COPD and Urban Air Pollution

GIS Based Spatial Pattern and the Geostatistical Analysis of Izmir

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Abstract: In Turkey, starting from the 1950's air pollution has been increasing because of rapid population increase, rapid urbanization and industrialization. These cause intense energy usage in settlement areas and this brings some problems in environmental health. The aim of the study is the examination of whether there is any statistical relationship between the level of air pollution with the number of COPD cases and incidence between 2006 and 2010 in Izmir City Center. The study area has six districts of Izmir City Center: Konak, Bornova, Buca, Karsiyaka, Cigli and Balcova. There are in total 89,776 COPD cases between 2006 and 2010. The spatial pattern of these cases is mapped via the GIS environment. Then, multivariate linear regression analysis is performed in the study. Additionally, the questionnaire was realized with 25 COPD inpatients in Dr.S.Seren Chest Diseases Hospital in Izmir in March - April 2014. The results show that there is a significant and positive relationship between the level of air pollution (PM and SO_2) and the number of COPD cases and incidence. In general, the increasing of the level of air pollutant and population cause an increase in the number of COPD cases and incidence. It is observed that the level of air quality in Karsiyaka, Bornova and Konak districts is lower than and incidence rates are higher than the other case districts. According to questionnaire results, there is a significant relationship between the inpatients' age and their period of smoking. Also, there are significant relationships among the diagnosis, sex, job, risk factor, genetic predisposition, smoking habits, environment lived in and heating preferences.

1 INTRODUCTION

Environment is quite important for human health. It has been stated that there have been various agents which can affect human health either directly or indirectly (The Ministry of Health of Turkey, 2008). Conducted studies generally show inequalities in health are emerging according to socioeconomic status, education level, geographic location, gender, ethnic groups and age groups. The World Health Organization Regional Office for Europe (WHO/ EURO) has started a major new project known as "Healthy Cities" at the local level to adopt a policy leading to 'Health for all'. Izmir Metropolitan Municipality also applied to be a member of Turkish Healthy Cities Association on Jun 02, 2006 by Resolution of the City Council. Within the studies of healthy cities and environmental impacts on health, some diseases among populations become noticeable such as chronic obstructive pulmonary disease (COPD).

COPD is defined as a clinical condition characterized by chronic obstructive disease and progressed on the basis of chronic bronchitis and/or emphysema (Koç et al., 2002). The cause of COPD in the literature is classified as smoking, air pollution, viral respiratory infections during childhood, organic and inorganic particles around people and inherited changes (URL1, 2014). In epidemiological studies, it has been determined that air pollution causes an increase in total mortality, and morbidity of respiratory diseases in adults and respiratory symptoms in children. Especially, it has been proved that the intensity of air pollutants (sulfur dioxide (SO_2) and particulate matter (PM)) causes COPD cases to increase (Koç et al., 2002; Chen et al., 2000; Zanobetti et al., 2000).

In Turkey, from the 1950's to today air pollution has been increasing because of rapid population growth, rapid urbanization and industrialization rates. The increasing use of fossil fuels, unplanned urbanization, inappropriate and inadequate

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combustion techniques, lack of green areas and increase of motor vehicles cause a significant increase in urban air pollution.

Urban air pollution is an inevitable component of modern life especially in urban areas. Therefore, it exposes a contradiction between the biological and economic requirements of human beings. More than half of the total population in Turkey are living in the settlement areas classified as “cities” that have a population greater than 10,000 people. The level of air pollutants in the atmosphere has been increasing continuously because of dense population in these settlement areas, in total comprising 1% of the land area of the country, and increasing demand of quality of life standards (Müezzinoğlu, 2000; İncecik, 1994; Godish, 1997).

The aim of the study is the examination of whether there is any statistical relationship between the level of air pollution (PM and SO_2) with the number of COPD cases and incidence in the years 2006-2010 in Izmir City Center. The study area is Konak, Bornova, Buca, Karsiyaka, Cigli and Balcova districts of Izmir City Center. In 2009, Konak district has been divided as Konak and Karabaglar, also Karsiyaka district has been divided as Karsiyaka and Bayrakli. COPD cases have been recorded in the districts of Konak and Karsiyaka until 2009 and have been started being recorded in the districts of Konak, Karabaglar, Bayrakli and Karsiyaka. In this study, for 2009 and 2010 COPD cases, Karabaglar cases have been counted in Konak district and also Bayrakli cases have been counted in Karsiyaka district. There are total 89,776 COPD cases between 2006 and 2010 (The Ministry of Health, Izmir Provincial Directorate of Health, Department of Statistics, *The Distribution of Patient and Deaths by Gender*, 2006-2010 Years). SPSS software is used to perform statistical analysis and ArcGIS is used to realize spatial analysis. Spatial patterns of these cases are mapped via a GIS environment. Multivariate regression analysis is performed in the study.

2 LITERATURE

Environmental health studies are related to the effects of environmental factors, such as air pollution, on human health and the effective health policies to handle their effects (Maantay and McLafferty, 2011).

In the literature, there exist a lot of studies thet the relationship and either positive or negative influence between air quality and respiratory system. These studies are differentiated in terms of the type of disease. Generally, respiratory system related diseases studies are performed by Tagil and Mentese, 2012; Cengiz et al., 2013; Unsal et al., 1999; Zhang et al., 2013; Darçın, 2013; Jerrett et al., 2009; Dockery et al., 1993 and Wong et al., 2001. Besides, some studies are performed just using COPD cases by Chen et al., 2000; Zanobetti et al., 2000; Faustini et al., 2012; Lingdren et al., 2009; and Cinarka et al., 2011.

A GIS is used as a common tool to be equipped with an electronic environment which links the exposure model with the demographic, migration and health data of the exposed population. The integration of the model in a GIS together with individual data and information from routine health statistics proved its usefulness in demarking the exposed population (Poulstrup and Hansen, 2004).

GISs have been applied in assessment of accessibility to opportunities such as education, employment, goods and services, recreation and health care services in urban environments. Related researches have examined the relationship between urban life and health levels. Additionally, GIS makes it possible to combine survey based data on COPD studies at the individual level with spatial objective data of the urban environment (Marans and Stimson, 2011).

In Turkey, despite the past and ongoing research and studies on spatial distribution of COPD and other diseases from the point of view of epidemiology, the amount of research is quite limited compared to studies in developed countries (Schikowski et al., 2005; Nuvolone et al., 2011).

3 THE STUDY AREA AND DATA

The study area has six districts of Izmir City Center: Konak, Bornova, Buca, Karsiyaka, Cigli and Balcova. There are in total 89,776 COPD cases between 2006 and 2010. In 2009, Konak district has been divided as Konak and Karabaglar. Also Karsiyaka district has been divided as Karsiyaka and Bayrakli. COPD cases have been recorded in the districts of Konak and Karsiyaka until 2009, and have been started being recorded in the districts of Konak, Karabaglar, Bayrakli and Karsiyaka. In this study, for 2009 and 2010 COPD cases, Karabaglar cases have been counted in Konak district and also Bayrakli cases have been counted in Karsiyaka district. The study area is represented in Figure 1, the distribution of the number of COPD cases between 2006 and 2010 at district level is shown in

Table 1 and the spatial distribution of them presented in Figure 3.

Figure 1: The Study Area (Turkey, Izmir, Districts of Study Area) (Google Earth, 2014).

As seen in Table 1 and Figure 3, Konak, Buca, Karsiyaka and Bornova districts have more intensive COPD cases in 2006-2010 in Izmir Province. The reason of this intensity can be explained by density of population and motor vehicles in these districts, also having more urban study areas than other districts. Additionally, the main transportation axes are in these districts; because of this, the level of air quality is lower than the other districts.

In this study, the number of COPD cases are related with the level of air quality. The level of air quality is measured as air pollutants (PM and SO_2) and these measurements are shown in Table 2 (URL2, 2014). Additionally, the spatial distributions of PM and SO_2 are presented in Figure 5 and Figure 6. In Table 2 and Figure 5, it is clearly observed that the level of PM has the highest values in Karsiyaka, Bornova, Konak and Balcova. As seen in Table 2 and Figure 6, the level of SO_2 has the highest values in Konak, Karsiyaka and Bornova.

Table 1: Total population, COPD cases and COPD incidence rate at district level (2006-2010).

		2006	2007	2008	2009	2010
Bornova	Population	470 645	470 211	392 631	402 453	412 275
	Case	1 342	1 815	1 920	1 472	5 614
	Incidence	285	386	489	366	1 362
Karsiyaka	Population	522 698	514 917	903 375	917 074	925 586
	Case	3 874	4 003	2 478	2 095	6 746
	Incidence	741	777	274	228	729
Buca	Population	376 189	393 934	404 472	412 639	419 693
	Case	2 580	5 643	5 535	5 456	8 422
	Incidence	686	1 432	1 368	1 322	2 007
Konak	Population	885 399	847 409	853 449	859 958	863 579
	Case	307	2 194	3 587	4 268	12 527
	Incidence	35	259	420	496	1 451
Balcova	Population	75 497	74 837	76 219	77 915	77 767
	Case	917	272	2 540	210	1 646
	Incidence	1 215	363	3 333	270	2 117
Cigli	Population	137 847	141 769	153 508	154 397	157 530
	Case	235	298	52	44	1 684
	Incidence	170	210	34	28	1 069

Table 1 shows total population of the case districts and COPD incidence rates. Additionally, Figure 2 and Figure 4 present these data spatially. As presented in Table 1, the most intense districts are Konak, Karsiyaka, Bornova and Buca in terms of total population.

Also as shown in Table 1 and Figure 4, the highest incidence rates are in Balcova, Buca, Bornova and Karsiyaka. The difference between total population and incidence rate is based on high population density, but low COPD cases in districts. The incidence rate is the number of new cases per population at risk in a given time period, in this study this rate represented per 100,000 persons. For example, Konak has the most crowded district; however its COPD incidence rate is lower than the other districts in Izmir Province. Therefore, the study considers both the number of COPD cases and COPD incidence rates in statistical analysis.

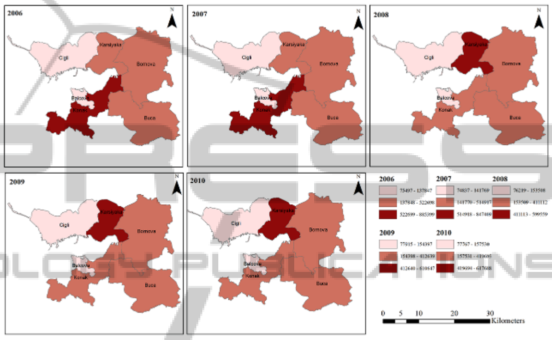

Figure 2: The spatial distribution of population at district level (2006-2010).

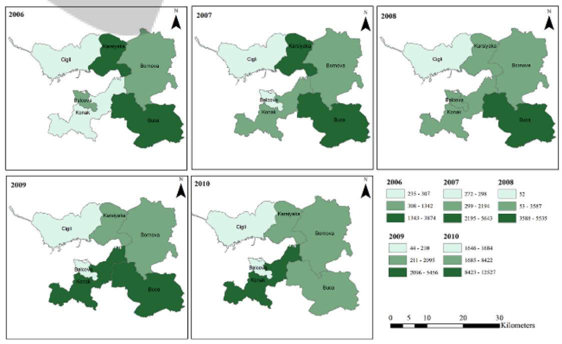

Figure 3: The spatial distribution of COPD cases at district level (2006-2010).

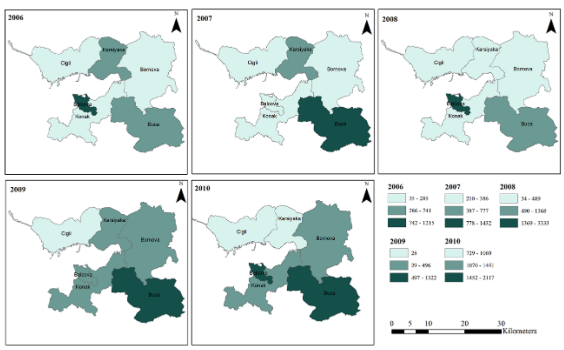

Figure 4: The spatial distribution of COPD incidence at district level (2006-2010).

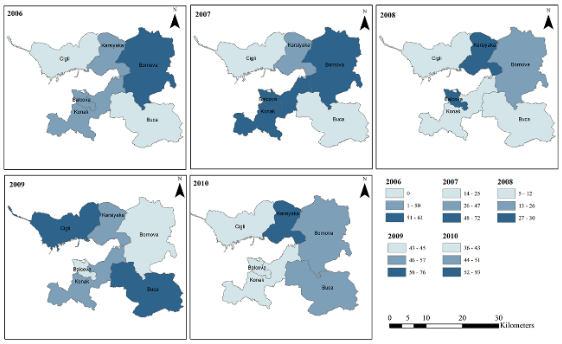

Figure 5: The spatial distribution of the level of PM at district level (2006-2010).

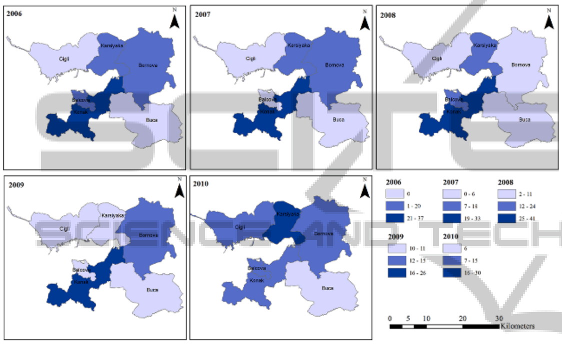

Figure 6: The spatial distribution of the level of SO_2 at district level (2006-2010).

Table 2: The levels of PM and SO_2 at district level (2006-2010).

		2006	2007	2008	2009	2010
Bornova	PM	61	66	26	45	51
	SO_2	15	12	11	15	15
Karsiyaka	PM	50	47	30	57	93
	SO_2	20	18	24	11	30
Buca	PM	0	25	11	76	51
	SO_2	0	0	2	11	6
Konak	PM	40	72	5	54	36
	SO_2	37	33	41	26	11
Balcova	PM	49	59	29	43	43
	SO_2	10	6	20	11	13
Cigli	PM	0	14	12	68	39
	SO_2	0	0	3	10	14

4 METHODOLOGY

Multivariate linear regression analysis is used in order to measure the relationship between dependent and independent variables. The number of COPD cases and COPD incidence are dependent variables; the level of air quality (PM and SO_2) and total population are independent variables in this study.

The independent variables are denoted as:
2006pm: PM value of 2006, 2007pm: PM value of 2007, 2008pm: PM value of 2008, 2009pm: PM value of 2009, 2010pm: PM value of 2010, 2006so2: SO_2 value of 2006, 2007so2: SO_2 value of 2007, 2008so2: SO_2 value of 2008, 2009so2: SO_2 value of 2009, 2010so2: SO_2 value of 2010, 2006tn: Total population of 2006, 2007tn: Total population of 2007, 2008tn: Total population of 2008, 2009tn Total population of 2009 and denoted 2010tn: Total population of 2010.

The dependent variables are denoted as:
2006t: The number of COPD cases (2006), 2007t: The number of COPD cases (2007), 2008t: The number of COPD cases (2008), 2009t: The number of COPD cases (2009), 2010t: The number of COPD cases (2010), i2006: COPD incidence rate (2006), i2007: COPD incidence rate (2007), i2008: COPD incidence rate (2008), i2009: COPD incidence rate (2009), and i2010: COPD incidence rate (2010).

Table 3 presents descriptive statistics of the number of COPD cases, PM values, SO_2 values, total population and COPD incidence rate.

Table 3: The descriptive statistics of parameters (2006-2010) (n=6).

Variable	Minimum	Maximum	Mean	Standard Deviation
2006t	235	3 874	1 542.50	1 426.868
2007t	272	5 643	2 370.83	2 117.215
2008t	52	5 535	2 685.33	1 817.575
2009t	44	5 456	2 257.50	2 191.245
2010t	1 646	12 527	6 106.50	4 163.903
2006pm	0	61	33.33	26.666
2007pm	14	72	47.17	23.250
2008pm	5	30	18.83	10.759
2009pm	43	76	57.17	12.891
2010pm	36	93	52.17	20.923
2006so2	0	37	13.67	13.952
2007so2	0	33	11.50	12.645
2008so2	2	41	16.83	14.770
2009so2	10	26	14.00	6.132
2010so2	6	30	14.83	8.085
2006tn	75 497	885 399	411 379	293 078.197
2007tn	74 837	847 409	407 179	279 446.619
2008tn	76 219	903 375	463 942	346 449.822
2009tn	77 915	917 074	470 739	350 179.356
2010tn	77 767	925 586	476 072	352 019.613
i2006	35	1 215	522.00	440.987
i2007	210	1 432	571.17	466.671
i2008	34	3 333	986.33	1 235.714
i2009	28	1 322	451.67	453.720
i2010	729	2 117	1 455.83	534.356

The number of COPD cases vary between 235 and 3,874 people, with a mean of 1,543 in 2006, between 272 and 5,643, with a mean of 2,371 in 2007, between 52 and 5,535 people, with a mean of 2,685 in 2008, between 44 and 5,456 people, with a mean of 2,258 in 2009 and between 1,646 and 12,527 people, with a mean of 6,107 in 2010. As seen in Table 3, it is clearly observed that there is a continuous increase in the number of COPD cases between 2006 and 2010.

PM values vary between 0 and 61 µg/m^3, with a mean of 33.33 µg/m^3 in 2006, between 14 and 72 µg/m^3, with a mean of 47.17 µg/m^3 in 2007, between 5 and 30 µg/m^3, with a mean of 18.83 µg/m^3 in 2008, between 43 and 76 µg/m^3, with a mean of 57.17 µg/m^3 in 2009 and between 36 and 93 µg/m^3, with a mean of 52.17 µg/m^3 in 2010. As shown in Table 3, although there is a slight decrease in PM value in 2008, the PM value trend is increase between 2006 and 2010.

SO_2 values vary between 0 and 37 µg/m^3, with a mean of 13.67 µg/m^3 in 2006, between 0 and 33 µg/m^3, with a mean of 11.50 µg/m^3 in 2007, between 2 and 41 µg/m^3, with a mean of 16.83 µg/m^3 in 2008, between 10 and 26 µg/m^3, with a mean of 14.00 µg/m^3 in 2009, and between 6 and 30 µg/m^3, with a mean of 14.83 µg/m^3 in 2010. As seen in Table 3, although there is a slight increase in SO_2 value in 2008, generally any significant increase or decrease SO_2 value is not observable between 2006 and 2010.

The total population of districts vary between 75,497 and 885,399 people, with a mean of 411,379 in 2006, between 74,837 and 847,409 people, with a mean of 407,180 in 2007, between 76,219 and 903,375 people, with a mean of 463,942 in 2008, between 77,915 and 917,074 people, with a mean of 470,739 in 2009, and between 77,767 and 925,586 people, with a mean of 476,072 in 2010. As seen in Table 3, there is a continuous increase in the total population between 2006 and 2010.

COPD incidence rates vary between 35 and 1,215 people, with a mean of 522 in 2006, between 210 and 1,432 people, with a mean of 571 in 2007, between 34 and 3,333 people, with a mean of 986 in 2008, between 28 and 1,322 people, with a mean of 452 in 2009, and between 729 and 2,117 people, with a mean of 1,456 in 2010. As shown in Table 3, COPD incidence rate increases approximately three times from 2006 to 2010.

In Table 4 and 5, according to the results surveyed a total of 25 patients diagnosed with COPD are almost all men, the average age is 65 and mainly work in very risky occupations (steam earnings, weavers, etc.). Inpatients reside mostly in Konak and Karabağlar Districts and the average residence period varies between 10 – 55 years. The time since diagnosis of COPD ranges from 1 to 3 years. The average one person in each household was found to consume a daily average of 1.5 packs of cigarettes and inpatients have been active smokers approximately 39 years. Residents in the districts mainly prefer heating type of wood – coal and air conditioning and the average residence time is 38 years. While travelling patients mainly prefer public transport and they often live in an open environment of green areas, not industrial areas.

Table 4: The descriptive statistics of the questionnaire (*n*=25).

Variables	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Age	45	85	65.04	10.964
Sex	1	2	1.92	0.277
Residence Period (year)	3	85	37.96	25.538
Occupation Risk	1	2	1.32	0.476
Smoking Habit (package)	0	3	1.56	0.154
Smoking Person in Residence	0	10	1.28	2.151
Smoking Habit (year)	0	65	39.12	2.666
Heating System at house (Coal)	0	1	0.52	0.510
Heating System at house (Natural Gas)	0	1	0.08	0.277
Heating System at house (AC)	0	1	0.36	0.490
Heating System at environment (Coal)	0	1	0.52	0.510
Heating System at environment (Natural Gas)	0	1	0.12	0.332
Heating System at environment (AC)	0	1	0.28	0.458
Travelling Preferences	1	3	1.60	0.707
Recreation Area Existing	0	1	0.52	0.510
Industrial Area Existing	0	1	0.16	0.374

Table 5: The frequency distribution of the questionnaire.

Variables	**Value**	**Frequency**	**Percent (%)**
Residence (district)	Konak	7	28
	Karabağlar	7	28
	Other	1	4
Residence Period (year)	10 - 15	2	8
	20 - 25	2	8
	30 - 35	2	8
	50 - 55	2	8
	Other	1	4
Occupation Risk	More Risky	17	68
	Less Risky	8	32
Diagnosis (year)	1	10	40
	2	2	8
	3	3	12
	Other	1	4
Smoking Habit (year)	30	5	20
	40	4	16
	50	6	24
	Other	1	4
Travelling Preferences	Public Transport	13	52
	Private Car	8	32
	Other	3	12

The results of the survey show that there is a significant and positive relationship between the ages of inpatients diagnosed with COPD. Additionally, there is a significant relationship between the inpatients' age and their period of smoking. Also, there are significant relationships among the diagnosis, sex, job, risk factor, genetic predisposition, smoking habits, lived in environment and heating preferences (natural gas) ($p < 0.05$). On the other hand, no significant relationship was determined between the diagnosis of COPD and preferred coal home and environment, smoking period and residence period ($p > 0.05$).

5 RESULTS AND DISCUSSION

Multivariate linear regression analysis is performed in order to estimate the statistical relationship between the independent (explanatory) and the dependent variables.

The result of multivariate linear regression analysis is interpreted on the basis of years. The model summary, which is done by using the number of COPD cases and independent variables (PM, SO_2 and total population) is presented in Table 6a-6b. In Table 6a, the selected model explains about 63% of the proportion of the variability in the dependent variables in 2006 (R^2=0.632); about 88% in 2007 (R^2=0.882); about 67% in 2008 (R^2=0.670); about 85% in 2009 (R^2=0.850); and about 99% in 2010 (R^2=0.988). In Table 6b, the relationship between the dependent variable (the number of COPD cases) and the independent variables (PM, SO_2 and total population) is statistically significant at the 0.05 level ($p<0.05$). In other words, PM, SO_2 and total population are found to be significant at the 0.05 level for the number of COPD cases.

In Table 8, according to the models' parameter estimations, the increasing trend of the level of air quality (PM and SO_2) and total population between 2007 and 2010 caused also an increase trend for the number of COPD cases. On the other hand, in 2006, it is observed that there exists a decrease for the number of COPD cases. Similarly, the increasing trend of the level of air quality (PM and SO_2) and total population between 2006 and 2009 caused also an increase trend for COPD incidence rate.

Table 6a: Model summary I (2006 - 2010).

Year	R	R^2	Adjusted R Square	Std. Error of the Estimate
2006	0.795	0.632*	0.263	0.920132
2007	0.939	0.882*	0.765	0.549404
2008	0.818	0.670*	0.34	0.995425
2009	0.922	0.850*	0.699	0.757914
2010	0.994	0.988*	0.976	0.148554

* The R^2 coefficient of determination is a statistical measure of how well the regression line approximates the real data points.

However, in 2010, it is observed that there exists a decrease for COPD incidence rate.

Table 6b: Model summary II (2006 - 2010).

Year / Model		Sum of Squares	df	Mean Square	F	Sig.
2006	Regression	4.354	3	1.451	1.714	0.025
	Residual	2.540	3	0.847		
	Total	6.894	6			
2007	Regression	6.789	3	2.263	7.497	0.050
	Residual	0.906	3	0.302		
	Total	7.694	6			
2008	Regression	6.031	3	2.010	2.029	0.028
	Residual	2.973	3	0.991		
	Total	9.003	6			
2009	Regression	9.738	3	3.246	5.651	0.050
	Residual	1.723	3	0.574		
	Total	11.461	6			
2010	Regression	5.371	3	1.790	81.128	0.002
	Residual	0.066	3	0.022		
	Total	5.437	6			

Table 7a: Model summary I (2006 - 2010).

Year	R	R^2	Adjusted R Square	Std. Error of the Estimate
2006	0.914	0.836*	0.671	1.464.763
2007	0.966	0.934*	0.867	0.973653
2008	0.931	0.866*	0.732	1.411.254
2009	0.975	0.951*	0.902	0.778403
2010	0.932	0.868*	0.737	1.610.722

* The R^2 coefficient of determination is a statistical measure of how well the regression line approximates the real data points..

Table 7b: Model summary II (2006 - 2010).

Year / Model		Sum of Squares	df	Mean Square	F	Sig.
2006	Regression	32.737	3	10.912	5.086	0.025
	Residual	6.437	3	2.146		
	Total	39.174	6			
2007	Regression	39.937	3	13.312	14.043	0.029
	Residual	2.844	3	0.948		
	Total	42.781	6			
2008	Regression	38.672	3	12.891	6.472	0.008
	Residual	5.975	3	1.992		
	Total	44.647	6			
2009	Regression	35.350	3	11.783	19.447	0.018
	Residual	1.818	3	0.606		
	Total	37.168	6			
2010	Regression	51.370	3	17.123	6.600	0.008
	Residual	7.783	3	2.594		
	Total	59.153	6			

The estimated model suggests that an increase in the level of urban air pollution (PM and SO_2) and

Table 8: Parameter Estimations (2006 - 2010).

Variable	Estimated Unstandardized Coefficients	t	Sig.
2006t	-207.2126	-0.984	0.025
2007t	170.5796	1.457	0.05
2008t	192.1966	0.127	0.028
2009t	165.611	1.498	0.05
2010t	111.46	5.489	0.002
i2006	611.3466	1.872	0.025
i2007	506.5806	2.087	0.029
i2008	675.9446	0.03	0.008
i2009	161.8033	1.35	0.018
i2010	-933.411	-0.038	0.008

population causes a decrease in number of COPD cases and an increase in incidence in 2006. An additional 1% population and amount of pollutants will cause 2,072 less number of COPD cases and 6,113 people more incidences for 2006. The model suggests that an increase in the level of urban air pollution (PM and SO_2) and population causes in number of COPD cases and incidence in 2007. An additional 1% population and amount of pollutants will cause 1,706 more COPD cases and 5,066 more incidences for 2007. The model suggests that an increase in the level of urban air pollution (PM and SO_2) and population causes an increase in number of COPD cases and incidence in 2008. An additional 1% population and amount of pollutants will cause 1,922 more COPD cases and 6,759 more incidences for 2008. An increase in the level of urban air pollution (PM and SO_2) and population causes an increase in number of COPD cases and incidence in 2009. An additional 1% population and amount of pollutants will cause 1,656 people more COPD cases and 1,618 more incidence for 2009. An increase in the level of urban air pollution (PM and SO_2) and population causes an increase in number of COPD cases and a decrease in incidence in 2010. An additional 1% population and amount of pollutants will cause 1,115 more COPD cases and 9,334 less incidence for 2010.

According to the findings of the analysis, the increasing rate of total population and the decreasing rate of air quality in the study area cause an important increase for the number of COPD cases and COPD incidence rate. In Karsiyaka, Konak and Bornova Districts, the level of air pollution is lower than the other districts because of the density of population and motor vehicles in these districts, also having more urban study areas than other districts and the location of these districts according to the main transportation axes.

In metropolitan cities, it is vitally important to minimize the level of air pollutant in the atmosphere for improving quality of life. Recently, several precautions have been introduced for the improvement of urban air quality such as the dissemination of the usage of natural gas for domestic heating, the emission controls for the reduction of the level of air pollutants because of dense motor vehicle in traffic and monitoring of coal sales. Despite these precautions, the level of air pollutants is still above the acceptable level especially during the winter months.

There will be important steps in order to solve air pollution problem especially in urban settlement areas, such as the dissemination of renewable and clean energy resources (natural gas, thermal energy, etc.) in domestic heating and industrial processes, more frequent controls for the measurements for air quality in terms of spatial and time tables, improving the control strategies, developing plan decisions in consideration of air corridors, the dissemination of open and green areas, encouragement of public transportation and railway transportation type by local governments and realizing studies to minimize carbon emissions and to improve the air quality and controlling over facilities of industrial areas.

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