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Effect of Particulate Matter and Nitrogen Dioxide Levels on Chronic Bronchitis Incidence and Mortality in Marmara Region: Retrospective Cohort Study

Marmara Bölgesi'nde Parçacık Madde ve Azot Dioksit Değerlerinin Kronik Bronşit İnsidansı ve Mortalite Üzerine Etkisi: Geriye Dönük Kohort Çalışması

Seher PALANBEK YAVAŞ[a], Ayşe Emel ÖNAL[a], Selvinur PACCİ[b], Çiğdem ÇAĞLAYAN[c]

[a]Department of Public Health and Environmental Health, İstanbul University İstanbul Faculty of Medicine, İstanbul, TURKEY
[b]Department of Public Health, İstanbul University İstanbul Faculty of Medicine, İstanbul, TURKEY
[c]Department of Public Health, Kocaeli University Faculty of Medicine, Kocaeli, TURKEY

ABSTRACT Objective: The harmful effects of air pollution on human health have been proven by epidemiological studies. The aim of this study was to investigate the effect of two parameters that are determinants of air quality: particulate matter (PM_{10}) and nitrogen dioxide (NO_2) pollution levels on the incidence of chronic bronchitis and deaths due to air pollution. **Material and Methods:** We made the calculations by entering the 2018 population, mortality and PM_{10} and NO_2 values of 11 provinces in the Marmara Region (İstanbul, Kocaeli, Edirne, Tekirdağ, Kırklareli, Sakarya, Bilecik, Bursa, Balıkesir, Çanakkale and Yalova) into the AirQ+ program [World Health Organization (WHO)]. All calculations made by AirQ+ are based on methodologies and dose-response functions established by epidemiological studies. In the calculations, the PM_{10} and NO_2 limit value has been accepted as 20 μg/m^3. **Results:** It has been determined that the annual average PM_{10} level of all provinces in our study and the annual average NO_2 level of eight provinces did not comply with the limit values recommended by WHO. Consistent with the particulate matter values, the highest incidence of chronic bronchitis among provinces are 43.71% [confidence interval (CI) 95%, relative risk (RR): 18.43-59.31] in Bursa and Sakarya 38.5% (CI 95%, RR: 15.71-52.96); the highest number of people with chronic bronchitis attributed to air pollution has been found to be 2,349 (minimum 912-maximum 3,404) in İstanbul. **Conclusion:** Findings indicate the incidence of chronic bronchitis attributed to air pollution and the share of air pollution in deaths. Studies in different cities may contribute to the literature.

Keywords: PM_{10}; NO_2; air pollution; chronic bronchitis; mortality

ÖZET Amaç: Hava kirliliğinin insan sağlığı üzerindeki zararlı etkileri epidemiyolojik çalışmalarla kanıtlanmıştır. Bu çalışmada, hava kalitesinin belirleyicisi olan 2 parametrenin; parçacık madde (PM_{10}) ve azot dioksit (NO_2) kirlilik düzeylerinin kronik bronşit insidansına ve hava kirliliğine bağlı ölümler üzerine etkisinin araştırılması amaçlandı. **Gereç ve Yöntemler:** Marmara Bölgesi'ndeki 11 ilin (İstanbul, Kocaeli, Edirne, Tekirdağ, Kırklareli, Sakarya, Bilecik, Bursa, Balıkesir, Çanakkale ve Yalova) 2018 nüfus, ölüm ve PM_{10} ve NO_2 değerlerini AirQ+ programına [Dünya Sağlık Örgütü (DSÖ)] girerek hesaplamaları yaptık. AirQ+ tarafından yapılan tüm hesaplamalar epidemiyolojik çalışmalar tarafından oluşturulan metodolojilere ve doz-yanıt fonksiyonlarına dayanmaktadır. Hesaplamalarda, PM_{10} ve NO_2 sınır değeri 20 μg/m^3 olarak alınmıştır. **Bulgular:** Çalışmamızda, tüm illerin yıllık ortalama PM_{10} düzeyinin ve 8 ilin yıllık ortalama NO_2 düzeyinin DSÖ tarafından önerilen sınır değerlere uymadığı tespit edilmiştir. Partikül madde değerleri ile uyumlu olarak, iller arasında en yüksek kronik bronşit insidansı Bursa'da %43,71 [güven aralığı (GA) %95, rölatif risk (RR): 18,43-59,31] ve Sakarya'da %38,5 (GA %95, RR: 15,71-52,96); hava kirliliğine atfedilen en yüksek kronik bronşitli kişi sayısı 2.349 (minimum 912-maksimum 3.404) olarak İstanbul'da bulundu. **Sonuç:** Bulgularımız, hava kirliliğine atfedilen kronik bronşit insidansı ve ölümlerde hava kirliliğinin payını göstermektedir. Farklı şehirlerde yapılacak çalışmalar, literatüre katkıda bulunabilir.

Anahtar Kelimeler: PM_{10}; NO_2; hava kirliliği; kronik bronşit; mortalite

Air, which is the main source of life, is indispensable for humans and living creatures. Air pollution is harmful to human health and ecosystems. Due to the air pollution experienced in the past, thousands of people have lost their lives, diseases have increased in a way that continues today and living standards have declined.[1] According to the World Health Organization (WHO), air pollution constitutes the

Correspondence: Seher PALANBEK YAVAŞ
Department of Public Health and Environmental Health, İstanbul University İstanbul Faculty of Medicine, İstanbul, TURKEY/TÜRKİYE
E-mail: eher.palanbekyavas@istanbul.edu.tr

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biggest environmental health risks and, along with climate change, is among the top 10 threats in terms of health for 2019. According to WHO data, a total of 8 million people in the world die prematurely every year due to diseases caused by indoor and outdoor air pollution. 4.2 million of these deaths are mainly due to outdoor air pollution caused by industry, traffic, and warming. It has also been stated that for children under 5 years old, one in 10 deaths is caused by air pollution. For Turkey, the number of deaths due to air pollution is estimated to be about 30 thousand per year by the Organisation for Economic Co-operation and Development.[2,3]

Atmospheric aerosols play an important role in the chemical structure of climate and atmosphere. Aerosols that are suspended in solid or liquid form in the atmosphere are called "particulate matter (PM)". PM can have aerodynamic diameters between 0.1 µm and 10 µm; while most of the coarse particles are retained in the nose and nasopharynx, fine particles diffuse from the alveoli to the intracapillary space, which directly causes health hazards.[4] It has been assessed that PM concentrations are found to be high in developing countries due to industrial activities and the ongoing construction sector.[5] The effect of the PM on the respiratory system in short-term exposure can be enumerated as respiratory tract irritation, cough, shortness of breath, feeling tightness in the chest, asthma, and bronchitis attacks, as well as increased sensitivity to respiratory tract infections. Long-term exposure to PM, on the other hand, can lead to decreased lung function, worsening of existing respiratory system disorders, development of chronic bronchitis, and premature death.[6-9] Another important air pollutant responsible for air quality is nitrogen dioxide (NO_2). While NO_2, which is formed as a result of the combustion of nitrogen and oxygen at high temperatures, causes respiratory irritation in acute exposure, disturbance in smell, and irritation in eyes, similar to PM; in chronic exposure, it causes chronic bronchitis and asthma.[10] In addition, it has been proven by epidemiological studies that there is a strong relationship between NO_2 and mortality.[11-13] In large cities where people live heavily, the source of outdoor nitrogen oxides is primarily motor vehicles, followed by fossil fuel-using industrial facilities and power plants such as thermal power plants.[10]

Marmara Region is a region where population and industry are concentrated. Besides, İstanbul, the most populous province of Turkey, is within the boundaries of this region. Exposure of air pollutants may vary depending on the industrial activities (construction, mining, iron-steel, automotive, etc.), geographical conditions of the region and human activities (agricultural combustion, domestic combustion, transportation, etc.). For these reasons, we aimed to determine the effect of PM_{10} levels measured in provinces located in the Marmara Region on the incidence of chronic bronchitis and NO_2 levels on mortality.

MATERIAL AND METHODS

LOCATION AND TIME

Our study has been conducted in the Marmara Region which is one of Turkey's 7 regions. All 11 provinces in the Marmara Region (İstanbul, Kocaeli, Edirne, Tekirdağ, Kırklareli, Sakarya, Bilecik, Bursa, Balıkesir, Çanakkale and Yalova) have been included in the study (Figure 1). The working period is determined as throughout 2018.[14]

AirQ+ SOFTWARE

AirQ + is a software tool developed by the WHO Regional Office for Europe 1 that measures health burden and the impact of air pollution. AirQ + calculates various health outcomes related to morbidity and mortality to assess the effects of long-term (and short-term exposure) ambient air pollution. Calculations made by AirQ+ are based on methodologies and

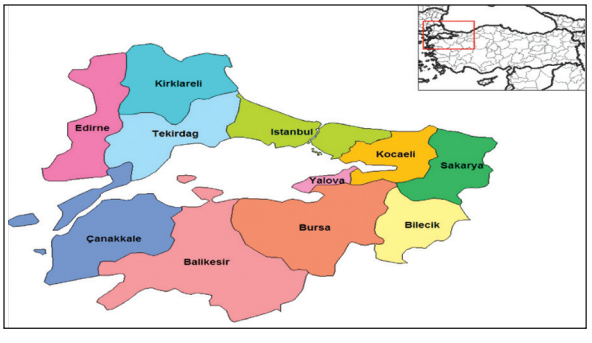

FIGURE 1: Marmara Region and provinces.[14]

dose-response functions established by epidemiological studies. Calculations can be made using $PM_{2.5}$, PM_{10}, NO_2, O_3 and black carbon.[15]

AIR QUALITY DATA

The average annual PM_{10} and NO_2 levels for 2018 in the provinces of the study have been calculated by collecting those levels on the basis of stations from the Air Quality Watch website of the Ministry of the Environment and Urbanization, summing up the annual averages of all stations with sufficient data available in the province and dividing by the number of stations.[16] The names of the stations from which the data were collected are shown in the table, some cities also have stations with the same name (Table 1). In our country, not all of the air pollutant parameters are measured in every station, so while PM_{10} and NO_2 are measured together in some stations, this could not be achieved in some stations. The PM_{10} limit value (WHO PM limit value recommendation) and the NO_2 limit value (recommended by the WHO Regional Office for Europe) were accepted as 20 $\mu g/m^3$.[3,15]

DEMOGRAPHIC DATA

The population and mortality data of each of the city has been collected from the Turkish Statistical Institute (TURKSTAT) (Address-based Population Registration System).[17,18] In order to calculate chronic bronchitis incidence with PM_{10} level in the program, population data of 15 years and over were used considering the age of onset of chronic bronchitis. Similarly, in order to calculate the number of deaths resulting from the NO_2 level calculated by the program (as suggested by the program), extrinsic injury and poisoning death numbers were excluded from each of the death data of cities. With dynamic query from TURKSTAT Death Statistics database the total number of deaths was obtained by provinces and age groups. "External causes of injury and deaths under the heading "poisonings" were removed (Depending on the AirQ+ program). The number of measurements obtained was entered into the program. Then the number of deaths found has been divided by the population of each city, the general death rate (per hundred thousand) of each city was calculated. Considering 95% confidence interval (CI) of the relative risk (RR) coefficient lowest and lowest deaths attributed to air pollution. the highest estimates were achieved. The demographic data used in the calculations are presented in Table 2.

OTHER DATA

In the option of calculating chronic bronchitis using the PM_{10} level in the environment included in the AirQ+ program, the incidence of chronic bronchitis in that society should be entered into the program as well as the demographic data of the country. Since there is no incidence of chronic bronchitis providing community representation in our country, we utilized chronic obstructive pulmonary disease (COPD) inci-

TABLE 1: Cities and stations, 2018.

City	Station
İstanbul	Aksaray, Alibeyköy, Başakşehir, Beşiktaş, Esenler, Esenyurt, Kadıköy, Kağıthane*, Kağıthane MTHM*, Kandilli, Kartal⁺, Mecidiyeköy, Sarıyer⁺, Şile, Silivri, Şirinevler, Sultanbeyli, Sultangazi, Ümraniye, Ümraniye MCAC, Üsküdar⁺, Üsküdar MCAC, Yenibosna⁺
Kocaeli	Kocaeli, Alikahya, Dilovası, Dilovası OIZ, Gölcük, İzmit, Kandıra, Körfez, Yeniköy
Edirne	Edirne, Karaağaç*, Keşan
Tekirdağ	Tekirdağ, Merkez, Çerkezköy
Kırklareli	Kırklareli, Limanköy, Lüleburgaz
Sakarya	Merkez, Ozanlar, Sakarya
Bilecik	Bilecik, Bozüyük
Bursa	Bursa*, Beyazıt Street., İnegöl, Kestel, Kültürpark⁺, Uludağ University⁺
Balıkesir	Balıkesir, Bandırma, Erdek
Çanakkale	Çanakkale, Çan, Lapseki*
Yalova	Yalova, Altınova*, Armutlu

*PM_{10} data not available; ⁺NO_2 data not available; MCAC: Marmara Clean Air Center; OIZ: Organized industrial zone.

TABLE 2: Population and mortality data, 2018.

City	Total population	Population above 15 years old	Number of deaths	Number of deaths excluding external causes	Mortality rate of cities (100,000)
İstanbul	15,067,724	12,837,098	59,921	58,275	386.75
Kocaeli	1,906,391	1,605,463	8,279	7,996	419.43
Edirne	411,528	370,010	3,420	3,307	803.59
Tekirdağ	1,029,927	881,148	5,499	5,279	512.56
Kırklareli	360,860	323,308	2,786	2,716	752.64
Sakarya	1,010,700	862,598	5,669	5,548	548.92
Bilecik	223,448	195,617	1,553	1,489	666.37
Bursa	2,994,521	2,557,926	16,309	15,595	520.78
Balıkesir	1,226,575	1,088,101	10,484	10,067	820.74
Çanakkale	540,662	483,555	4,420	4,252	786.44
Yalova	262,234	2,273,61	1,653	1,599	609.76

dence obtained from the study of National Burden of Disease of Turkey (72.7 per hundred thousand) in the study.[19] The Turkish Thoracic Society has already announced that for the last 25 years, chronic bronchitis and emphysema disease have been combined and called COPD.[20] In the AirQ+ program, the RR coefficient was determined as 1.117 (95% CI: 1.040-1.189) to calculate the incidence of chronic bronchitis due to the PM_{10} level and 1.041 (95% CI: 1.040-1.189) for all deaths from the NO_2 level.[15] Finally, the city area measurements that need to be used in the program have been collected from the web page of the General Directorate of Mapping of Turkey.[21]

This study was conducted in accordance with the Declaration of Helsinki Principles.

RESULTS

The criteria taken as the basis for air pollution assessment are the limit values determined by WHO. The AirQ+ program also takes into account WHO limits while performing the calculations. With this program, we tried to find the answer to the question "If we could reduce the air pollution values (for PM_{10} and NO_2) to the WHO limit value in the Marmara Region, how many people could we avoid dying and developing chronic bronchitis?".

The average (±standard deviation) of PM_{10} concentrations of cities in the Marmara Region is shown in Figure 2.

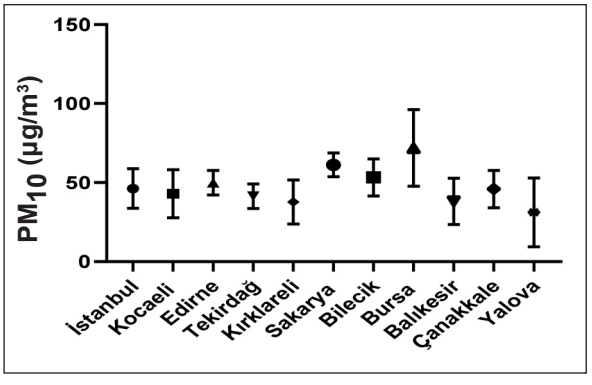

FIGURE 2: Average (±standard deviation) of PM_{10} concentrations of cities.

PM values of cities in the Marmara Region, the incidence of chronic bronchitis attributed to air pollution, the number of people with chronic bronchitis attributed to air pollution and the risk values attributed to the community are given in Table 3.

It has been established that the annual average PM level of cities varies between 31.16-71.94 µg/m^3. The three provinces with the highest annual PM_{10} levels were calculated as Bursa 71.94 µg/m^3, Sakarya 63.57 µg/m^3, Bilecik 53.25 µg/m^3, respectively. The lowest PM_{10} value was established as 31.16 µg/m^3 in Yalova. Consistent with the PM values, the highest incidence of chronic bronchitis among provinces is 43.71% (CI 95%, RR: 18.43-59.31) in Bursa and the lowest chronic bronchitis incidence is 11.62% in Yalova, (CI 95%, RR: 4.28-17.57). The number of people with chronic bronchitis attributed to air pol-

TABLE 3: Incidence of chronic bronchitis attributed to long-term exposure to PM_{10}, risk attributed to community, number of people with chronic bronchitis.

City	PM_{10} (mean)	Incidence of chronic bronchitis (mean; minimum-maximum)	Risk attributed to community (100,000) (mean; minimum-maximum)	Number of people with chronic bronchitis (mean; minimum-maximum)
İstanbul	46.21	25.17 (9.77-36.47)	18.30 (7.10-26.52)	2,349 (912-3,404)
Kocaeli	42.94	22.42 (8.6-32.77)	16.30 (6.26-23.83)	262 (100-383)
Edirne	49.92	28.18 (11.07-40.43)	20.49 (8.08-29.39)	76 (30-109)
Tekirdağ	41.30	21.0 (8.01-30.84)	15.26 (5.83-22.42)	135 (51-198)
Kırklareli	37.71	17.8 (6.71-26.4)	12.94 (4.88-19.20)	42 (16-62)
Sakarya	63.57	38.25 (15.71-52.96)	27.81 (11.42-38.50)	240 (99-332)
Bilecik	53.25	30.78 (12.23-43.76)	22.38 (8.99-31.82)	44 (17-62)
Bursa	71.94	43.71 (18.43-59.31)	31.78 (13.40-43.12)	813 (343-1,103)
Balıkesir	38.05	18.1 (6.83-26.84)	13.16 (4.97-19.51)	143 (54-212)
Çanakkale	45.87	24.89 (9.65-36.1)	18.10 (7.01-26.24)	88 (34-127)
Yalova	31.16	11.62 (4.28-17.57)	8.44 (3.11-12.77)	19 (7-29)

PM: Particulate matter.

lution was calculated as 2,349 in İstanbul (the lowest number of people was 912-the highest number of people was 3,404), 813 in Bursa (343-1,103), and 329 (129-472) in Kocaeli. At the same time, these provinces are the densest provinces of Turkey in terms of industry and population. When we look at the risk rates attributed to the community, it has been determined that the highest rate is 31.78 per hundred thousand in Bursa and 27.81 per hundred thousand in Sakarya.

The average NO_2 concentrations (±standard deviation) of the cities in the Marmara Region is shown in Figure 3.

Besides, the annual NO_2 average of the cities, the number of deaths attributed to air pollution, death rate and mortality rate (per hundred thousand) are shown in Table 4.

The annual average highest NO_2 levels of the cities were calculated as 43.30 μg/m^3 in İstanbul, 34.52 μg/m^3 in Kocaeli and 30.12 μg/m^3 in Sakarya. The lowest NO_2 levels were determined as 11.10 μg/m^3 for Kırklareli, 15.49 μg/m^3 for Edirne and 15.71 μg/m^3 for Çanakkale. In all provinces except Edirne, Kırklareli and Çanakkale, NO_2 values are above 20 μg/m^3, which is the limit value determined by the WHO European Environment Agency. When the effect of NO_2 pollution on mortality is examined, the percentage of death attributed to air pollution from NO_2 is 8.94% in İstanbul (CI 95%, RR: 4.29-13.46), and 5.59 in Bursa (CI 95%, RR: 2.66-8.50), and 5.57% (CI 95%, RR: 5.57-8.47) in Kocaeli.

Although the number of deaths attributed to air pollution caused by NO_2 in İstanbul is higher than in other cities, it was calculated as 5,851 people (the lowest number of people is 2,500-the highest number of people is 7,843). Mortality rate attributed to air pollution was found to be 34.57 per hundred thousand in İstanbul, 29.12 per hundred thousand in Bursa, 23.36 per hundred thousand in Kocaeli, 21.87 per hundred thousand in Sakarya, and higher in accordance with the level of NO_2 pollution, and it has been determined that they are higher than other cities.

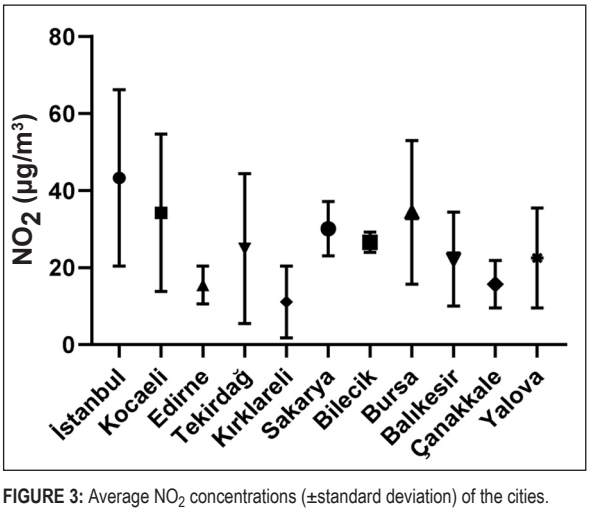

FIGURE 3: Average NO_2 concentrations (±standard deviation) of the cities.

TABLE 4: Percentage of deaths, number of deaths and mortality rates per 100,000 inhabitants attributed to long term NO_2 exposure.

Cities	NO_2 value (mean)	Deaths attributed to air pollution (mean; minimum-maximum)	Death attributed to air pollution % Average (mean; minimum-maximum)	Mortality rate attributed to air pollution (per 100,000) (mean; minimum-maximum)
İstanbul	43.30	5,208 (2,500-7,843)	8.94 (4.29-13.46)	34.57 (16.59-52.05)
Kocaeli	34.26	445 (212-677)	5.57 (2.65-8.47)	23.36 (11.11-35.51)
Edirne*	15.49	72 (34-111)	2.18 (1.03-3.35)	17.53 (8.26-26.91)
Tekirdağ	24.93	104 (49-159)	1.96 (0.92-3.01)	10.05 (4.73-15.44)
Kırklareli*	11.11	12 (6-19)	0.45 (0.21-0.69)	3.35 (1.57-5.16)
Sakarya	30.12	221 (105-338)	3.98 (1.89-6.08)	21.87 (10.36-33.40)
Bilecik	26.57	39 (18-59)	2.61 (1.23-3.99)	17.36 (8.19-26.61)
Bursa	34.32	872 (415-1,326)	5.59 (2.66-8.50)	29.12 (13.85-44.27)
Balıkesir	22.22	89 (42-138)	0.89 (0.42-1.37)	7.29 (3.42-11.23)
Çanakkale*	15.71	96 (45-148)	2.27 (1.07-3.48)	7.84 (8.41-27.37)
Yalova	22.49	16 (7-25)	1.0 (0.47-1.539)	6.07 (2.85-9.35)

*Cut-off value for NO_2 is accepted as 10 μg/m^3.

DISCUSSION

Due to the rapid urbanization of the world population, industrialization and transportation, the harmful effects of long-term exposure of people to air pollutants should be better understood and known by the community. Epidemiological studies show that PM contamination causes the development of COPD and exacerbation of existing lung diseases.[22-24]

AirQ+ program, in case the NO_2 values in the outdoor air exceed 20 μg/m^3, among all the measurements associated with long-term air pollution; it accepts non-external causes (RR coefficient) as 1.041 (95% CI: 1.040-1.189).[15]

The number of deaths estimated with the program in question estimates the expected number of deaths when the NO_2 level exceeds 20 μg/m^3, in other words, the number of deaths that can be prevented by eliminating NO_2-sourced air pollution.

WHO has published the annual average PM_{10} limit value as 20 μg/m^3.[3] It has been determined as 40 μg/m^3 in the Air Quality Assessment and Management Regulation of our country (Resmî Gazete: 06.06.2008-26898).[25] When evaluated according to the WHO limit level, we can say that all provinces in the Marmara Region have exceeded the limit values and have air pollution. When the provinces are examined according to the PM_{10} limit values of our country, more than half of the provinces have PM_{10} levels higher than the determined values. In accordance with our study, in the Air Pollution Report published by the The Union of Chambers of Turkish Engineers and Architects Chamber of Environmental Engineers in 2018, it was stated that according to the annual average data of PM_{10}, the annual average limit value was exceeded in 45 of 81 provinces and approximately 60 million people had to live in places where the PM_{10} annual average limit has been exceeded (where there is air pollution).[1]

In our study, the incidence of chronic bronchitis in Bursa and Sakarya, 2 provinces where PM_{10} values were calculated as the highest, was also calculated higher than other provinces (43.71%; 38.25%, respectively). In other words, as the PM_{10} pollution level of the provinces included in our study has increased, the possibility of people suffering from chronic bronchitis has increased. Similarly, in a cross-sectional study conducted in the Rhine-Ruhr Basin in Germany (4,757 women participants), 7 μg/m^3 increase of PM_{10} decreased lung capacity by 5.1% (95% CI: 2.5-7.7) and increased the risk of developing COPD odds ratio of 1.33 (95% CI: 1.03-1.72) 1.33 times.[26] In another study conducted in the south-

ern region of China where air pollution is high, it was found that PM_{10} values between 50-150 μg/m^3 are more harmful to the respiratory system (odds ratio 2.442) compared to PM_{10} values of 50 μg/m^3 (95% CI: 1.449 to 4.117).[22] The number of people with chronic bronchitis attributed to the air pollution we calculated in our study is affected by the value of the population living in the province together with the pollution level. Accordingly, the number of people with chronic bronchitis attributed to air pollution was found to be 2,349 (minimum 912-maximum 3,404) in İstanbul, where the population density is high. Similarly, in the study conducted in Ahvaz, Iran using the AirQ+ program, PM pollution levels had been determined for four years (2009-2013) and the number of people with COPD attributed to PM pollution was found to be 121, 111, 94, 102 and 98, respectively.[23] In another study, the annual mean PM_{10} concentration was measured 97 μg/m^3 (maximum 731 μg/m^3) and it was found that 10.21% (95% CI: 4.19-14.89) of respiratory mortality were associated with PM_{10}.[27] In a study conducted in 2018 found that among respiratory deaths, the rate attributed to PM_{10} air pollution was 7.02% (2.82-10.41) [attributable proportion (AP)] and the estimated number of excess case was 18.8 (17.6-27.8).[28]

In recent years, cohort studies and meta-analyzes have shown that long-term exposure to NO_2 has an effect on mortality.[29,30] In a case-crossover study conducted in Spain, it was determined that there was a relationship between the mortality of patients suffering from asthma exacerbation and the NO_2 level (22.9 μg/m^3 increase).[31] In a study conducted in Iran (Tehran), 3.4% of deaths originating from cardiovascular and respiratory systems were attributed to NO_2 level above 60 μg/m^3 *(Goudarzi G, Nadafi K, Mesdaghiniya A. Quantification of health effects of air pollution in Tehran and determining the impact of a comprehensive program to reduce air pollution in Tehran on the third axis [PhD Dissertation]. Tehran, Iran: Tehran University; 2007)*. In our study, in all cities except Edirne, Kırklareli and Çanakkale, NO_2 values are above 20 μg/m^3 determined by WHO, which is determined as the limit value in the AirQ+ program. In Turkey, it is noteworthy that the determined limit value is twice (40 μg/m^3) the limit value determined by WHO.[25] When the effect of NO_2 pollution on mortality in cities is examined, the percentage of death attributed to air pollution caused by NO_2 was determined to be higher in İstanbul and Kocaeli, where the pollution is highest (8.94%; 5.57%, respectively). Similarly, mortality rates attributed to air pollution are higher in these provinces compared to other provinces (34.57 per hundred thousand, 23.36 per hundred thousand, respectively). In the study conducted in 2016, every 10 μg/m^3 increase in NO_2 level increased the RR ratio for total deaths by 0.4% and, the AP of total mortality attributed to this pollutant was 2.21% (CI 95%) of the total mortality (correct for the non-accident) occurred in the year of study.[32] In another study, the rate attributed to NO_2 pollution among all deaths was determined as 1.74% (1.17-2.31) (AP) and the estimated number of excess case was 51.9 (34.8-68.7).[28]

It is known that NO_2 pollution has increased due to the increase in the number of vehicles and industries in developing countries. In İstanbul and Kocaeli, where population density is higher than in other cities, the number of vehicles and factories are also high, NO_2 pollution may be related to this. Besides, the number of deaths attributed to NO_2 pollution, which is also affected by population density, is higher in these two provinces (5,851 people; 445 people, respectively).

LIMITATIONS

Since we have not found the incidence of chronic bronchitis, which is in the calculation parameters of our study, in another national study, we used the COPD incidence data of 2004. For this reason, the estimated values we obtained in the calculations may actually be less than the real situation and can be considered as a limitation of this study.

CONCLUSION

Despite studies on air quality, air pollution continues to pose a threat to human health in many countries of the world. In this study, only the annual average NO_2 values in three provinces comply with the WHO limit value. The annual average PM_{10} value of all provinces is higher than the WHO recommended value. Accordingly, the mortality rate attributed to air

pollution and the incidence of chronic bronchitis were determined. To prevent the health impacts of air pollution on air quality limit values in Turkey should be redefined taking into consideration the WHO limit. Epidemiological studies are valuable in showing the health impact of air pollution. It is important to do research with other regions of the country and different pollutants in other studies.

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Conflict of Interest

No conflicts of interest between the authors and /or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Çiğdem Çağlayan, Seher Palanbek Yavaş;* ***Design:*** *Seher Palanbek Yavaş, Ayşe Emel Önal;* ***Control/Supervision:*** *Çiğdem Çağlayan, Ayşe Emel Önal;* ***Data Collection and/or Processing:*** *Seher Palanbek Yavaş;* ***Analysis and/or Interpretation:*** *Seher Palanbek Yavaş;* ***Literature Review:*** *Seher Palanbek Yavaş;* ***Writing the Article:*** *Seher Palanbek Yavaş, Selvinur Pacci;* ***Critical Review:*** *Ayşe Emel Önal, Çiğdem Çağlayan.*

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