MEYA
MEYAFARQIN MEDICAL JOURNAL
Year: 2022 Volume: 1 Issue: 1-2

MINI REVIEW

10.5281/zenodo.7482444

Air pollution and cancer biology

Hani Abu Tziam[1]

1. Department of Family Medicine, Clalit City, Lod, Israel

OPEN ACCESS

Correspondence
Abu Tziam H, Department of Family Medicine, Clalit City, Lod, Israel

e-mail
abusiamhani@gmail.com

Received: 5 October 2022
Revised: 30 October 2022
Accepted: 1 November 2022
Published: 26 December 2022

Keywords
- Air pollution
- Biology
- Cancer
- Lung cancer
- Particulate matter

meyamed.com
2022 Published by The MEYA.

Abstract

The development of an urban city is primarily influenced by three major trends: industrialization, urbanization, and rapid socioeconomic advancement. The slow degradation of the environment that results from these activities is caused by an increase in harmful pollutants, the effects of which will become apparent in the not-too-distant future in the form of a number of natural disasters, diseases, and ecological repercussions. The main criteria of urban health in terms of delivering multiple benefits to the surrounding biota are various urban ecosystems, such as urban forestry, wetland, grassland, parks/gardens, and so on and so forth. However, these regulatory systems have been hit hard by a variety of industrial pollution stresses, which has led to a decline in both their physicochemical quality and their biotic diversity. On the other hand, there has been discussion regarding the impact that air pollution has on human and animal populations in terms of a variety of diseases, such as bronchitis, cardiopulmonary arrest, cancer, liver dysfunction, and kidney dysfunction.

Since it raises people's susceptibility to a wide range of illnesses, including cancer, air pollution has emerged as a major worldwide concern to human health. In the modern world, air pollution is caused by a wide variety of enterprises, some of which include petrochemical companies, chemical factories, fertilizer units, and metallurgical installations. In addition to the manufacturing sector, the primary contributors to air pollution include a few distinct kinds of power plants, automobiles, trains, airports, and combustion engines. The link between air pollution, particulate matter and air pollution, and DNA methylation, with a particular focus on lung cancer, was looked into in this study.

Introduction

The contamination of the atmosphere that occurs as a direct consequence of the presence of chemical compounds, gases, or particulate matter is referred to as "air pollution" (1). These polluting compounds have the potential to cause annoyance, illnesses, or even the deaths of millions of people each year (1,2). They are also able to cause harm to the flora and fauna, as well as other living creatures, such as animals and crops used for food. These pollutant elements have the potential to produce smog as well as acid rain, both of which may contribute to the development of respiratory and cancerous illnesses as well as the loss of the ozone layer, which plays a role in the acceleration of global warming. Air pollution has a negative impact on many aspects of society, including labor productivity, the number of hours worked by agricultural laborers, and the cognitive performance of pupils in schools (3,4).

This article's primary purpose is to investigate the findings of previously published research on the negative impacts of air pollution on human health and well-being, and its concentration is on more recent findings. Several categories of the most prevalent air pollutants and the many sources of those pollutants were discussed. Additionally, the link between the concentrations of air pollutants and respiratory diseases, lung malignancies, as well as worker productivity and performance, was shown and explained.

Pollution problem

The problem of pollution has emerged as one of the most significant existential obstacles of the Anthropocene period. Pollution endangers the stability of the Earth's support systems and threatens the continued existence of human civilizations, much as climate change, the loss of biodiversity, ocean acidification, desertification, and the depletion of the world's fresh water supply (5). In the last five hundred years, there has been a rapid rise in pollution, particularly pollution generated by industrial emissions, automotive exhausts, and hazardous chemicals. The highest increases in pollution that are being witnessed now are in nations with low incomes and those with intermediate incomes. Industrial, vehicular, and chemical pollution in developing countries has been largely overlooked in international development and global health agendas, and programs for pollution control have received little attention or resources from either international agencies or philanthropic donors, despite the fact that its magnitude is both large and growing (6). Pollution is currently a significant issue that threatens the health of billions of people, damages the ecosystems of the Earth, weakens the economic security of countries, and is responsible for a tremendous worldwide burden of sickness, disability, and death at an early age. The state of the environment on a global scale is directly influenced by pollution (7). Fuel combustion, which includes fossil fuel combustion in high-income and middle-income countries as well as the burning of biomass in low-income countries through inefficient cookstoves, open fires, agricultural burns, forest burning, and obsolete brick kilns, is responsible for 85 percent of the airborne particulate pollution as well as almost all of the pollution caused by oxides of sulphur and nitrogen. Combustion of fuel is the primary source of greenhouse gases and other short-lived climate pollutants, which are the primary anthropogenic contributors to the progression of global climate change. The costs associated with pollution are substantial (8). These costs include lost productivity, increased medical expenses, and expenditures incurred as a consequence of damaged ecosystems. However, despite the size of these expenses, the vast majority of them are not apparent, and the majority of the time, they are not recognized as being caused by pollution. The decreases in productivity that result from illnesses caused by pollution are hidden deep within labor statistics (9). The consequences of pollution to health are often not taken into account when hospital budgets are created. As a consequence of this, the entire costs of pollution are underappreciated, are often not measured, and are not readily accessible to counter one-sided, economically based arguments against the regulation of pollution. The characteristics of pollution are shifting, and in many parts of the globe, the problem is becoming more worse (8,9). These shifts are a result of a rise in energy consumption, an increase in the use of new materials and technologies, the fast industrialization of low-income and middle-income nations, and the migration of inhabitants from rural regions into urban centers around the globe. There has been a gradual improvement in the quality of air and water in residential areas, two types of pollution that have traditionally been linked to extreme poverty and more conventional ways of living. Air pollution, chemical pollution, and soil pollution are all on the rise, but ambient air pollution is growing the most (9).

Particulate matters (PM)

The aggregate of potentially harmful solid and liquid particles that are floating in the air is referred to as particulate matter (9). They are made up of both organic and inorganic particles and include things like dust, pollen, and droplets of liquid. On the basis of their diameters, PM may be divided into three distinct categories: coarse (with a diameter of 10 micrometers; PM10), fine (with a diameter of 2.5 micrometers; PM2.5), and ultrafine (with a diameter of 0.1 micrometers; PM0.1). Fine particles are formed during the combustion process and are made of metals, organic molecules, sulfate, nitrate, and other such substances (9,10). Coarse PM is mainly created by dust on roadways, dust generated from construction operations, and industrial emissions. These minute particles have the potential to travel significant distances, perhaps more than 100 kilometers. The PM concentration, on the other hand, fluctuates depending on the area and is often more hazardous during working hours owing to the increased volume of traffic. The disorders that are caused by PM are outlined in further detail in Table 1. In addition to causing a variety of ailments, particulate matter 2.5 micrometers in diameter (PM2.5) also change epigenetic age, which is a measure of mortality and disease risk (11). Another piece of research has shown that exposure to PM 2.5 promotes disturbance of the circadian rhythm and metabolic dysfunction. This is accomplished by downregulating histone deacetylases 2, 3, and 4, which in turn changes the dynamics of the chromatin. Alterations in the transcriptome profile that were brought on by air pollution have also been identified. The presence of PM2.5 in the environment during pregnancy has been connected to distinct gene expressions in the early stages of life, which is significant for the development of complicated disorders. In bronchial epithelial cells, a different transcriptome and DNA methylomic profile was found to be created based on the amount of PM2.5 that was present as well as the length of time that the cells were exposed to the substance (Figure 1) (12).

Air pollution and DNA methylation

Emerging data suggest that air pollutants may modify epigenetic states, such as DNA methylation and the expression of miRNAs. These epigenetic states include: Epithelial cells taken from the aerodigestive tract of heavy smokers have been shown to have abnormal methylation of numerous genes linked to the development of lung cancer. It has been shown that the bronchial epithelium and peripheral lymphocytes of smokers have an elevated level of the chemical

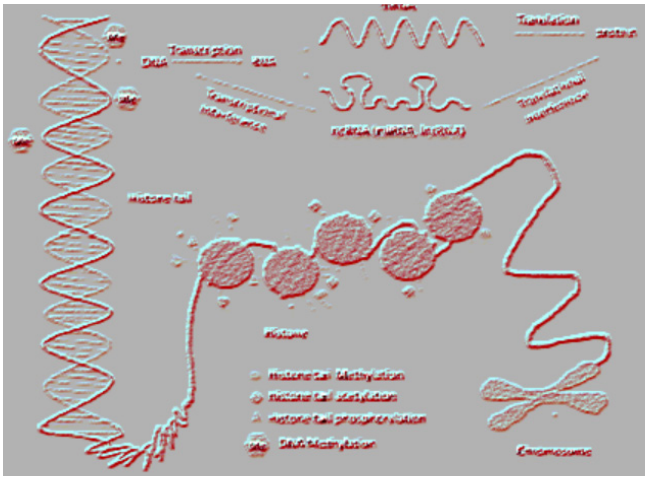

Figure 1: DNA methylation

Table 1: Epigenetic modifications caused by air pollution increase the risk of a variety of diseases

	Air pollutants	Epigenetic mark	Disease /interact
1	PM2.5	Promoter methylation of the tumor suppressor p16gene	Lung cancer
2	PM2.5	H3K27ac (histone 3 lysine 27 acetylation)	Inflammatory responses
3	Prenatal exposure to PM2.5	Lower expression levels of the miR-17/92 cluster in cord blood	Cancer risk, disease predisposition in later life
4	PM2.5, PM10, PAH, O3	Hypermethylation of Foxp3 locus	Asthma
5	PAH, Nitro-PAH, PM2.5	Promoter methylation of CDKN2A, APC, and MLH1 genes and hypomethylation of the LINE-1	Cancer risk
6	Coke oven emissions (COE), PAHs	Hypomethylation of LINE-1 and AhRR gene	Lung cancer
7	Cigarette smoke	CpG methylation of gene AIRE, PENK, and SLC6A3	Non-small cell lung cancer
8	Second-hand-smoke	DNA methylation of several CpG loci	Bladder cancer
9	Smoke	Altered methylation of GSTP1, FHIT, and CDKN2A, SCGB3A1 and BRCA1 genes	Breast cancer

methylation known as hypermethylation, which has been linked to the growth of cancer (13). Both the methylation of DNA and the alteration of histones may be caused by exposure to metals. Metal-rich air particles cause certain promoters of transcriptionally active genes to develop H3K4me2 and H3K9ac patterns (13,14). When mitochondrial DNA is exposed to metals, methylation also occurs in it. It is important to keep in mind that fine PM has a pro-oxidant character that is rather powerful, and mitochondrial DNA is more prone to oxidative damage than other types of DNA owing to the absence of introns and histone proteins (14). DNA extracted from the sperm of mice that had been exposed to the air of a steel industry was found to be in a persistently hypermethylated condition, even after the mice's exposure to the air had terminated. In leukocytes and buccal cells, exposure to PM2.5 and PM10 has been shown to cause hypomethylation of Alu and/or LINE1 (Long Interspersed Nuclear Element-1) elements. This was discovered via epidemiological research. PM exposure also changes the DNA methylation in the NOS2A gene, which is involved in the synthesis of nitric oxide, which is essential for the health of the cardiovascular system and respiratory system (15,16). There is a correlation between exposure to PM2.5 during pregnancy, particularly in the first trimester, and worldwide DNA hypomethylation in the placental tissue. Exposure to high amounts of particulate matter (PM) as well as ozone is linked to hypermethylation of the FOXP3 gene in regulatory T cells. In addition, direct exposure to PM2.5 promotes methylation of the p16 promoter, which is a gene that inhibits the growth of tumors, in the alveolar epithelial cells of mice as well as in human lungs (17). It has been shown that patients who have been exposed to PM have a higher expression level of DNA methyltransferase 1, also known as DNMT1. This might be one of the mechanisms that induces methylation in the p16 promoter region. Studies have shown that exposure to PM2.5 induces DNA methylation in several CpG loci of inducible nitric oxide synthase (iNOS) genes. iNOS genes are the primary enzyme responsible for the production of nitric oxide in the airways (18). These studies were conducted in an effort to establish a link between childhood asthma and air pollution. According to the findings of another piece of research, even brief periods of exposure to air pollution may cause changes in the DNA methylation

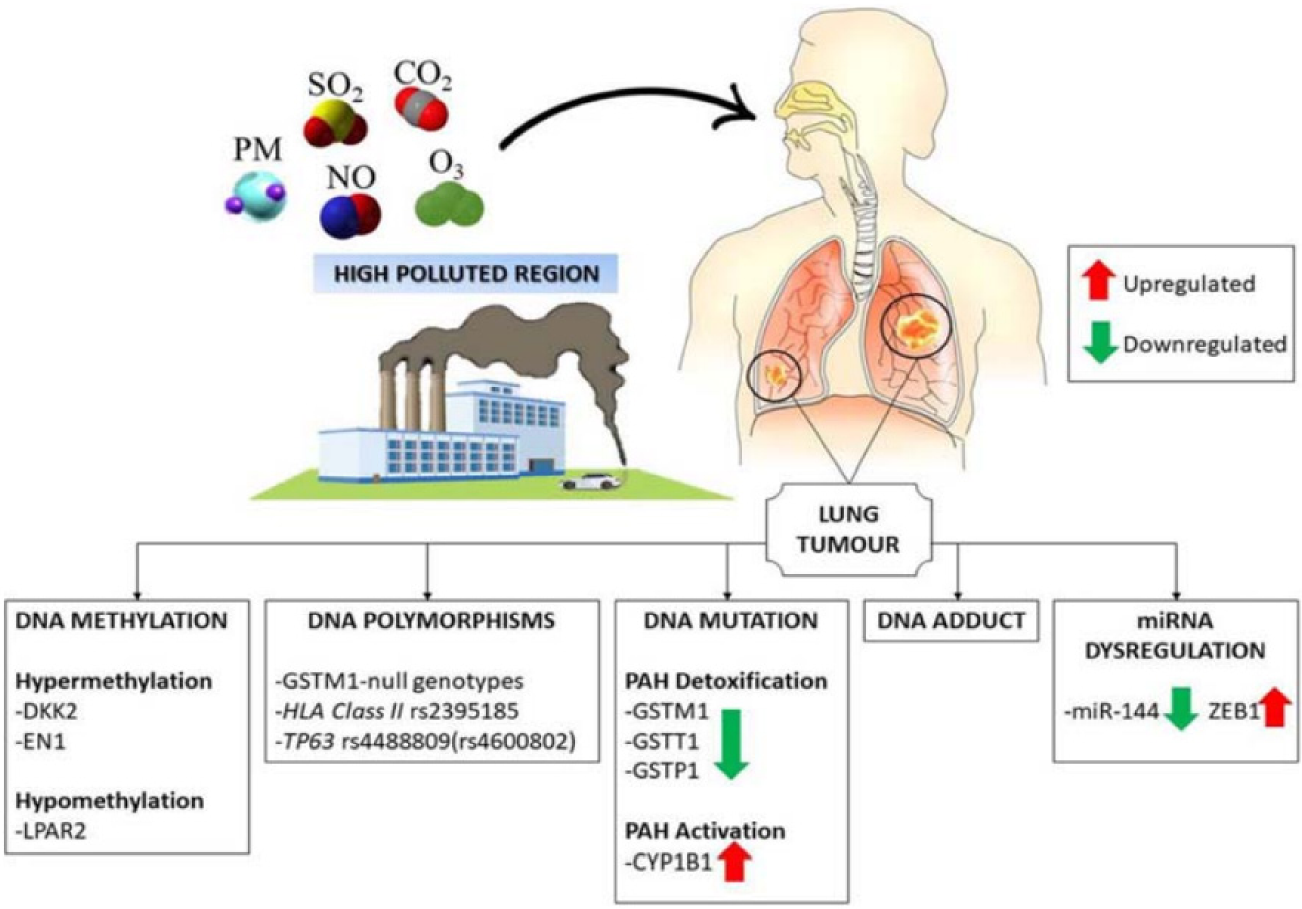

Figure 2: The potential mechanism and biomarkers in air pollution-related lung cancer

pattern in the promoter region of the iNOS gene. All of these findings point to separate channels via which air pollution may have an effect on the phenotypic expression of organisms (19,20).

Lung Cancer

The World Health Organization (WHO) just recently made the announcement that air pollution is now considered to be a human carcinogen. This was done in response to the growing body of evidence that has been gathered by researchers all over the world indicating that air pollutants are risk factors for developing cancers of the lung, nasopharyngeal, head, and neck. It has also been claimed that environmental air pollution is the major cause of mortality from cancer. Furthermore, particulate matter, depending on the size of its particles, might enter the alveoli (21). Carcinogenesis in the respiratory system may be caused by particulate matter as it travels to alveoli. In addition, the researchers came to the conclusion that lung cancer caused by exposure to PM2.5 accounts for 7% of the overall death rate (22). Figure 2 illustrates the various mechanisms and biomarkers involved in lung cancer caused by exposure to air pollution. The findings of epidemiological research have provided conclusive evidence that air pollution are substantially associated to the development of lung tumors. Knibbs et al. (23) conducted research to investigate the connection between the lung function of Australian children and the amount of time they were exposed to air pollution. As evidence for lung function, measurements of forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), and fraction exhaled nitric oxide (FENO) were taken, and the findings were correlated with each child's most recent exposure to NO2 near their respective schools. According to the results of their research, an increase in NO2 exposure was substantially related to a decrease in FEV1 and FVC of roughly 1.3% and 1.19%, respectively. On the other hand, FENO was shown to be roughly 71% higher as a result of exposure to NO2 (24).

In adult non-smokers, a connection was found between short-term exposure to air pollution and inflammatory markers as well as lung function. This association was not seen in smokers. The findings demonstrated that an increase in NO2 led to a reduction in FEV1/FVC ratio, FVC, and FEF at 75% of FVC by 0.38%, 1.7%, and 3.07%, respectively; on the other hand, an increase in PM10 led to a reduction in FEF at 75% of FVC by 1.41 (24). These findings were supported by the findings that an increase in PM10 led to a reduction in FEF at 75% of FVC by 1.41. In conclusion, an increase in O3 levels was shown to be associated with a higher blood eosinophil count (+ 2.41 [0.10; 4.77]). It has been found that the findings obtained by Kinbbs et al. (23) about the impact of exposure to NO2 on the decreasing rate of FVC as evidence of lung function were considerably near to those obtained by Dauchet and co-workers (24). This is something that has been seen. In 2015, researchers Kulhánová and her colleagues analyzed the experimental findings that relate the inhalation of fine particulate matter PM2.5 with the development of lung cancer in France (25). They came to the conclusion that being exposed to PM2.5 may be held responsible for 3.6% of all incidences of lung cancer that were identified during that time period. In addition to this, researchers investigated whether or not there was a link between lung cancer mortality (LCM) and air pollution (25,26). An increase in lung cancer mortality rate of around 6% was estimated to have been caused by increments of 10 ug/m3 in PM2.5, PM10, and SO2 air pollutants. Additionally, it was shown that the relative humidity and the amount of particulate matter in the air are the two most significant parameters linked with LCM. It has been established via prior studies that the researchers have shed light on the influence that NO2 and particulate matter have on lung cancer, but they have forgotten to investigate the effect that the other air pollutants have (27,28).

Conclusions

Research on the key causes of air pollution and the adverse impacts it has is experiencing a surge at the moment. Air pollution has a negative impact on human health, degrades the environment in which plants grow, and corrodes civilization on several levels, including the physiological, psychological, and economic levels. The effects of air pollution on human well-being, working hours, and productivity were discussed at the very end of the presentation.

Conflict of interest

The authors report no conflict of interest.

Funding source:

No funding was required.

Ethical approval:

No need for reviews.

Acknowledge: No

Contributions

Research concept and design: **HAT**
Data analysis and interpretation: **HAT**
Collection and/or assembly of data: **HAT**
Writing the article: **HAT**

Critical revision of the article: **HAT**
Final approval of the article: **HAT**

References

1. Scovronick N, Dora C, Fletcher E, Haines A, Shindell D. Reduce short-lived climate pollutants for multiple benefits. Lancet. 2015;386(10006):e28-31.
2. Schmale J, Shindell D, von Schneidemesser E, Chabay I, Lawrence M. Air pollution: clean up our skies. Nature. 2014;515(7527):335-7.
3. Scovronick N, Budolfson M, Dennig F, Errickson F, Fleurbaey M, Peng W, Socolow RH, Spears D, Wagner F. The impact of human health co-benefits on evaluations of global climate policy. Nat Commun. 2019;10(1):2095.
4. Lemjabbar-Alaoui H, Hassan OU, Yang YW, Buchanan P. Lung cancer: Biology and treatment options. Biochim Biophys Acta. 2015;1856(2):189-210.
5. Ji H, Khurana Hershey GK. Genetic and epigenetic influence on the response to environmental particulate matter. J Allergy Clin Immunol. 2012;129(1):33–41.
6. White AJ, Kresovich JK, Keller JP, Xu Z, Kaufman JD, Weinberg CR, Taylor JA, Sandler DP. Air pollution, particulate matter composition and methylation-based biologic age. Environ Int. 2019;132:105071.
7. Palanivel R, Vinayachandran V, Biswal S, Deiuliis JA, Padmanabhan R, Park B, Gangwar RS, Durieux JC, Ebreo Cara EA, Das L, Bevan G, Fayad ZA, Tawakol A, Jain MK, Rao S, Rajagopalan S. Exposure to air pollution disrupts circadian rhythm through alterations in chromatin dynamics. iScience. 2020;23(11):101728.
8. Merid SK, Bustamante M, Standl M, Sunyer J, Heinrich J, Lemonnier N, Aguilar D, Antó JM, Bousquet J, Santa-Marina L, Lertxundi A, Bergström A, Kull I, Wheelock ÅM, Koppelman GH, Melén E, Gruzieva O. Integration of gene expression and DNA methylation identifies epigenetically controlled modules related to PM2.5 exposure. Environ Int. 2021;146:106248.
9. Cohen AJ. Outdoor air pollution and lung cancer. Environ Health Perspect. 2000;108(Suppl 4):743–750.
10. Molina JR, Yang P, Cassivi SD, Schild SE, Adjei AA. Non-small cell lung cancer: epidemiology, risk factors, treatment, and survivorship. Mayo Clin Proc. 2008;83(5):584-94.
11. Feng J, Cavallero S, Hsiai T, Li R. Impact of air pollution on intestinal redox lipidome and microbiome. Free Radic Biol Med. 2020;151:99-110.
12. Breton CV, Marutani AN. Air pollution and epigenetics: recent findings. Curr Envir Health Rpt. 2014;1:35–45.
13. Brock MV, Hooker CM, Ota-Machida E, et al. DNA methylation markers and early recurrence in stage I lung cancer. N Engl J Med. 2008;358(11):1118–1128.
14. Byun HM, Panni T, Motta V, et al. Effects of airborne pollutants on mitochondrial DNA methylation. Part Fibre Toxicol. 2013;10:18.
15. Cantone L, Tobaldini E, Favero C, Albetti B, Sacco RM, Torgano G, Ferrari L, Montano N, Bollati V. Particulate air pollution, clock gene methylation, and stroke: effects on stroke severity and disability. Int J Mol Sci. 2020;21(9):3090.
16. Bhargava A, Tamrakar S, Aglawe A, et al. Ultrafine particulate matter impairs mitochondrial redox homeostasis and activates phosphatidylinositol 3-kinase mediated DNA damage responses in lymphocytes. Environ Pollut. 2018;234:406–419.
17. Callahan CL, Bonner MR, Nie J, Wang Y, Tao MH, Shields PG, Marian C, Eng KH, Trevisan M, Freudenheim JL. Active and secondhand smoke exposure throughout life and DNA methylation in breast tumors. Cancer Causes Control. 2019;30(1):53–62.
18. De Nys S, Duca RC, Nawrot T, et al. Temporal variability of global DNA methylation and hydroxymethylation in buccal cells of healthy adults: Association with air pollution. Environ Int. 2018;111:301–308.
19. Breton CV, Salam MT, Wang X, Byun HM, Siegmund KD, Gilliland FD. Particulate matter, DNA methylation in nitric oxide synthase, and childhood respiratory disease. Environ Health Perspect. 2012;120(9):1320–1326.
20. Yauk C, Polyzos A, Rowan-Carroll A, et al. Germ-line mutations, DNA damage, and global hypermethylation in mice exposed to particulate air pollution in an urban/industrial location. Proc Natl Acad Sci U S A. 2008;105(2):605–610.
21. Wong IC, Ng YK, Lui VW. Cancers of the lung, head and neck on the rise: perspectives on the genotoxicity of air pollution Chin J Cancer. 2014;33:476–480.
22. Falcon-Rodriguez CI, Osornio-Vargas AR, Sada-Ovalle I, Segura Medina P. Aeroparticles, composition, and lung diseases. Front Immunol. 2016;7:3.
23. Knibbs LD, Cortés de Waterman AM, Toelle BG, Guo Y, Denison L, Jalaludin B, Marks GB, Williams GM. The Australian Child Health and Air Pollution Study (ACHAPS): A national population-based cross-sectional study of long-term exposure to outdoor air pollution, asthma, and lung function. Environ Int. 2018;120:394-403.
24. Dauchet L, Hulo S, Cherot-Kornobis N, Matran R, Amouyel P, Edme JL, Giovannelli J (2018) Short-term exposure to air pollution: associations with lung function and inflammatory markers in non-smoking, healthy adults. Environ Int 121:610–619
25. Kulhánová I et al. The fraction of lung cancer incidence attributable to fine particulate air pollution in France: impact of spatial resolution of air pollution models. Environ Int 2018;121:1079–1086.
26. Demetriou CA et al. Biomarkers of ambient air pollution and lung cancer: a systematic review. Occup Environ Med 2012;69:619–627.
27. Zhu F et al. The short-term effects of air pollution on respiratory diseases and lung cancer mortality in Hefei: a time-series analysis. Respir Med 2019;146:57–65.
28. Dicleli M, Alabalık U, Bıçak T, Yıldız G, Sertakan H, Nacir M. Plasmacytoma: A Rare Case of Bone Malignancy . J Clin Trials Exp Investig. 2022;1(1 March-June):17-21.