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Research Article

# Investigation of the relationship between air quality and health outcomes in Bilecik, Türkiye: A descriptive ecological study

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## Abstract

**Objective:** To evaluate temporal trends in air quality indicators and their ecological-level associations with respiratory and cardiovascular hospital admissions in two districts of Bilecik Province between 2020 and 2024.

**Method**: This ecological, retrospective study used annual district-level data from two public hospitals and two fixed air-monitoring stations in Bilecik city center and Bozüyük. Annual mean concentrations of $PM_{2.5}$, $PM_{2.5}$, $SO_2$, $NO_2$, $O_3$ and CO were obtained from routine monitoring records. Hospital admissions were classified using ICD-10 codes for major respiratory and cardiovascular conditions. Descriptive trends were examined, and ecological co-variation between pollutants and total respiratory/cardiovascular admissions was assessed using Spearman's rank correlation ($p<0.05$).

**Results:** $PM_{2.5}$ levels declined in both districts, whereas $PM_{2.5}$ concentrations increased and remained higher in Bozüyük. Respiratory and cardiovascular admissions decreased in 2020–2021 and rose again from 2022 onwards. At the district–year level, respiratory admissions were positively correlated with $PM_{2.5}$'in Bozüyük and negatively correlated in the city center, while $NO_2$ showed negative correlations in both districts. Cardiovascular admissions were positively correlated with $PM_{2.5}$ and temperature, whereas $PM_{2.5}$ showed a negative association, particularly in Bozüyük.

**Conclusion:** Air quality indicators and hospital admissions displayed distinct temporal and spatial patterns across the two districts, with a stronger $PM_{2.5}$ burden and clearer ecological associations in Bozüyük, the more industrialized and traffic-intense district. Although not implying individual-level causality, the findings provide policy-relevant evidence supporting prioritization of $PM_{2.5}$-focused monitoring, emission-control measures, and integration of environmental indicators into local health-surveillance systems in medium-sized industrial regions.

**Keywords:** air pollution; $PM_{2.5}$; respiratory diseases; cardiovascular admissions; ecological study

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## 1. INTRODUCTION

Air pollution is recognized as one of the leading environmental determinants of population health worldwide. According to the World Health Organization (WHO), ambient air pollution is responsible for an estimated 4.2 million premature deaths annually, mainly due to cardiovascular and respiratory causes (1). Evidence from the Global Burden of Disease (GBD) study indicates that fine particulate matter ($PM_{2.5}$) contributes substantially to morbidity and mortality, accounting for approximately 12% of the global burden attributable to major chronic diseases (2). In addition, multi-country modelling studies have shown that increases in ambient $PM_{2.5}$ concentrations are associated with higher all-cause mortality at the population level (3).

A growing body of epidemiological and meta-analytical evidence indicates that long-term exposure to $PM_{2.5}$, $PM_{10}$, $NO_2$, $SO_2$ and $O_3$ is associated with adverse health outcomes, particularly chronic respiratory and cardiovascular diseases (4-6). Previous reviews have reported increased risks of COPD, asthma exacerbations, acute myocardial infarction and lung cancer among populations chronically exposed to particulate matter and traffic-related pollutants (5-8). Although substantial reductions in $SO_2$ and $PM_{10}$ emissions have been reported in parts of Europe, recent assessments suggest that population exposure to $PM_{2.5}$ and $NO_2$ remains above recommended thresholds in many regions (9).

In Türkiye, air quality assessments indicate that a large proportion of the population continues to be exposed to pollutant concentrations exceeding WHO guideline values, particularly with respect to $PM_{2.5}$ (10). However, most available studies have focused on major metropolitan areas such as Istanbul, Ankara and Bursa, whereas evidence from small-to-medium sized industrial provinces remains limited. This gap is particularly relevant for regions where industrial activities and transport corridors coexist with residential settlements, but where long-term ecological evaluations are scarce.

Bilecik is a medium-sized province in north-western Türkiye characterized by industrial production, mining activities and varying topographic and meteorological conditions across its districts. The provincial centre and Bozüyük district differ considerably in terms of traffic load, industrial density and urban structure, providing a meaningful context for comparative ecological assessment. Building on previous work linking long-term air pollution exposure to cardiopulmonary outcomes this study evaluates five-year air pollutant trends alongside hospital admission profiles (7,8).

Accordingly, this ecological study aimed to examine the relationship between annual average concentrations of selected ambient air pollutants ($PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$ and $O_3$) and hospital admissions for predefined respiratory and cardiovascular disease groups in two districts of Bilecik Province between 2020 and 2024.

Specifically, the study pursued the following sub-objectives: (i) to evaluate five-year trends in ambient air pollutant concentrations in the selected districts, (ii) to compare air pollutant profiles between Bilecik city center and the industrial district of Bozüyük, and (iii) to explore district-level correlations between annual pollutant concentrations and hospital admission indicators for respiratory and cardiovascular diseases.

Rather than establishing causal inference at the individual level, the study seeks to provide a district-level descriptive assessment that may support local environmental health monitoring and contribute to evidence-informed policy development in medium-sized industrial provinces.

## 2. METHODS

### 2.1. Study design

This ecological and retrospective epidemiological study covered the years 2020–2024 and evaluated district-level variation in annual air pollutant concentrations and hospital admission profiles in Bilecik Province. Analyses were conducted at the district–year level, using annual averages of

environmental indicators and annual counts of hospital admissions as the unit of observation. The study included data from two public hospitals and two fixed ambient air monitoring stations.

The study does not aim to establish individual-level causal associations; rather, it provides a population-level descriptive assessment of the co-variation between air quality indicators and health service utilization.

### 2.2. Study location

This study was conducted in Bilecik, a province in the Southern Marmara Region of Türkiye, with an estimated population of 228,000 in 2024.[11] The province is characterized by industrial activity, mining sites and a semi-continental climate, with winter months marked by reduced air circulation and temperature inversion conditions that may increase pollutant accumulation.

Two districts with contrasting structural characteristics were included:

(1) Bilecik city center, located in a basin-like topography with lower traffic density and fewer large-scale industries, and

(2) **Bozüyük**, situated along the D650 transportation corridor with higher industrial density and freight traffic.

The primary health data sources were Bilecik Training and Research Hospital (city center) and Bozüyük State Hospital (industrial district), both of which serve as referral centers and maintain comprehensive electronic admission records.

### 2.3. Air quality and meteorological data

Annual mean concentrations of particulate matter ($PM_{10}$, $PM_{2.5}$), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), ozone ($O_3$) and carbon monoxide (CO) for 2020–2024 were obtained from the Bilecik Provincial Directorate of Environment, Urbanization and Climate Change. Data from two fixed monitoring stations (Bilecik Merkez and Bozüyük) were used.

Hourly measurements were screened using station-level quality-control flags. Valid hourly records were aggregated to daily means and then to **annual averages per station**, consistent with the ecological design.

Meteorological data were obtained from the same authority. In line with the annual aggregation structure, **only annual mean temperature** was used as a contextual variable; other meteorological indicators (e.g. humidity, wind speed/direction) and seasonal stratification were not included.

### 2.4. Health data

Health data were retrospectively retrieved from hospital admission records for 2020–2024 through the Bilecik Provincial Directorate of Health, using the International Classification of Diseases, 10th Revision (ICD-10) codes. Disease groups were defined as a priori based on conditions frequently reported in the literature as being sensitive to long-term air pollution exposure. Respiratory and cardiovascular diagnoses constituted the primary analytical focus, while selected cancer and allergic disease groups were examined descriptively. Relevant ICD-10 subcodes were included for each group (Table 1).

Data included daily emergency and outpatient admissions. Because the dataset reflects routine health-service utilization, repeated admissions for the same patient on different dates may be present and were retained as an indicator of service burden. Duplicate technical entries (identical patient ID, diagnosis and timestamp) and inter-facility transfer records were excluded.

### 2.5. Data preparation

Separate datasets (hospital admissions, air pollutants and meteorological variables) were harmonized into a unified district–year structured database. Air pollutant and temperature variables were expressed as annual means.

| Table 1. Disease groups and ICD-10 codes used in the study | | |
|---|---|---|
| **Disease group** | **ICD-10 codes** | **Description** |
| Acute bronchitis | J20, J20.8, J20.9 | Acute bronchitis and unspecified subtypes |
| Asthma | J45.* | Asthma and allergic/intrinsic subtypes |
| COPD | J44.* | Chronic obstructive pulmonary disease |
| Pneumonia | J15–J18 | Bacterial, viral and unspecified pneumonia |
| Respiratory failure | J96.* | Acute, chronic and unspecified respiratory failure |
| Rhinitis | J30.0–J30.4 | Allergic and vasomotor rhinitis |
| Lung cancer | C34.* | Malignant neoplasms of bronchus and lung |
| Skin cancers | C43–C44 | Melanoma and other skin cancers |
| Bladder cancer | C67.* | Bladder cancer |
| Allergic conditions | T78.0–T78.4 | Anaphylaxis and allergic reactions |
| Dermatitis | L20–L30 | Atopic and contact dermatitis |
| Myocardial infarction | I21 | Acute myocardial infarction |
| Heart failure | I50 | Heart failure |
| Hypertension | I10–I15 | Hypertension |

### 2.6. Ethical considerations

The research was approved by the KTO Karatay University Faculty of Medicine, Non-Drug and Non-Medical Device Research Ethics Committee (Date: 26/12/2024; Approval No: 2024/018). Institutional permissions were granted by the Provincial Health Directorate and the Provincial Directorate of Environment, Urbanization and Climate Change. The study was conducted in accordance with the principles of the **Declaration of Helsinki.** All data were anonymized prior to analysis, and no individual-level identifying information was used.

### 2.7. Statistical analysis

Analyses were performed using SPSS for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). Numerical variables were assessed for distributional characteristics using visual (histograms, Q–Q plots) and analytical (Kolmogorov–Smirnov) methods.

Between-district differences in annual mean pollutant concentrations were examined using the independent samples t-test. Year-to-year variation within districts was assessed using one-way ANOVA for parametric variables. Hospital admissions were summarized as annual counts and rates by disease group and district. To explore population-level co-variation between environmental indicators and health service utilization, Spearman correlation coefficients were calculated between annual mean pollutant concentrations and annual respiratory and cardiovascular admission indicators. A two-tailed p-value <0.05 was considered statistically significant.

## 3. RESULTS

Between 2020 and 2024, annual average concentrations of major air pollutants showed distinct spatial and temporal patterns across the two districts. $PM_{10}$ levels exhibited a decreasing trend in both districts, whereas $PM_{2.5}$ concentrations increased over time, with a more pronounced rise in Bozüyük. Mean annual concentrations of $PM_{10}$, $PM_{2.5}$ and $NO_2$ were consistently higher in Bozüyük compared with the city centre throughout the study period. While $SO_2$ levels declined markedly in the city centre, a fluctuating pattern was observed in Bozüyük. Annual mean temperature remained higher in the city centre in all study years (Table 2).

The distribution of hospital admissions by disease group demonstrated a noticeable decline during the early pandemic period (2020–2021), followed by a gradual increase from 2022 onwards. This pattern was observed for both respiratory and cardiovascular disease groups in both districts, with the post-pandemic rise being more evident in 2023–2024.

These changes likely reflect not only epidemiological variation but also shifts in healthcare-seeking behaviour over the pandemic and post-pandemic phases (Table 3).

**Table 2. Descriptive statistics of air quality variables by year and station**

| Air quality parameters | Location | Years | | | | | p** |
|---|---|---|---|---|---|---|---|
| | | 2020 | 2021 | 2022 | 2023 | 2024 | |
| **$PM_{10}$** | Center | 30,02 | 27,34 | 22,22 | 23,27 | 24,27 | **<0,001** |
| | Bozüyük | 57,43 | 51,24 | 44,33 | 44,23 | 43,77 | **<0,001** |
| | p* | **<0,001** | **<0,001** | **<0,001** | **<0,001** | **<0,001** | |
| **$PM_{2.5}$** | Center | 9,09 | 11,92 | 12,16 | 14,66 | 14,63 | **<0,001** |
| | Bozüyük | 21,27 | 20,90 | 19,31 | 24,62 | 25,52 | **<0,001** |
| | p* | **<0,001** | **<0,001** | **<0,001** | **<0,001** | **<0,001** | |
| **$SO_2$** | Center | 6,31 | 4,23 | 5,46 | 2,54 | 2,18 | **<0,001** |
| | Bozüyük | 6,27 | 6,67 | 10,34 | 11,08 | 8,53 | **<0,001** |
| | p* | 0,892 | **<0,001** | **<0,001** | **<0,001** | **<0,001** | |
| **NO** | Center | 11,02 | 4,90 | 9,27 | 7,85 | 5,39 | **<0,001** |
| | Bozüyük | 22,84 | 21,35 | 20,11 | 19,75 | 21,54 | 0,452 |
| | p* | **<0,001** | **<0,001** | **<0,001** | **<0,001** | **<0,001** | |
| **$NO_2$** | Center | 8,84 | 15,44 | 29,09 | 18,62 | 10,72 | **<0,001** |
| | Bozüyük | 23,13 | 24,58 | 26,32 | 20,70 | 32,72 | **<0,001** |
| | p* | **<0,001** | **<0,001** | **0,002** | **0,004** | **<0,001** | |
| **$O_3$** | Center | 58,26 | 53,00 | 51,08 | 40,36 | 43,72 | **<0,001** |
| | Bozüyük | 59,92 | 38,66 | 29,89 | 29,52 | 58,32 | **<0,001** |
| | p* | 0,679 | **<0,001** | **0,011** | **<0,001** | **<0,001** | |
| **Temperature** | Center | 13,75 | 13,34 | 13,01 | 14,11 | 14,65 | **0,043** |
| | Bozüyük | 12,19 | 12,00 | 11,48 | 12,65 | 13,05 | 0,072 |
| | p* | **0,007** | **0,022** | **<0,001** | **0,009** | **0,006** | |

Annual average values for air quality parameters are given. *Independent simple t test; **One-Way ANOVA

When district-year level ecological associations were examined, total respiratory admissions showed a **positive correlation with $PM_{2.5}$ in Bozüyük and a negative correlation in the city centre**, alongside a negative correlation with $NO_2$ in both districts. The strength of the association between $PM_{2.5}$ and respiratory admissions was greater in Bozüyük, where a concurrent positive correlation with temperature was also observed. Correlations with $PM_{10}$ were weaker and of smaller magnitude. Total cardiovascular admissions demonstrated a positive correlation with $PM_{2.5}$ and temperature in both districts. In addition, a strong negative correlation was observed between cardiovascular admissions and $PM_{10}$ in Bozüyük, whereas a moderate negative association was present in the city centre. Correlations with $NO_2$ were weaker and less consistent across districts (Table 4).

## 4. DISCUSSION

The present ecological study revealed notable temporal and spatial differences between the two districts of Bilecik in terms of both air quality indicators and hospital admissions over the period 2020–2024. Consistent with national emission inventories and regional assessments from other industrial provinces in Türkiye, $PM_{10}$ levels showed a declining trend in both districts (9,12,13). This pattern likely reflects the combined impact of emission control measures in stationary sources, improvements in residential fuel quality and temporary reductions in traffic-related emissions

during the early pandemic period. The downward trend in $PM_{10}$ therefore appears to be partly policy-linked, suggesting that long-term emission control strategies may have yielded measurable improvements in coarse-particle exposure.

**Table 3. Distribution of health visits by year and hospital location**

| Type of disease | Location | Years | | | | |
|---|---|---|---|---|---|---|
| | | 2020 | 2021 | 2022 | 2023 | 2024 |
| Acute bronchitis | Center | 422 | 761 | 186 | 554 | 2391 |
| | Bozüyük | 1063 | 330 | 966 | 1485 | 857 |
| Asthma | Center | 3119 | 2768 | 1681 | 1640 | 1967 |
| | Bozüyük | 3226 | 2431 | 2194 | 3806 | 3689 |
| COPD | Center | 1909 | 2087 | 1721 | 2594 | 2319 |
| | Bozüyük | 2769 | 1216 | 1527 | 2099 | 2427 |
| Pneumonia | Center | 4019 | 2791 | 1251 | 834 | 746 |
| | Bozüyük | 3762 | 1675 | 1790 | 2818 | 2867 |
| Respiratory failure | Center | 87 | 109 | 39 | 55 | 36 |
| | Bozüyük | 184 | 181 | 243 | 320 | 382 |
| Rhinitis | Center | 6350 | 7989 | 7976 | 11808 | 12124 |
| | Bozüyük | 4054 | 3148 | 5846 | 10237 | 5596 |
| Lung cancer | Center | 74 | 72 | 72 | 140 | 97 |
| | Bozüyük | 17 | 14 | 40 | 64 | 73 |
| Skin cancers | Center | 3 | 11 | 4 | 187 | 331 |
| | Bozüyük | 5 | 8 | 20 | 103 | 62 |
| Bladder cancer | Center | 119 | 172 | 90 | 93 | 138 |
| | Bozüyük | 55 | 62 | 44 | 4 | 3 |
| Allergic conditions | Center | 3301 | 4513 | 3808 | 4503 | 5330 |
| | Bozüyük | 2456 | 3324 | 3141 | 3842 | 3164 |
| Dermatitis | Center | 217 | 262 | 283 | 330 | 474 |
| | Bozüyük | 185 | 219 | 320 | 279 | 271 |
| Myocardial infarction | Center | 193 | 79 | 153 | 294 | 450 |
| | Bozüyük | 676 | 697 | 396 | 340 | 328 |
| Heart failure | Center | 814 | 900 | 1031 | 1386 | 1037 |
| | Bozüyük | 1166 | 1310 | 1182 | 879 | 1330 |
| Hypertension | Center | 12692 | 10601 | 14242 | 21545 | 25649 |
| | Bozüyük | 8505 | 6817 | 9486 | 10274 | 12876 |

The total number of applications for diseases is given annually.

In contrast, $PM_{2.5}$ concentrations increased over the study period, with higher and more persistent levels observed in Bozüyük. This divergence between $PM_{10}$ and $PM_{2.5}$ trends is in line with international evidence indicating that, although reductions in coarse particles may be achieved through technological and regulatory measures, fine particulates remain strongly influenced by combustion processes, secondary aerosol formation and mixed industrial sources. (1,14,15). In mid-sized industrial settlements such as Bozüyük, where freight transport and industrial activity are more pronounced, these mechanisms may contribute to a sustained $PM_{2.5}$ burden, even in the presence of reductions in $PM_{10}$.

The temporal distribution of hospital admissions also reflected pandemic-related dynamics. Both respiratory and cardiovascular admissions declined

in 2020–2021 and increased again from 2022 onwards, consistent with hospital-based studies from Türkiye and international literature reporting fluctuations in respiratory hospitalizations in relation to changes in air pollution levels and healthcare utilization patterns during and after the pandemic (16,17). This pattern likely represents the combined effect of reduced healthcare attendance in the early pandemic phase and the resumption of routine care and mobility in later years, underlining the importance of interpreting environmental health indicators within their broader social and service-delivery context.

**Table 4. Correlation between key air pollutants and total respiratory / cardiovascular admissions at the district–year level (2020–2024)**

| Pollutant / Variable | Respiratory total r (p) | Cardiovascular total r (p) |
|---|---|---|
| **Merkez** | | |
| $PM_{10}$ | **0,980** (<0.001)* | **–0.551** (<0.001) |
| $SO_2$ | **0.430** (<0.001) | **–0.653** (<0.001) |
| NO | 0.136 (0.130) | 0.054 (0.547) |
| $NO_2$ | **–0.897** (<0.001) | 0.143 (0.109) |
| $PM_{2.5}$ | **–0.777** (<0.001) | **0.774** (<0.001) |
| $O_3$ | **0.777** (<0.001) | **–0.774** (<0.001) |
| Temperature | 0.128 (0.153) | **0.690** (<0.001) |
| **Bozüyük** | | |
| $PM_{10}$ | **0.211** (0.001) | **–0.858** (<0.001) |
| $SO_2$ | **–0.211** (0.001) | **0.626** (<0.001) |
| NO | **0.397** (<0.001) | **–0.235** (<0.001) |
| $NO_2$ | **–0.526** (<0.001) | **0.264** (<0.001) |
| $PM_{2.5}$ | **0.497** (<0.001) | **0.673** (<0.001) |
| $O_3$ | **0.397** (<0.001) | **–0.235** (<0.001) |
| Temperature | **0.497** (<0.001) | **0.673** (<0.001) |

r values represent the Spearman correlation coefficient.

At the district–year level, total respiratory admissions showed a positive correlation with $PM_{2.5}$ in Bozüyük and a negative correlation in the city centre, while $NO_2$ was negatively associated with respiratory admissions in both districts. These results should be interpreted in light of pollutant mixtures and local emission profiles rather than as single-pollutant effects. Nevertheless, they remain broadly compatible with previous reviews and regional studies demonstrating that particulate-matter exposure is associated with increased hospitalizations for asthma, COPD and acute bronchitis at the population level (16,17). In this context, the stronger and directionally positive $PM_{2.5}$ association in Bozüyük may reflect the higher industrial and traffic-related exposure burden in this district. By contrast, the negative association observed in the city centre should not be interpreted as indicating a causal or protective effect. Instead, it may reflect ecological characteristics of the dataset, including concurrent temporal trends in both pollutant concentrations and healthcare utilization, as well as other contextual factors such as population mobility and healthcare-seeking behaviour during the study period. Because the analysis relied on annual aggregated indicators, inverse correlations may arise from overlapping temporal patterns rather than a direct causal relationship. Therefore, the observed negative relationship should be interpreted cautiously as a population-level association within the limitations of the ecological study design.

Similarly, total cardiovascular admissions were positively correlated with $PM_{2.5}$ and temperature

in both districts, while $PM_{10}$ showed a negative association, particularly in Bozüyük. The positive association with $PM_{2.5}$ is consistent with ecological and time-series evidence linking fine particulate exposure with cardiovascular morbidity through pathways such as systemic inflammation, oxidative stress and endothelial dysfunction (18,19). The negative association with $PM_{10}$, by contrast, likely reflects the relative decline of coarse-particle emissions over time in parallel with the increasing dominance of $PM_{2.5}$, rather than a protective effect of $PM_{10}$ itself. The stronger associations observed in Bozüyük may therefore be interpreted in terms of its higher industrial intensity and pollutant burden. In addition, recent analyses have highlighted the modifying role of ambient temperature on respiratory and cardiovascular morbidity, supporting the descriptive association observed in the present study (20).

Taken together, the findings of this study indicate patterns of co-variation between air quality indicators and major disease-group admissions at the ecological level, rather than individual-level causal effects. The heterogeneity across districts and years suggests that local emission characteristics, climatic factors and healthcare-seeking behaviour may modulate the strength and direction of associations. Even so, the parallel rise in $PM_{2.5}$ concentrations and the stronger ecological associations observed in Bozüyük provide context-specific, policy-relevant evidence emphasizing the need to prioritize fine-particulate monitoring and control strategies in medium-sized industrial provinces.

## 5. CONCLUSION

This five-year ecological analysis demonstrates that air quality indicators and major respiratory and cardiovascular admissions exhibit distinct temporal and spatial patterns across two districts with differing industrial and traffic characteristics. While $PM_{10}$ levels declined, $PM_{2.5}$ concentrations increased — particularly in Bozüyük — where higher pollutant levels coincided with stronger district-level associations with healthcare utilization. Although the results do not imply causality at the individual level, they highlight the importance of strengthening $PM_{2.5}$-focused monitoring, integrating environmental indicators into local health-surveillance systems and supporting targeted environmental–public-health policies in mid-sized industrial regions.

## 6. LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. First, the ecological design does not allow individual-level exposure assessment, and therefore causal relationships between air pollution and health outcomes cannot be established. Second, air pollution exposure was estimated using annual mean concentrations from fixed monitoring stations, which may not fully capture intra-district variability or individual exposure differences. Third, hospital admission data reflect healthcare utilization rather than true disease incidence and may have been influenced by changes in healthcare-seeking behavior, particularly during the COVID-19 pandemic period. Finally, because the analyses were conducted using annual aggregated data, seasonal variations and short-term exposure effects could not be evaluated. Despite these limitations, the study provides a district-level overview of air quality and health indicators in a medium-sized industrial province where long-term environmental health evaluations remain limited.

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### Peer-Review

Double blind both externally and Internally Peer Reviewed

### Conflict of Interest

The authors declare that they have no conflict of interests regarding content of this article..

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## Ethical Declaration

This study was approved by the KTO Karatay University Faculty of Medicine Non-Drug and Medical Device Research Ethics Committee (IRB: 26.12.2024-018). Subsequent permissions were obtained from the Bilecik Provincial Health Directorate and the Bilecik Provincial Directorate of Environment, Urbanization and Climate Change.

## Authorship Contributions

Concept: MY, Design: MY, Supervising: MY, HK, Financing and equipment: MY, HK, Data collection and entry: MY, HK, Analysis and interpretation: MY, HK, Literature search: MY, HK, Writing: MY, Critical review: MY, HK

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