (1994)	60	n.a.
SUM	27,721,862	15,819,723	–	–	–	–
MEAN	1,459,045	832,617	8	108	76	7.82

are a number of ceramic factories in the city. However, province-wide respiratory disease incidence, 6.5% in the year 2001, was moderate compared to that in other provinces. This might be due to somewhat lower urbanization rate (25.4%, which is the province center population's proportion to province total population) in the province.

Industrial and transportation sources and residential structures both cause air pollution. A ten fold difference exists between the shares of Ankara and İstanbul in terms of their gross economic productions. While Ankara supplies only a low 4.3% gross production in the country's total, İstanbul generates 42.35% of total gross national production (Zaim, 1997; Elbir *et al.*, 2003). Moreover, only 11.35% of all roadway vehicles are registered in the state capital, Ankara, 15.66% of all roadway vehicles are registered in İstanbul (DİE, 2003). Coal-fired power plants accounted for 59.56% of total electric generation in 1999 in Turkey (DPT, 2001a). However, natural gas, which is imported from various countries, usage in house heating and electric generation has recently become popular especially in the metropolitan areas. Additionally, there are recently built electricity generation plants powered by imported natural gas.

It should be underlined that only Yatağan (Muğla-Yatağan), Ankara-Çayırhan and Bursa-Orhaneli power plants are equipped with air pollution control measures out of 12 important coal-fired power plants situated in Turkey. Muğla is 23 km away from Yatağan Thermal Power Plant, annual mean SO_2 concentration in air exceeded Turkish national standards only in 1997. Denizli is 95 km away from Yatağan Power Station (630 MW) and has notable SO_2 and TSP levels in the city center. Despite the fact that there are potentially rich geothermal power sources in nearby areas, the province depends on fossil fuels for both house heating and notable industrial operations in the region.

The nation's largest coal-fired power station (2,064 MW capacity Afşin-Elbistan), is located 65 km away from Kahramanmaraş. There are no pretreatment facilities in this plant. Another notable power station (1,034 MW power capacity plant, Soma) within Manisa is 60 km away from Balıkesir. Despite its higher moisture and ash content, which are 34.9% and 20.8%, respectively, Soma lignite has only 1% sulfur in it. Air pollution abatement facilities, such as lignite pretreatment and emission control at the stacks, were not installed up to date. Zonguldak is situated at a distance of 15 km from Çatalağzı Power Plant (300 MW). Çatalağzı is the only hardcoal powered energy station in Turkey. Only suspended matter in air is a serious problem in the city. Kangal Power Plant (457 MW) is located 65 km away from Sivas. Despite very low sulfur percentage, both extreme moisture and notably high ash content causing low energy capacity make the power plant partly responsible for air pollution in the city.

In Tables I and II, province centers total and province centers populations (DİE, 2002a,b) are also submitted in addition to their health related, only upper respiratory system problems prevalence rate, data. It should be noted that the sickness prevalence rates are based on whole province populations.

Mean annual SO_2 concentrations (1992–2001) in selected air impaired cities and cities with recently improved air quality are illustrated and compared in Figure 2. Based on Figure 2, in general, the Turkish urban atmosphere experienced an improvement in SO_2 levels over the past 10 years despite there is only a fluctuation in total SO_2 levels in Yozgat, Kütahya and Çanakkale. The dramatic decrease of SO_2 concentrations in outdoor air in some populous cities of Turkey should be underlined. İzmir has made a notable progress in decreasing SO_2 pollution though it has not yet started use of natural gas for residential heating and industrial purposes. The progress in İstanbul is more notable than that in İzmir: more than 400% decrease in mean annual outdoor SO_2 level has been realized from 1992 to 1999 and beyond (though the values for 2000 and 2001 are missing).

Figure 3 illustrates TSP concentration trends in selected Turkish cities between 1992 and 2001. Both decreasing (e.g. in Ankara and in Bursa) and fluctuating

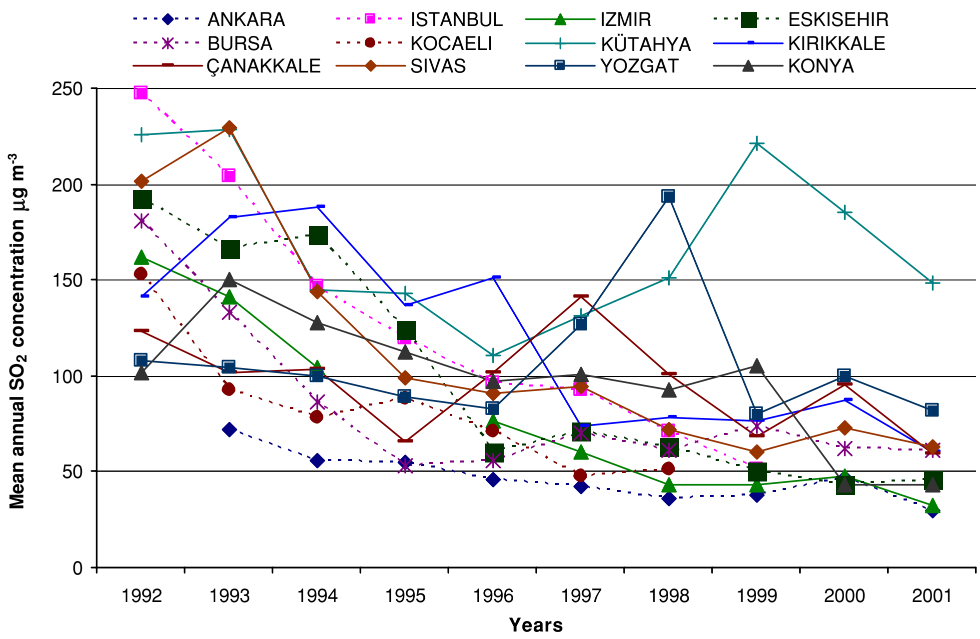

Figure 2. Mean annual SO_2 levels in selected Turkish cities between 1992 and 2001.

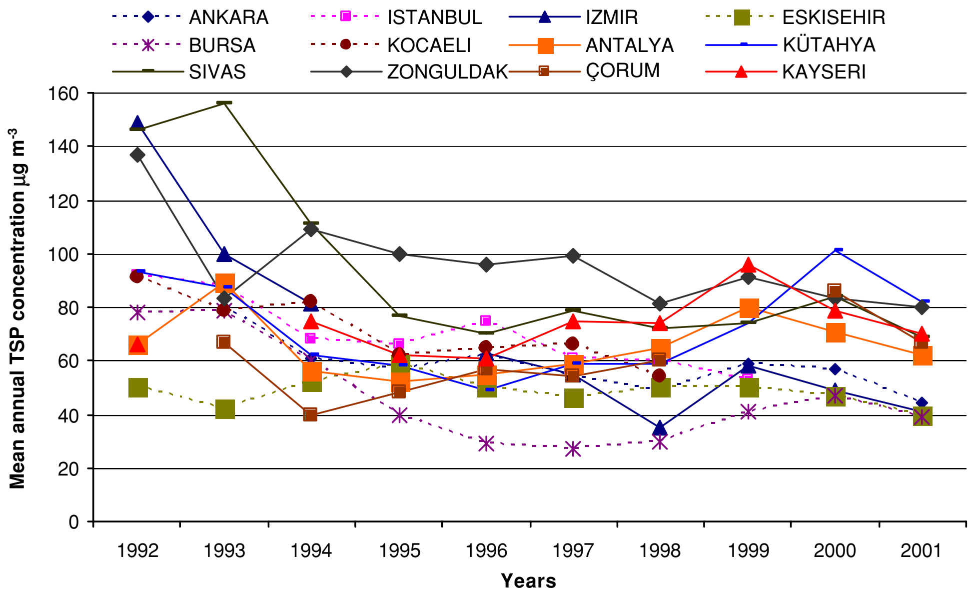

Figure 3. Mean annual TSP levels in selected Turkish cities between 1992 and 2001.

(e.g. in Kütahya and in Zonguldak) and increasing (e.g. in Kayseri) TSP levels are important to look at.

3.2. Air pollution related diseases in Turkey

In Table III, the health related data from the air impaired cities, which appeared at least once in Turkey's air pollution records between 1992 and 2001, is compiled. As mentioned before, Table III includes the respiratory disease diagnoses in the provinces listed (TCSB, 2001a). The cities included in Table III were taken into account on the basis of their appearance in impaired outdoor air, in terms of SO_2 and total particulate matter concentrations, cities, which were compiled by the State Statistical Institution (DİE) in the years between 1992 and 2001. The data set is consisted of number of upper respiratory disease diagnoses, sinusitis and bronchitis diagnoses, and pneumonia cases on province basis reported by Turkish state medical facilities in 2001 (TCSB, 2001b).

According to Tanrıtanır (1997), in some European Union countries (Austria, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Spain, England) respiratory diseases such as bronchitis, emphysema and asthma cases are the 8th largest cause of death. Pneumonia related deaths rank as the 10th most important reason in the EU. On the other hand, in Turkey respiratory diseases other than bronchitis, emphysema and asthma and pneumonia ranked 6th as the primary cause of death followed by pneumonia cases which rank 7th and bronchitis, emphysema and asthma cases which ranked 10th. However, prevailing values between the EU countries and Turkey are very different probably because of differences in industrialization, population patterns, topography, urbanization, and transport, shortly life styles and other environmental factors. Prevalence of bronchitis, emphysema, and asthma is 0.09% and pneumonia is 0.08‰ in the EU countries; whereas in Turkey, other respiratory system diseases and pneumonia each have a prevalence of 0.03‰ and bronchitis, emphysema, and asthma mortalities have an incidence of 0.02‰. In this study, a comparison of number of cars, industrialization levels, topographic features, etc. was not made between the countries of the European Union and Turkey. If such a study could have been completed, the current and future expected health related figures would have been more reliably available. However, here it is not our goal to make a comparison between the EU countries and Turkey.

Based on respiratory system disease prevalence rates, population weighted disease rate computed for 27 provinces listed in Table III was found to be 8.4%. The mean respiratory system disease incidence percentages for only high SO_2 concentration provinces was calculated to be 7.2% and for only high particulate matter provinces was found to be 7.3%; whereas, both high SO_2 and particulate matter provinces' mean respiratory system related disease prevalence rate was computed to be 7.5%. From this point of view, when both SO_2 and TSP are high in outdoor air, it can be said that residents of such cities are expected to be impacted more than the residents living in only SO_2 impaired or only TSP impaired cities. In

TABLE III

Respiratory system diseases in the Turkish cities with notably high air pollution (Bold ones indicate the city has both SO_2 and TSP pollution, italicized ones indicate only SO_2 pollution, underlined indicate only TSP pollution in outdoor air)

Province	Number of upper respiratory system disease diagnoses	No. of sinusitis diagnoses	No. of bronchitis diagnoses	No. of pneumonia diagnoses
Kütahya	73,293	5,944	11,323	676
Zonguldak	40,144	5,848	7,459	4,517
Afyon	115,193	12,709	17,306	1,734
Denizli	202,771	34,978	35,517	2,019
Kayseri	116,632	15,593	19,720	359
Rize	72,386 (2)	10,563	11,658	2,075
Sivas	58,466	6,430	6,727	1,354
Kahramanmaraş	144,691	13,465	25,433	1,981 (2)
Balıkesir	127,771	10,293	24,645	393
Edirne	62,951	3,545	7,467	553
Yozgat	65,756	8,872	10,228	635
Erzurum	60,515	10,980	6,482	848
Çanakkale	49,173	3,331	5,849	45
Gaziantep	87,127	9,304	25,849 (2)	5,134 (9)
Diyarbakır	121,226	6,709	15,015	1,132
Antalya	273,383	23,025	34,001	1,474
Konya	352,656	57,455	81,108	14,393 (15)
Kırşehir	42,590	2,274	3,054	198
Kırıkkale	48,905	4,514	3,683	95 (3)
Çorum	74,333	10,313	17,104	1,565
Ağrı	17,863	2,208 (1)	7,091	1,384
Mardin	54,482	4,084	11,929	394
Muş	26,822	2,836	1,876	555
İzmir	599,264	34,520	61,437	3,585 (20)
İstanbul	420,476	45,186	105,402	5,334 (21)
Adıyaman	49,558	4,085	6,600	1,458
Muğla	113,142	8,214	18,500	1,425
SUM	3,471,569 (2)	357,278 (1)	582,463 (2)	55,315 (67)
MEAN	128,576	13,233	21,573	2,049 (2)

Numbers in parentheses indicate total mortalities related to the disease in 2001.

Table III, the numbers in parentheses indicate total number of deaths from the individual diseases in 2001. Based on this data set, İstanbul has a very high mortality rate caused by pneumonia. Konya and Gaziantep, which are relatively large cities (province population is more than a million for each), have also reported notably

TABLE IV
Clean air cities in Turkey: Population and health figures for 2001

Province	Province population	Province center population	Respiratory disease incidence,%	No. of upper respiratory system cases	No. of sinusitis diagnoses	No. of bronchitis diagnoses	No. of pneumonia diagnoses
Ankara	4,007,860	3,203,362	3.2	369,158	43,639	36,861	3,370
Eskişehir	706,009	482,793	4.4	35,000	18,908	12,398	84
Bursa	2,125,140	1,194,687	5.4	203,661	18,999	38,922	1,828
Kocaeli	1,206,085	195,699	7.1	151,017	17,093	33,206	4,056 (1)
Total	8,045,094	5,076,541	–	758,836	98,639	121,387	9,338 (1)
A. mean	2,011,274	1,269,135	5.0	189,709	24,660	30,347	2,335
G. mean	–	–	4.5	263,414	30,980	34,711	2,777

numbers in parentheses indicate the mortalities.
A. mean is the arithmetic mean.
G. mean is the geometric mean (based on province total population).

high mortalities because of pneumonia. On the other hand, extremely high mortalities caused by upper respiratory system impairments (pneumonia) were recorded by the state medical facilities situated in İzmir.

In Table IV, the cities that have been using natural gas for house heating and some of their industrial operations are listed along with their respiratory sickness diagnoses reported by Turkish state health care facilities in 2001 (TCSB, 2001b). It should be noted here that after clean air programs (natural gas usage) launched in Ankara in 1988, in Bursa and İstanbul in 1992, in Eskişehir and İzmit in 1996, an improvement in outdoor air quality has been observed. Despite the fact that İstanbul is a metropolis that has completed natural gas pipelines throughout the province center, there were campaigns to support transformation from conventional fossil fuels to natural gas use for its residents as of summer 2005. Overall, the ratio of province cars to province total population is approximately 21% in Ankara, 16% in İzmir and Eskişehir, 14% in Bursa, 12% in İstanbul, 11% in Kocaeli (province center: İzmit), and on average 10% for the other provinces listed in Table IV (DİE, 2003; DİE 2002b). However, in terms of number of vehicles, İstanbul has approximately 16% of the total number of vehicles in Turkey (DİE, 2003). Because of population, vehicles, industry, life style, etc. it is not surprising that unexpectedly high respiratory sickness incidences were reported for the year 2001 in İstanbul. It should be stated that air-quality related sickness cases are notably high even though İstanbul is not in top 10 worst air quality cities' list in the last 5 years.

Based on statistical analyses, only sinusitis prevalence rates were found to be different between air-polluted provinces and relatively clean-air provinces ($p < 0.001$). Table V summarizes Pearson correlation coefficients between air pollution related diseases. However, sinusitis is easily diagnosed even at smaller healthcare facilities. In spite of the fact that other (than sinusitis) air pollution related

TABLE V
Pearson correlation coefficient for air-pollution related diseases

Disease	Upper respiratory system cases	Sinusitis	Bronchitis	Pneumonia
Upper respiratory system cases	1			
Sinusitis	0.844 ($p < 0.000$)	1		
Bronchitis	0.860 ($p < 0.000$)	0.884 ($p < 0.000$)	1	
Pneumonia	0.525 ($p < 0.003$)	0.713 ($p < 0.000$)	0.705 ($p < 0.000$)	1

health problems seem to be statistically insignificant between clean-air provinces and air-polluted provinces, it should be noted that Turkey has a unique health care record keeping system as explained in the following chapter (3.3). For this reason, bronchitis, upper respiratory problems and pneumonia cases in clean-air cities and impaired outdoor air cities are indeed different.

3.3. Expected monetary gain if Turkish urban air quality could be improved

Prior to providing the details and make comparisons between sicknesses caused by air pollution in the relatively clean air cities and in the air impaired cities, it would be necessary to illustrate the Turkish national health care record keeping system. Turkish health care system has a different operational method in terms of sickness recording system. If the nearest health care facility does not have any remedial solutions to the sick person after record-keeping, he/she is sent to larger hospital nearby or to hospital in the province center. In the larger hospitals, another record is kept in their record notebooks. However, it is popular among civil servants and others that they generally search for remedies in metropolitan hospitals, which are thought to have better facilities. Therefore, it is not surprising to expect higher respiratory sickness sufferings, upper respiratory impairments, asthma, bronchitis, sinusitis and pneumonia, reported by hospitals of large cities (especially in İstanbul and Ankara) too in Turkey. Furthermore, once the local health care facility writes down a dispatch to a sick person, the diagnoses are also noted in there. Then, there are at least two medical records, one at the local health care facility and one at the last visited medical facility, about the sickness. The explanation of large number of sinusitis, bronchitis and pneumonia cases reported in 2001 in İstanbul and Ankara is this double-record keeping as well as sufferers coming from their towns and villages.

As summarized in Table IV, clean air cities have reported lower air pollution related diseases in 2001. Over a period of time, Kocaeli Province (province center: İzmit), Bursa, Eskişehir, and up to some extent İstanbul are also expected to have decreasing rates of (probably less than 3.5% incidence) respiratory system related sicknesses, sinusitis, bronchitis, and pneumonia cases in the future years. Indeed, both Kocaeli and Bursa are remarkably industrialized provinces. Therefore, industrial and occupational hygiene should also be considered as important parameters that affect human health there.

There are three different scenarios and one alternative approach that were developed in the present study as explained below. The first projection is the reduction of air pollution related disease incidence rates in 27 cities, which is 7.81% to the respiratory system incidence rate in Ankara, which is 3.2% or close to this rate. The second projection is the decrease of air pollution in 27 worst air quality cities to better air quality assuming coastal cities and inland cities have different air-quality criteria and the cities have different urbanization and industrialization levels. In this case, the most important factors to compute expected air pollution related diseases are the proportion of province center population to total province population, industrialization rate of the city/province, local climatic specifications (mean annual temperature, harshness of winters, etc.), local topographic properties (inland or coastal city, elevation, etc.). The third projection a decrease of air pollution related sufferings by the factor of $^{5.0}/_{7.8}$, the proportion of mean clean-air cities' respiratory system disease incidence to 27 worst-urban air cities' respiratory system disease incidence.

Under the best case scenario, (1), more than two-fold reduction in diseases listed above would be expected in the cities with impaired outdoor air quality when they reach better urban air quality. Moreover, overall respiratory disease incidence rate would optimally be expected to be around 5%, or even below it, if better air could be provided in the cities that have higher SO_2 and particulate matter concentrations. This was projected using overall values of Table IV. Under such conditions, the expected diagnosis numbers in 27 Turkish cities tabulated in Table III will be reduced from 3,471,569 for upper respiratory disease cases to an approximately 1,422,410; from 257,278 for sinusitis cases to roughly 105,415 cases; from 582,463 for bronchitis to about 238,653; and from 55,315 pneumonia cases to around 22,664. Additionally, one person suffering from upper respiratory sicknesses and 40 people suffering from pneumonia could be saved from death under this projection.

Using the moderately optimistic approach, (2), the individual cities were evaluated in the light of data from clean-air cities' (Ankara, Bursa, Eskişehir, and Kocaeli (İzmit)). Among these cities, only İzmit (province center of Kocaeli) is located by the sea. Therefore, Antalya, Çanakkale, İstanbul, Rize, and Zonguldak (despite the fact that İzmit and İstanbul are highly industrialized) are expected to have similar disease case figures after sometime when they start to use natural gas for their urban heating and industrial operations. The other cities should be similar to Ankara and Eskişehir. Based on the pessimistic projection applied to the 27 cities tabulated in Table III, expected cases might be as low as 1,848,000 for upper respiratory system diagnoses; 238,400 for sinusitis; 425,000 for bronchitis; and 24,000 for pneumonia annually. Additionally, approximately 25 people per annum could be saved from death caused by pneumonia.

Similar to the best case and moderate projections, one more projection, conservative case, (3), was produced assuming all provinces are similar in terms of their urban atmosphere and only upper respiratory incidence will be reduced to 5.0% after clean urban air target will be achieved. In other words, natural gas usage will improve air quality in the cities, whose current air quality is polluted. In this case overall disease case numbers could be calculated multiplying the current sum of the diseases (given in Table III) by 0.640 (which equals $^{5.0}/_{7.8}$). Therefore, the total upper respiratory disease diagnoses would be expected to drop to 2,222,515 in the future years; whereas, for sinusitis cases it would be 164,711; for bronchitis cases it would probably be 372,896; and for pneumonia cases it would possibly be 35,413, annually. Moreover, optimistically, one person suffering from upper respiratory diseases or bronchitis and 24 people suffering from pneumonia would probably be saved from death under this scenario.

One alternative approach was also tried. This trial was developed by using clean-air cities. Interestingly, in clean-air province centers, there is a strong relationship between proportion of province center population to total province population (P) and upper respiratory system diagnoses prevalence (URSP). This relationship is expressed invert quadratic form with $URSP = (-7.9567 \times P^2) + (1.5342 \times P) + 7.0595$ equation that has $r^2 = 1$. Therefore, the reduction of upper respiratory system diseases prevalence in impaired cities was individually calculated by the equation given above. Surprisingly, İstanbul, Diyarbakır, Yozgat, Edirne, İzmir, Erzurum, Kırıkkale and Kayseri showed remarkable reductions (more than 3% per year) in upper respiratory system disease prevalence. In spite of the fact that ten provinces (Kütahya, Çorum, Kahramanmaraş, Denizli, Konya, Çanakkale, Balıkesir, Kırşehir, Antalya and Ağrı) showed a slightly increase in upper respiratory system prevalence in this projection due to their low province center population over province total population and low upper respiratory system prevalence rates reported, their rates are expected to be constant in future years.

Expected monetary gain could be calculated by using reductions based on the three approaches mentioned above and the average expense of a sick person to Turkish state medical facilities. Keeping in mind that the medical expenses per person vary throughout the country, the average expense per sick citizen was taken as reference for the sake of simplicity. According to Turkish State Statistical Institution (TCSB, 2002), the average total medical expense for each sick person from any disease in Turkey was \$135.3 in 2000. Thus, every incidence of disease caused by polluted air that was prevented could save approximately \$135 (if mean annual inflation rate of the USA between 2000 and 2005 is taken into account, it became approximately \$145 in 2005).

Table VI summarizes the findings posterior to application of this projection. It is noteworthy that the outcome is close to that calculated under the best case approach. Therefore, even this projection is safe to use when one tries to predict monetary gain in outdoor air-impaired urban areas when cleaner urban air is achieved.

TABLE VI
Projected annual monetary gain if urban outdoor air quality can be improved

Projection	Initial sickness cases	Expected sickness cases	Reduction in sickness cases	Monetary profit, US $
The best case (1)	4,366,625	1,789,142	2,577,483	348,733,433
Moderate case (2)	4,366,625	2,535,400	2,202,987	298,064,414
The worst case (3)	4,366,625	2,795,535	1,571,090	212,568,472
Alternative approach (4)	4,366,625	2,262,334	2,476,053	335,009,971

In conclusion, this would mean that the burden on the health care system of the country could be reduced and the saved money would be used for other health problems, such as protective health measures, cardiovascular diseases, children's health, etc.

4. Conclusions and Recommendations

It should be pointed out that Turkey has been experiencing notable outdoor air pollution in some of its provinces. Provinces that are near coal-fired thermal electricity generation plants and that use environmentally impaired fuels such as coal and lignite for residential heating and industrial operations are an especially important urban air pollution hazard. Such thermal power generation plants should be equipped with fuel qualification systems and/or smokestack gas treatment units to minimize their suspended particulate matter and SO_2 emissions. A couple of cities have been using imported natural gas in homes and industries since early 1990's. Many cities throughout the nation have been waiting for completion of natural gas pipelines. Therefore, if an improvement in urban air pollution in Turkish cities is realized, the number of people suffering from the diseases that are caused by air pollution will decline dramatically. However, this decline depends on the remedial measures that need to be taken and their effect will be seen after some time. If natural gas pipeline systems are constructed in the near future and industrial facilities start using more effective and more environmentally friendly fuels, the urban air quality will probably improve and number of sicknesses due to impaired air quality will probably decline in Turkey. By effective reduction of diseases caused by air pollution, a notably great amount of money would be saved and this could be used for other health care expenses of the country. It is estimated that mean annual monetary gain could be as high as US$ 350 million.

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