DOI: 10.4274/jbuch.galenos.2023.25582
J Behcet Uz Child Hosp 2023;13(3):151-159

Original Article

The Relationship Between Air Pollution and Suicide Attempts in Children

Çocuklarda Hava Kirliliği ve İntihar Girişimleri Arasındaki İlişki

Gülşen Yalçın[1], İzzettin Toktaş[2], Aylin Gürbay[3], Murat Anıl[4]

[1]İzmir Democracy University, Buca Seyfi Demirsoy Training and Research Hospital, Department of Pediatrics, Division of Pediatric Emergency Medicine, İzmir, Turkey
[2]Diyarbakır Provincial Health Directorate, Diyarbakır, Turkey
[3]Hacettepe University Faculty of Pharmacy, Department of Pharmaceutical Toxicology, Ankara, Turkey
[4]İzmir Democracy University Faculty of Medicine, Department of Pediatrics, Division of Pediatric Emergency Medicine, İzmir, Turkey

ABSTRACT

Objective: In this study we aimed to investigate the relationship between acute exposure to air pollution and suicide attempts in children.

Method: In this study, we retrospectively investigated over a 10-year period the likely relationship between suicide attempts in children, two air pollutants (PM_{10} and SO_2), and meteorological factors affecting their life-endangering behavior.

Results: We have determined that every one-unit increase in air pollution level of PM_{10} increased the risk of suicide attemps 1,002 times in all cases (p=0.016). One unit increase in air pressure, relative humidity, and wind speed increased the risk of suicide attemps in all cases 1,064 (p=0.014), 1,012 (p=0.045), 1,400 (p<0.0001) times, respectively. No statistical significance was found wih respect to air pollution level of SO_2.

Conclusion: This study revealed that even small increases in ambient air pollutant levels increased hospital admissions due to suicide attemps, and that meteorological conditions aggravating air pollution also act as predisposing factors.

Keywords: Air pollution, meteorological factors, suicide attempts

ÖZ

Amaç: Bu çalışmanın amacı, çocuklarda akut hava kirliliği maruziyeti ile intihar girişimleri arasındaki ilişkiyi incelemektir.

Yöntem: Bu çalışmada retrospektif olarak, 10 yıllık bir süre içinde çocuklarda görülen intihar girişimleri ile iki hava kirletici faktör (PM_{10} ve SO_2) ve bunları etkileyen meteorolojik faktörler arasındaki olası ilişki araştırıldı.

Bulgular: PM_{10} hava kirleticisi düzeyinde bir birimlik artışın tüm olgularda intihar girişim riskini 1.002 kat artırdığı saptanmıştır (p=0,016). Hava basıncı, nispi nem ve rüzgar hızında bir birimlik artış, tüm olgularda intihar girişim riskini sırasıyla, 1.064 (p=0,014), 1.012 (p=0,045), 1.400 (p<0,0001), kat artırmıştır. SO_2 hava kirleticisi düzeyinde ise istatistiksel bir anlam saptanmadı.

Sonuç: Bu çalışma, ortamdaki hava kirletici düzeyindeki düşük seviyelerde bile artışların, intihar girişimi nedeniyle artan hastane başvurularıyla ilişkili olduğunu ve hava kirliliğini etkileyen meteorolojik faktörlerin bu sonucu etkilediğini ortaya koymuştur.

Anahtar kelimeler: Hava kirliliği, meteorolojik faktörler, intihar girişimleri

Received: 03.01.2023
Accepted: 07.04.2023

Corresponding Author
Gülşen Yalçın,
İzmir Democracy University, Buca Seyfi Demirsoy Training and Research Hospital, Department of Pediatrics, Division of Pediatric Emergency Medicine, İzmir, Turkey
drgyalcin@gmail.com
ORCID: 0000-0002-5938-2619

Cite as: Yalçın G, Toktaş İ, Gürbay A, Anıl M. The Relationship Between Air Pollution and Suicide Attempts in Children. J Behcet Uz Child Hosp 2023;13(3):151-159

INTRODUCTION

Suicide (intentional self-harm) is an important global public health problem affecting also both children and adolescents. In the United States, it reportedly continues to be the third leading cause of death among children and adolescents[1]. Most adolescents have suicidal thoughts[2]. Eaton et al.[3] performed a nation wide survey in the USA in 2011, and reported that 12.8% of adolescent students stated that they had seriously considered attempting suicide in the previous 12 months, and 7.8% of them indicated that they had attempted suicide one or more times. According to the Turkish Statistical Institute, suicide attempts were reported at a rate of 1.8% under the age of 15 and at a rate of 9.3% between the ages of 15-19[4]. In the Diyarbakır Province located in the Southeastern Anatolia Region of Turkey with a population of 1,783 million, the total suicide rate between 2006 and 2015 was reported as 4.52 per 100,000 population[5].

Self-harm and suicide have different etiologies including biological psychological, social and cultural factors and genetic predisposition[6]. In recent years; studies have been conducted on the relationship between air pollution, which is an important environmental problem all over the world and suicidal attempts[7]. It is known that polluted air increases morbidity and mortality in cardiovascular and respiratory system diseases[7]. Particulate matter (e.g. $PM_{2.5}$, PM_{10}), gases [e.g. carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2)], organic compounds [e.g. polycyclic aromatic hydrocarbon (PAH)] and excessive concentrations of metals (e.g.: lead) in the air are among the causes of air pollution[7]. Air pollution can affect the central nervous system through deleterious effects of neuropathic inflammation, oxidative stress, or damage to blood vessels[7]. Among their other harmful effects, air pollutants pass throughthe blood-brain barrier, and affect the brain[8]. It has been reported that air pollution mainly induces cell cycle arrest and apoptosis in neurons, and degenerative destruction in the brain through oxidative stress and genetic damage[9,10]. Possible impact of air pollution on emotional disorders in children should be also emphaized. Experimental studies have shown that ultrafine particulate matter has a harmful effect on the prenatal development of the central nervous system, resulting in an increased risk of depression[11]. In addition, other deleterious compounds such as PAHs cause anxiety and depression in children[12]. Besides,exposure to air pollution may impair brain development and lead to cognitive disorders in late childhood[13]. To our knowledge, there are few studies in the literature on short-term exposure to air pollution and acute psychiatric outcomes in children and adolescents[14].

The aim of this study is to investigate the relationship between exposure to air pollution and relevant meteorological factors inpediatric patients brought to the pediatric emergency department of a hospital in Diyarbakır Province for suicidal attempts.

MATERIALS and METHODS

Data Collection

The archive data recorded between January 1, 2009 and April 30, 2019 by Diyarbakır Children's Diseases Hospital Data Processing Centerwere used. According to the International Classification of Diseases (ICD-10), suicide cases were determined based on the ICD codes of X60-X69. Since trauma patients were not taken into consideration, cases withassigned ICD codes of X71-X84 were excluded from the study and 1,132 patients were included in the study.

Patients

Patients under the age of 18 who attempted suicide by any method and applied to the emergency department of our hospital were evaluated by psychiatry consultation, and included in the study. All patients were evaluated in consultation with a child psychiatrist.

Patients with a psychiatric disorder (psychotic depression, alcohol/substance abuse, obsessive-compulsive disorder, generalized anxiety disorder, panic disorder, etc.), acute/chronic physical illness, malignancy, acute infection, chronic inflammatory diseases, hematopoietic disease, mental retardation, those receiving anti-inflammatory, immunosuppressive, immunomodulatory drugs, chemotherapy, and steroids, etc., and pregnants were excluded from the study.

Air Pollution and Meteorological Data

In Diyarbakir Province, only air pollutants of PM_{10} (μg/m³) and SO_2 (μg/m³) can be measured. Therefore, the relevant data involving the period between January 1, 2009 and April 30, 2019 have been retrieved from the official website (https://sim.csb.gov.tr) of T.R. Air Quality Monitoring Stations of the Ministry of Environment and Urbanization. The nationwide average limit values stipulated by the Ministry are 50 μg/m³/24 hr for PM_{10}, and 350 μg/m³/24 hr for SO_2. Meteorological data concerning daily average relative humidity (%), wind speed (m/s), temperature (°C), total precipitation (mm), actual air pressure (hPa) were obtained from the

Ministry of Agriculture and Forestry General Directorate of Meteorology of Diyarbakır Region.

For this study, ethics committee approval was obtained from the Ethics Committee of University of Health Sciences Turkey, Diyarbakır Gazi Yaşargil Training and Research Hospital (approval number: 340, date: 27.09.2019).

Statistical Analysis

Patient data collected within the scope of the study were analyzed with SPSS ver.21.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows ver. 21.0 Armonk, NY) and R ver.3.6 (R Foundation for Statistical Computing, ver.3.6; Vienna, Austria) package programs. The mean, median, interquartile range (IQR), minimum and maximum descriptive values were given for the total number of suicidesand seasonal variables. Poisson regression analysis was used to determine the seasonal variables affecting the change in the number of suicides. A time-conditioned Poisson regression model was chosen to investigate the relationship between seasonal variables and suicide. The Poisson regression model was classified according to gender groups and the probability of delayed effects of seasonal variables was examined 1-7 days before each observation. The results were considered statistically significant when the p-value was less than 5 percent.

RESULTS

The median age of the study population was 16 years (IQR: 15-18). A total of 340 (30.0%), male, and 792 (70.0%) female patients attempted suicide. There were 292 (25.8%) suicide attempts in spring, 271 (23.9%) in summer, 277 (24.5%) in autumn and 292 (25.8%) in winter. There was no case of death due to suicide.

In Diyarbakir Province, meanconcentrations of PM_{10} (131.4 μg/m^3), and SO_2 (13.9 μg/m^3) between January 1, 2009 and April 30, 2019 were as indicated. Mean values of meteorological variables affecting the incidence rates of suicide attempts were as follows: air pressure 935.4 hPa; humidity 53.8%; wind speed 2.8 m/s; air temperature 16.3°, and precipitation 38.8 mm (Table 1). Air pollution rates according to the seasons are givenin Figure 1.

Everyone-unit increasein the enironmenal concentration of pollutant PM_{10} in the air increased the risk of suicide attempts 1,002 times in all cases (p=0.016). Every one unit increase in relative humidity and wind speed increased the probability of suicide attempts by 1,017 times in the female, and 1,429 times in the male patient group (p=0.020, and p=0.001, respectively). Every one unit increase in air pressure, relative humidity, and wind speed increased the risk of suicide attempts in all cases by 1,064, 1,012, 1,400 times, respectively (p=0.014; p=0.045; p<0.0001, respectively). No statistical significance was found concerning the air pollution level for SO_2 (Table 2).

The Poisson conditional regression models used to examine the delayed effect for each type of pollutant and relevant meteorological factors are shown in Table 3. Although a significant negative difference was observed in the estimation of 3 and 7 days of delay in boys in PM_{10} air pollutant, a significant positive difference was observed in the estimation of 1, 3, 5, 7 days of delay in girls and in the general evaluation. In SO_2 air pollutant, although a significant positive difference was observed

Table 1. Information obtained from the records of daily clinical visits for suicide attempts of children, air pollutants and meteorological factors in Diyarbakır province between January 1, 2009 and April 30, 2019

Variables	Mean	Min[a]	P25[b]	P50[b]	P75	Max[a]	IQR[c]
Suicide attempts	7	1	4	6	10	18	6
Ambient air pollutants							
PM_{10} (μg/m^3)	131.4	55.9	85.0	116.9	170.6	264.2	85.6
SO_2 (μg/m^3)	13.9	1.1	5.8	11.1	17.3	68.1	11.5
Age (year)	16	15	16	16	16	18	0
Ambient meteorological factors							
Air pressure (hPa)	935.4	925.8	932.4	935.8	939.2	943.6	6.8
Humidity (%)	53.8	17.4	30.2	58.1	71.9	90.0	41.7
Wind speed (m/s)	2.8	1.2	2.3	2.8	3.2	4.6	0.9
Temperature (°C)	16.3	-3.5	7.6	15.8	26.1	32.3	18.5
Precipitation (mm)	38.8	0	2.0	21.6	63.8	168.9	61.8

Min: Minimum, Max: Maximum, P25: 25th centile; P50: 50th centile, P75: 75th centile, IQR: Interquartile range

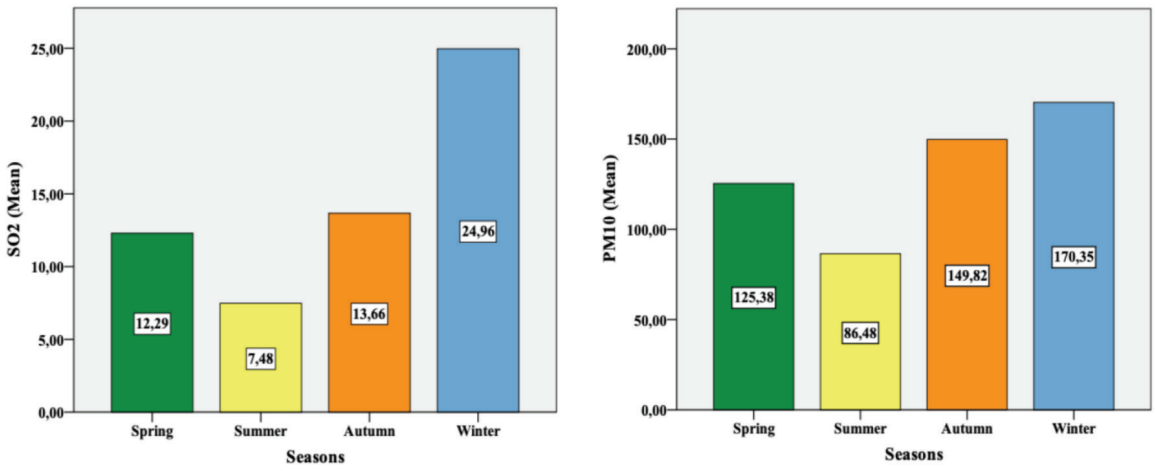

Figure 1. Average PM_{10} and SO_2 levels according to seasons

in the estimation of 5 days delay in boys and a significant negative difference in the estimation of 7 days in delay, a significant positive difference was observed in the estimation of 1, 3, 5, 7 days of delay in girls and in the general evaluation. A significant positive difference was observed in the air pressure factor in girls and in the delay of 1, 3, 5 days in the general evaluation. In the wind speed factor, a significant negative difference was found in the 1, 3, 5 days delay evaluations in girls and in the general evaluation.

DISCUSSION

Suicidal behavior is a complex disorder that is affected by mental disorders, symptoms, inadequate social support, and sociocultural factors. In addition to these factors in suicide risk, it is important to determine the relationship between suicidal behavior and weather conditions and to carry out studies to clarify the true impact of this relationship on suicidal behaviour. In the present study, we have investigated the relationship between the increase in the number of referrals to a single pediatric emergency service in Diyarbakır province for suicide attempts, levels of the pollutants PM_{10} and SO_2 in the environmental air, and meteorological factors. In this study, in compliance with literature findings, we have shown that there is a positive and statistically significant relationship between suicide attempts, air pollution and meteorological conditions[15]. Similar studies on this subject have also reported a positive relationship between air pollution and suicide mortality rates[16].

Studies investigating the relationship between air pollution and suicide, have shown that the number of suicide attempts increases during periods of the highest concentrations of particulate matter in the atmosphere[17]. However, previous studies have indicated that the risk of suicide varies depending on the type of air pollutant and workplace. For example, similar to our study; Casas et al.[18] stated that the increases in PM_{10} levels particularly affect children under 14 years of age, and that there is a seasonal difference and significance in the 6-day delay estimations. A study conducted in 10 cities in Northeast Asia, revealed that the younger age group (10-24 years old) had a higher risk of death due to suicide related to air pollution caused by NO_2, SO_2 and PM_{10} in some cities compared to older age groups[19]. In their study, Kim et al.[20] found a significant relationship between exposure to high concentrations of O_3 and particulate matter and suicide rates, but they could notreveal any relationship between exposure to NO_2, CO, SO_2 and suicide rates. They determined that every one unit increase in PM_{10} levels creates 0.047-fold increases in weekly suicide rates per 10 million people at zero lag time. In a survey study conducted in Japan, Ng et al.[21] could not find a relationship between SO_2 as an air pollutant and suicide risk. Similarly, in our study, a relationship was found between the number of suicide attempts and only PM_{10} O_3 but not between SO_2 levels. However, Yang et al.[22] determined that air pollutants such as SO_2 and O_3 increase the risk of suicide, and indicated that the decreased rate of sunlight is associated with the increased number of suicides. Brokamp et al.[14] found that there was a significant relationship between the increased number of psychiatric emergency unit admissions of children and levels of $PM_{2.5}$ in theenvironmental air. Although Liu et al.[23] found a positive association between psychiatric emergency presentations, including referrals for suicide attempts, and $PM_{2.5}$ levels they could not detect any

seasonal changes in the suicide rates. However, in the present study, as $PM_{2.5}$ levels in the environmental air were not determined in Diyarbakır province; no comparison could be made in this regard. We thought that this inconsistency in the results may be due to the differences in air pollution sources, pollutants, climatic conditions, cultural backgrounds, socioeconomic factors and neuropsychiatric diseases. Additionally, different modeling strategies and results of statistical evaluation make it difficult to make comparisons between studies.

It is a known fact that meteorological factors have a strong effect on increases in suicide rates[24]. Bakian et al.[15] performed a survey study in regions with very different meteorological, geographical and cultural characteristics, and revealed the presence of a positive correlation between air pollution and suicide completion rates. In our study, a significant relationship was found between air pressure, humidity and wind speed in all suicide attempts. In a study conducted in China, Lin et al.[16] investigated the relationship between the confounding effects of three air pollutants (PM_{10}, SO_2 and NO_2) and meteorological factors (daily average temperature, relative humidity, atmospheric pressure, duration of sunshine) and increases in suicide risk, and revealed that the effects of all pollutants were statistically significant in cold seasons. The suicide risk caused by exposure to three air pollutants was found to be positively associated with ambient air pollution levels[16]. In our study, although PM_{10} levels in the ambient air were higher in winter, the reasons for the lack of seasonal differences in the risks of suicide attempts in children have been thought to be related firstly to the increase in time spent indoors during cold periods and the decrease in personal exposure to outdoor air pollution. Secondly, although the composition of PM_{10} changes throughout the year, the highest proinflammatory concentration of PM_{10} is measured in summer[25]. In another study, the authors found a significant positive correlation between the number of suicides and air temperature. They indicated that there was a weak positive correlation between air humidity and the number of suicidal attempts, but a significantly negative correlation between the number of suicides and atmospheric pressure was indicated[26]. Bando et al.[27] reported that the minimum temperature was associated with a 2.28% increase in the total number of suicides with each 1 °C increase in weekly averages; however Gao et al.[28] found that rising temperature had a positive correlationwith increased risk of suicide, especially completed suicide. Although it is not known exactly how the atmospheric temperature affects the human organism, it has been stated that the brown adipose tissue is overactivated in the human body, which produces heat after cold nights and in the early spring and summer seasons, and consequenly, the risk of suicide may increase with the intensification of anxiety and mental activity. Overactivated brown adipose tissue increases tolerance to cold, while tolerance to heat decreases. One hypothesis is that decreased tolerance to heat aggravates anxiety, agitation, and can cause changes in mood (mood-altering effect). As a result, it may facilitate the emergence of suicidal thoughts[29,30]. Another explanation is that high temperature can aggravate impulsive and aggressive behaviorsby increasing serotonin levels or overactivating 5-HT receptors[31]. However, it is clear that a sudden increase in temperature with increasing humidity may cause evaporation of body heat and cause thermoregulational imbalance[29]. In our study, however, no relationship was found between ambient temperature and relative humidity and suicide cases. It was thought that this result may be related to the absence of sudden changes in meteorological factors and the absence of completed suicide cases in our survey.

Falak et al.[32] reported a significant relationship between intentional self-harming behavior, ambient air pressure and wind speed. In our study, a positive relationship was found between air pressure, wind speed, humidity and number of suicide attempts. It is thought that the average lowwind speed of 2.8 m/s in Diyarbakır province is insufficient in the distribution of air pollution in the city, and from time to time it accumulates emissions on the city and causes pollution.

Our findings suggest that people are more likely to commit suicide when air pollution is high. As an extremely important issue the distribution of mental disorders among people who commit suicide should be taken into account, otherwise it would be impossible to predict the effects of pollution on suicide-related outcomes. The exact mechanism why an increase in the levels of air pollutants may be associated with suicide is unknown. It has been stated that high levels of air pollution induce proinflammatory cytokines that may directly or indirectly lead to a neuroinflammatory effect in the brain (for example, dysregulation of the hypothalamic-pituitary-adrenal axis and changes in neurotransmitter levels), and these pathways may be involved in the development of depression, suicidal behavior or both[33]. Results obtained from systematic reviews suggest that there is a statistically significant relationship between air pollution and the risk of depression and suicide[34]. Further clinical and experimental studies are needed to

Table 2. Poisson multivariable conditional regression models for daily suicide attemps among boys and girls in Diyarbakır province between January 1, 2009 and April 30, 2019

Ambient air pollutants and meteorological factors	Boys		Girls		All	
	IRR (95% CI)	p-value	IRR (95% CI)	p-value	IRR (95% CI)	p-value
Air pollutants						
PM_{10} (μg/m³)	1.002 (0.998-1.006)	0.371	1.003 (1.000-1.005)	0.060	**1.002 (1.000-1.005)**	**0.016**
SO_2 (μg/m³)	0.997 (0.983-1.010)	0.625	0.995 (0.985-1.005)	0.312	0.996 (0.998-1.003)	0.270
Meteorological factors						
Air pressure (hPa)	1.088 (0.993-1.192)	0.071	1.057 (0.997-1.119)	0.063	**1.064 (1.013-1.117)**	**0.014**
Humidity (%)	1.003 (0.982-1.025)	0.800	**1.017 (1.003-1.031)**	**0.020**	**1.012 (1.000-1.024)**	**0.045**
Wind speed (m/s)	1.387 (0.974-1.974)	0.069	**1.429 (1.148-1.780)**	**0.001**	**1.400 (1.161-1.687)**	**<0.0001**
Temperature (°C)	1.014 (0.952-1.080)	0.659	1.039 (0.998-1.081)	0.062	1.029 (0.995-1.064)	0.100
Precipitation (mm)	0.997 (0.991-1.002)	0.272	1.001 (0.997-1.004)	0.695	0.999 (0.997-1.002)	0.687

Data were presented with IRR and 95% CI; IRR: Incidence rate ratio, CI: Confidence interval

Table 3. Poisson conditional regression models for lagged PM_{10} and SO_2 effects on daily suicide attempts among boys and girls in Diyarbakır province between January 1, 2009 and April 30, 2019

Ambient air pollutanst and meteorological factors	Lag	Men		Women		All	
		IRR (95% CI)	p-value	IRR (95% CI)	p-value	IRR (95% CI)	p-value
Pollutants							
PM_{10} (μg/m³)	L1	1.009 (0.999-1.020)	0.071	**0.996 (0.994-0.998)**	**<0.0001**	**0.997 (0.995-0.998)**	**<0.0001**
	L2	0.999 (0.995-1.003)	0.520	0.999 (0.997-1.002)	0.651	0.999 (0.997-1.001)	0.398
	L3	**1.008 (1.001-1.014)**	**0.021**	**0.997 (0.995-0.999)**	**0.001**	**0.997 (0.996-0.999)**	**0.004**
	L4	1.002 (0.998-1.006)	0.376	1.001 (0.998-1.003)	0.590	1.001 (0.999-1.003)	0.292
	L5	1.001 (0.996-1.007)	0.603	**0.997 (0.996-0.999)**	**0.007**	**0.998 (0.996-1.000)**	**0.016**
	L6	1.003 (0.999-1.007)	0.136	0.999 (0.996-1.001)	0.227	0.999 (0.997-1.001)	0.481
	L7	**1.008 (1.003-1.013)**	**0.003**	**0.998 (0.996-1.000)**	**0.015**	**0.999 (0.997-1.001)**	**0.020**
SO_2 (μg/m³)	L1	1.006 (0.974-1.039)	0.715	**0.983 (0.974-0.992)**	**<0.0001**	**0.986 (0.977-0.995)**	**0.001**
	L2	0.991 (0.972-1.010)	0.327	0.999 (0.986-1.014)	0.943	0.995 (0.985-1.005)	0.332
	L3	0.977 (0.934-1.022)	0.310	**0.985 (0.976-0.994)**	**0.001**	**0.985 (0.975-0.994)**	**0.001**
	L4	0.985 (0.957-1.013)	0.285	0.990 (0.978-1.002)	0.110	0.992 (0.981-1.004)	0.182
	L5	**0.958 (0.921-0.996)**	**0.033**	**0.977 (0.966-0.987)**	**<0.0001**	**0.976 (0.966-0.986)**	**<0.0001**
	L6	0.997 (0.980-1.015)	0.752	0.991 (0.978-1.003)	0.155	0.992 (0.982-1.002)	0.106
	L7	**1.017 (1.001-1.035)**	**0.042**	**0.985 (0.975-0.994)**	**0.002**	**0.990 (0.982-0.998)**	**0.016**
Meteorological factors							
Air pressure (hPa)	L1	1.013 (0.922-1.112)	0.788	**0.976 (0.957-0.995)**	**0.013**	**0.974 (0.955-0.992)**	**0.006**
	L2	1.006 (0.959-1.055)	0.806	1.012 (0.980-1.046)	0.468	1.013 (0.987-1.040)	0.319
	L3	1.062 (0.984-1.146)	0.123	**0.974 (0.954-0.995)**	**0.015**	**0.976 (0.956-0.995)**	**0.016**
	L4	1.018 (0.969-1.069)	0.475	1.015 (0.984-1.048)	0.346	1.021 (0.995-1.048)	0.117
	L5	1.040 (0.972-1.113)	0.254	**0.975 (0.955-0.995)**	**0.015**	**0.978 (0.958-0.997)**	**0.027**
	L6	1.014 (0.964-1.066)	0.588	1.002 (0.974-1.031)	0.883	0.998 (0.975-1.023)	0.886
	L7	1.069 (0.997-1.146)	0.060	0.986 (0.965-1.007)	0.186	0.990 (0.970-1.010)	0.324

Table 3. Continued

Ambient air pollutanst and meteorological factors	Lag	Men		Women		All	
		IRR (95% CI)	p-value	IRR (95% CI)	p-value	IRR (95% CI)	p-value
Meteorological factors							
Humidity (%)	L1	0.995 (0.972-1.017)	0.634	0.999 (0.995-1.004)	0.801	1,000 (0.996-1.005)	0.911
	L2	1.002 (0.991-1.012)	0.770	1.002 (0.996-1.009)	0.510	1.003 (0.998-1.009)	0.213
	L3	1.011 (0.995-1.028)	0.163	1.000 (0.995-1.004)	0.930	1.001 (0.997-1.005)	0.645
	L4	0.999 (0.988-1.010)	0.865	1.003 (0.997-1.009)	0.365	1.004 (0.999-1.010)	0.115
	L5	1.003 (0.989-1.018)	0.631	1.000 (0.995-1.004)	0.834	0.999 (0.995-1.004)	0.719
	L6	0.993 (0.981-1.004)	0.199	1.004 (0.998-1.010)	0.208	1.002 (0.997-1.007)	0.519
	L7	0.997 (0.983-1.010)	0.619	1.000 (0.995-1.004)	0.934	0.998 (0.994-1.002)	0.350
Wind speed (m/s)	L1	1.028 (0.536-1.972)	0.933	**1.185 (1.034-1.359)**	**0.015**	**1.256 (1.101-1.434)**	**0.001**
	L2	1.026 (0.727-1.448)	0.883	0.893 (0.722-1.103)	0.292	0.924 (0.773-1.105)	0.387
	L3	0.722 (0.442-1.181)	0.194	**1.256 (1.089-1.448)**	**0.002**	**1.237 (1.077-1.420)**	**0.003**
	L4	0.936 (0.669-1.310)	0.701	1.043 (0.842-1.293)	0.700	0.980 (0.822-1.168)	0.819
	L5	0.998 (0.679-1.467)	0.991	**1.201 (1.042-1.384)**	**0.011**	**1.245 (1.092-1.419)**	**0.001**
	L6	1.209 (0.876-1.670)	0.248	1.052 (0.880-1.257)	0.580	1.123 (0.961-1.311)	0.144
	L7	0.807 (0.524-1.242)	0.330	1.210 (1.045-1.401)	0.051	1.144 (0.998-1.312)	0.054
Temperature (°C)	L1	1.001 (0.951-1.052)	0.984	**1.010 (1.001-1.020)**	**0.034**	1.008 (0.999-1.017)	0.092
	L2	1.001 (0.979-1.024)	0.915	0.996 (0.981-1.010)	0.577	0.995 (0.984-1.008)	0.460
	L3	0.978 (0.945-1.012)	0.205	1.009 (0.999-1.019)	0.088	1.007 (0.997-1.016)	0.165
	L4	1.004 (0.979-1.029)	0.781	0.996 (0.983-1.010)	0.615	0.994 (0.982-1.006)	0.300
	L5	0.991 (0.958-1.025)	0.603	1.010 (0.999-1.020)	0.069	1.008 (0.998-1.018)	0.109
	L6	1.000 (0.976-1.026)	0.979	0.995 (0.982-1.008)	0.425	0.997 (0.986-1.009)	0.653
	L7	0.978 (0.946-1.011)	0.196	1.006 (0.996-1.017)	0.216	1.006 (0.997-1.016)	0.194
Precipitation (mm)	L1	0.974 (0.946-1.004)	0.086	**1.003 (1.001-1.006)**	**0.012**	**1.005 (1.002-1.007)**	**0.001**
	L2	0.999 (0.992-1.007)	0.869	0.998 (0.994-1.003)	0.476	1.000 (0.996-1.004)	0.949
	L3	0.991 (0.977-1.005)	0.219	1.002 (0.999-1.005)	0.197	1.002 (0.999-1.005)	0.138
	L4	0.990 (0.980-1.001)	0.065	1.001 (0.997-1.005)	0.566	1.000 (0.997-1.004)	0.909
	L5	0.992 (0.980-1.005)	0.218	1.002 (0.999-1.005)	0.227	1.002 (0.999-1.005)	0.194
	L6	**0.989 (0.980-0.998)**	**0.016**	0.999 (0.994-1.003)	0.529	0.996 (0.993-1.000)	0.057
	L7	0.989 (0.976-1.003)	0.129	1.002 (0.999-1.005)	0.237	1.002 (0.999-1.005)	0.299

Data were presented with IRR and 95% CI; IRR: Incidence rate ratio, CI: Confidence interval

better understand the impact of air pollution on mental health and especially to define its effectson biological systems.

Study Limitations

The first major limitation of our study is the use of information on ambient air pollutants and meteorological factors gathered from monitoring stations, rather than using actual personal exposure data. Therefore, it is necessary to measure the potential impact of air pollution on people with mental disorders in order to investigate whether there is any interaction between the environmental factors and individual sensitivity. Second, due to our limited data we could not assess differences in exposure to air pollutants in urban and rural areas. Therefore, evaluations of these findings in geographical regions with different degrees of pollution could not be made. It is also important to consider the possibility of misclassification and missing suicide data due to coding and diagnostic errors.

We suggest that future studies should include studies on mental health disorders, and it would be appropriate to compare regions with high and low air

pollutant concentrations in these studies. It is important to analyze the relationships with the entire spectrum of suicidal behavior, as suicide attempts may have different risk profiles from completed suicide.

CONCLUSION

Suicide attempts are among increasingly preventable behavioral disorders. The results obtained in this study, in line with the literature, have show that suicidal behavior may be associated with changes in the levels of airborne pollutants and meteorological factors, so further research is required to understand its underlying mechanisms. It is understood that prospective, multicenter studies, including healthy populations and populations with mental health disorders, are necessary in order to evaluate the data more comprehensively and to obtain more accurate data. On the other hand, comparing the ratios of high and low pollutant concentrations could add important information to the relevant literature studies.

Ethics

Ethics Committee Approval: For this study, ethics committee approval was obtained from the Ethics Committee of University of Health Sciences Turkey, Diyarbakır Gazi Yaşargil Training and Research Hospital (approval number: 340, date: 27.09.2019).

Informed Consent: Retrospective study.

Peer-review: Externally peer reviewed.

Author Contributions

Concept: G.Y., Design: A.G., Data Collection or Processing: G.Y., M.A., Analysis or Interpretation: İ.T., Literature Search: G.Y., Writing: G.Y.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Kochanek KD, Kirmeyer SE, Martin JA, Strobino DM, Guyer B. Annual summary of vital statistics: 2009. Pediatrics. 2012;129(12):338-48. doi: 10.1542/peds.2011-3435
2. Clarke S, Ragan E, Berk M. Management of suicidal youth. In: Singh MK, editor. clinical handbook for the diagnosis and treatment of pediatric mood disorders. American Psychiatric Association Publishing. Washington DC: 2019. p.391.
3. Eaton DK, Kann L, Kinchen S, Shanklin S, Flint KH, Hawkins J, et al. Youth risk behavior surveillance - United States, 2011. MMWR Surveill Summ. 2012;61(4):1-162.
4. TUİK. Ölüm ve Ölüm Nedeni İstatistikleri, 2020. Available from: https://data.tuik.gov.tr/Bulten/Index?p=Olum-ve-Olum-Nedeni-Istatistikleri-2020-37243. cited 02.12.2020.
5. Asirdizer M, Kartal E, Etli Y, Tatlisumak E, Gumus O, Hekimoglu Y, et al. The effect of altitude and climate on the suicide rates in Turkey. J Forensic Leg Med. 2018;54:91-5. doi: 10.1016/j.jflm.2017.12.012
6. Hawton K, Saunders KE, O'Connor RC. Self-harm and suicide in adolescents. Lancet. 2012;379(9834):2373-82. doi: 10.1016/S0140-6736(12)60322-5
7. Gładka A, Rymaszewska J, Zatoński T. Impact of air pollution on depression and suicide. Int J Occup Med Environ Health. 2018;31(6):711-21. doi: 10.13075/ijomeh.1896.01277
8. Thomson EM. Air pollution, stress, and allostatic load: linking systemic and central nervous system impacts. J Alzheimers Dis. 2019;69(3):597-614. doi: 10.3233/JAD-190015
9. Wei H, Feng Y, Liang F, Cheng W, Wu X, Zhou R, et al. Role of oxidative stress and DNA hydroxymethylation in the neurotoxicity of fine particulate matter. Toxicology. 2017;380:94-103. doi: 10.1016/j.tox.2017.01.017
10. Ku T, Ji X, Zhang Y, Li G, Sang N. PM2.5, SO2 and NO2 co-exposure impairs neurobehavior and induces mitochondrial injuries in the mouse brain. Chemosphere. 2016;163:27-34. doi: 10.1016/j.chemosphere.2016.08.009
11. Davis DA, Bortolato M, Godar SC, Sander TK, Iwata N, Pakbin P, et al. Prenatal exposure to urban air nanoparticles in mice causes altered neuronal differentiation and depression-like responses. PLoS One. 2013;8(5):e64128. doi: 10.1371/journal.pone.0064128
12. Perera FP, Tang D, Wang S, Vishnevetsky J, Zhang B, Diaz D, et al. Prenatal polycyclic aromatic hydrocarbon (PAH) exposure and child behavior at age 6-7 years. Environ Health Perspect. 2012;120(6):921-6. doi: 10.1289/ehp.1104315
13. Calderón-Garcidueñas L, Engle R, Mora-Tiscareño A, Styner M, Gómez-Garza G, Zhu H, et al. Exposure to severe urban air pollution influences cognitive outcomes, brain volume and systemic inflammation in clinically healthy children. Brain Cogn. 2011;77(3):345-55. doi: 10.1016/j.bandc.2011.09.006
14. Brokamp C, Strawn JR, Beck AF, Ryan P. Pediatric Psychiatric Emergency Department Utilization and Fine Particulate Matter: A Case-Crossover Study. Environ Health Perspect. 2019;127(9):97006. doi: 10.1289/EHP4815
15. Bakian AV, Huber RS, Coon H, Gray D, Wilson P, McMahon WM, et al. Acute air pollution exposure and risk of suicide completion. Am J Epidemiol. 2015;181(5):295-303. doi: 10.1093/aje/kwu341
16. Lin GZ, Li L, Song YF, Zhou YX, Shen SQ, Ou CQ. The impact of ambient air pollution on suicide mortality: a case-crossover study in Guangzhou, China. Environ Health. 2016;15(1):90. doi: 10.1186/s12940-016-0177-1
17. Szyszkowicz M, Willey JB, Grafstein E, Rowe BH, Colman I. Air pollution and emergency department visits for suicide attempts in vancouver, Canada. Environ Health Insights. 2010;4:79-86. doi: 10.4137/EHI.S5662
18. Casas L, Cox B, Bauwelinck M, Nemery B, Deboosere P, Nawrot TS. Does air pollution trigger suicide? A case-crossover analysis of suicide deaths over the life span. Eur J Epidemiol. 2017;32(11):973-81. doi: 10.1007/s10654-017-0273-8
19. Kim Y, Ng CFS, Chung Y, Kim H, Honda Y, Guo YL, et al. Air Pollution and Suicide in 10 cities in Northeast Asia: A time-stratified case-

crossover analysis. Environ Health Perspect. 2018;126(3):037002. doi: 10.1289/EHP2223

20. Kim Y, Myung W, Won HH, Shim S, Jeon HJ, Choi J, et al. Association between air pollution and suicide in South Korea: A nationwide study. PLoS One. 2015;10(2):e0117929. doi: 10.1371/journal.pone.0117929
21. Ng CF, Stickley A, Konishi S, Watanabe C. Ambient air pollution and suicide in Tokyo, 2001-2011. J Affect Disord. 2016;201:194-202. doi: 10.1016/j.jad.2016.05.006
22. Yang AC, Tsai SJ, Huang NE. Decomposing the association of completed suicide with air pollution, weather, and unemployment data at different time scales. J Affect Disord. 2011;129(1-3):275-81. doi: 10.1016/j.jad.2010.08.010
23. Liu JJ, Wang F, Liu H, Wei YB, Li H, Yue J, et al. Ambient fine particulate matter is associated with increased emergency ambulance dispatches for psychiatric emergencies. Environ Res. 2019;177:108611. doi: 10.1016/j.envres.2019.108611
24. Carleton TA. Crop-damaging temperatures increase suicide rates in India. Proc Natl Acad Sci U S A. 2017;114:8746-51. doi: 10.1073/pnas.1701354114
25. Hetland RB, Cassee FR, Låg M, Refsnes M, Dybing E, Schwarze PE. Cytokine release from alveolar macrophages exposed to ambient particulate matter: heterogeneity in relation to size, city and season. Part Fibre Toxicol. 2005;2:4. doi: 10.1186/1743-8977-2-4
26. Kurokouchi M, Miyatake N, Kinoshita H, Tanaka N, Fukunaga T. Correlation between suicide and meteorological parameters. Medicina (Kaunas). 2015;51(6):363-7. doi: 10.1016/j.medici.2015.11.006
27. Bando DH, Teng CT, Volpe FM, Masi E, Pereira LA, Braga AL. Suicide and meteorological factors in São Paulo, Brazil, 1996-2011: a time series analysis. Braz J Psychiatry. 2017;39(3):220-7. doi: 10.1590/1516-4446-2016-2057
28. Gao J, Cheng Q, Duan J, Xu Z, Bai L, Zhang Y, et al. Ambient temperature, sunlight duration, and suicide: A systematic review and meta-analysis. Sci Total Environ. 2019;646:1021-9. doi: 10.1016/j.scitotenv.2018.07.098
29. Dumenčić B, Rajc J, Marjanović K, Požgain I, Pavoković D. Impact of Meteorological Factors on Suicide Attempts and Completed Suicides in Croatia, Osijek-Baranja County. Psychiatr Danub. 2019;31(4):405-12. doi: 10.24869/psyd.2019.405
30. Holopainen J, Helama S, Partonen T. Does diurnal temperature range influence seasonal suicide mortality? Assessment of daily data of the Helsinki Metropolitan Area from 1973 to 2010. Int J Biometeorol. 2014;58(6):1039-45. doi: 10.1007/s00484-013-0689-0
31. Olivier JD, Cools AR, Deen PM, Olivier B, Ellenbroek BA. Blockade of dopamine, but not noradrenaline, transporters produces hyperthermia in rats that lack serotonin transporters. Eur J Pharmacol. 2010;629(1-3):7-11. doi: 10.1016/j.ejphar.2009.11.049
32. Falak H, Silić A, Golob M, Perišić A, Košec A, Udovičić M. The influence of meteorological parameters on intentional self-harm emergency admissions. Psychiatr Danub. 2019;31(2):204-5. doi: 10.24869/psyd.2019.204
33. Kim C, Cho J. Air pollution and mental health. Hazardous air pollutants: Case studies from Asia. CRC Press; 2016. p. 137-49.
34. Gu X, Liu Q, Deng F, Wang X, Lin H, Guo X, et al. Association between particulate matter air pollution and risk of depression and suicide: Systematic review and meta-analysis. Br J Psychiatry. 2019;215(2):456-67. doi: 10.1192/bjp.2018.295