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(*) Corresponding author
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THE IMPACT OF AIR POLLUTION ON ALLERGIC REACTIONS OF THE UPPER RESPIRATORY TRACT

Gabriel Zhivkovikj*
Clinical Hospital Dr. Trifun Panovski – Bitola
gabriel.zhivkovikj@gmail.com

Denis Arsovski
University St. Kliment Ohridski Bitola, Higher Medical School Bitola
denis.arsovski@uklo.edu.mk

Angelka Jankulovska
University St. Kliment Ohridski Bitola, Higher Medical School Bitola
angelka.jankulovska@uklo.edu.mk

Abstract

Introduction*: Air pollution is a growing concern due to its adverse effects on health, particularly respiratory conditions such as allergic reactions of the upper respiratory tract. This study investigates the relationshipbetween air pollution exposure and thefrequency and severity of allergicsymptoms in individuals from differentdemographic backgrounds.*
Materials and Methods*: A questionnaire-based study will be conducted among individuals of varying ages, occupations, and living conditions. The survey will include questions about personal exposure to outdoor and indoor air pollution, the frequency of allergic symptoms, and the perceived quality of air in the participant's environment. Participants will also be asked to assess any correlation between air pollution and their allergic symptoms, including sneezing, nasal congestion, throat irritation, and eye itching.*
Discussion*: Preliminary data suggest a strong correlation between exposure to both outdoor and indoor air pollution and the frequency of allergic reactions, particularly during high-pollution seasons like spring and autumn. Many participants reported worsening symptoms in polluted environments and improvement in cleaner air settings, highlighting the role of air quality in managing allergic conditions.*
Conclusion*: The study confirms that air pollution significantly affects allergic reactions in the upper respiratory tract. Measures such as improving air quality and reducing exposure to pollutants, especially in urban and industrial areas, are essential for managing respiratory allergies. Further research is needed to explore long-term effects and interventions to mitigate the impact of air pollution on respiratory health.*

Keywords:Air pollution; Allergic reactions; Upper respiratory tract; Respiratory health

INTRODUCTION

Air pollution has emerged as a significant public health issue due to the rapid processes of industrialization, urbanization and global population growth.[1]

Harmful pollutants released into the atmosphere, PM-10 and PM-2.5 particles, sulfur dioxide (SO2), nitrogen oxides (NOx), ozone (O3) and various organic compounds, pose

significant health risks to every individual.[2]These pollutants arise from a variety of sources, such as motor vehicle emissions, industrial operations, the burning of fossil fuels, and natural occurrences, including volcanic eruptions and forest fires.[3]

Allergy is far more than huffing and sneezing for a couple of weeks during the pollen season. The quality of life of patients suffering from allergic rhinitis and allergic asthma is often severely impaired as is their social life, their career and even their school performance and work productivity and health care systems. These conditions can vary in severity, ranging from mild discomfort to significant disruption of the body's natural defenses on a daily basis.

This paper examines the role of environmental factors in the development of respiratory allergic diseases through a comprehensive review of the existing literature and scientific research, highlighting the importance of interdisciplinary approaches to address this growing public health issue. It explores the relationship between exposure to indoor and outdoor air pollution, the occurrence of allergic reactions in the upper respiratory tract, analyzing the influence of demographic variables and the increasing global prevalence of these conditions. By investigating the negative effects of air pollution on individual health, including the occurrence and management of respiratory allergies, the study seeks to improve understanding and inform the development of more effective policies. Ultimately, it aims to raise awareness of the importance of clean air and promote personal preventive measures.

Air pollution and its impact on health

Air pollution represents one of the most pressing environmental challenges of contemporary society, significantly impacting both human health and the quality of the environment.[4]

The quality of the air we inhale has a significant effect on our health. In numerous urban regions characterized by elevated pollution levels, air contaminants can lead to both acute and chronic health issues.[5]Populations particularly vulnerable to the adverse effects of polluted air include children, the elderly, pregnant women, and individuals with preexisting respiratory and cardiovascular conditions.[6]

Air pollution has emerged as a significant concern owing to its detrimental health effects, particularly with respect to respiratory disorders affecting the upper respiratory tract.This tract encompasses the nasal cavity, sinuses, and throat, which function as the primary line of defense against environmental pollutants.[7]

Allergic reactions of the upper respiratory tract

An allergy is characterized as an exaggerated, inappropriate, and non-specific response of the body to an external stimulus that is typically considered harmless, such as pollen, dust, mold spores, and various other airborne pollutants.[8]

Allergens are substances that induce allergic reactions and primarily impact the nasal passages, sinuses, throat, and ocular regions.

As the prevalence of allergies continues to increase, it is becoming increasingly critical to understand the specific mechanisms by which air pollutants affect allergic responses in the upper respiratory tract.[9] Allergic reactions typically occur in two stages. The first phase, also known as the sensitization phase, occurs when the body is exposed to a particular allergen for the first time. During this first contact, the immune system recognizes the inhaled allergen and produces proteins known as immunoglobulin E (IgE) antibodies, which are specific to that particular allergen. Second phase: allergic reaction, this phase transpires when the body is re-exposed to the allergen. The previously generated immunoglobulin E (IgE) antibodies bind to the allergen, resulting in the formation of an

antigen-antibody complex. This complex subsequently stimulates the release of pro-inflammatory mediators from mast cells, which are integral components of the immune system, thereby eliciting allergic symptoms in the upper respiratory tract.[10]

The primary conditions associated with allergic reactions in the upper respiratory tract include allergic rhinitis, sinusitis, and allergic conjunctivitis.[11]

Allergic rhinitis is among the most prevalent allergic reactions affecting the upper respiratory tract. This condition arises when the immune system responds to inhaled allergens by releasing histamines and other inflammatory mediators. The hallmark symptoms include sneezing, rhinorrhea, nasal congestion, pruritus of the nose and throat, and postnasal drip. Allergic rhinitis can be classified as seasonal, with symptoms triggered by pollen during specific times of the year, or perennial, with symptoms persisting throughout the year.[12]

Allergic sinusitis is characterized by inflammation of the sinus cavities as a result of exposure to allergens. This inflammatory response can lead to mucus build-up and subsequent sinus congestion, thereby increasing the risk of secondary infections. Common symptoms associated with allergic sinusitis include pressure and pain in the sinuses, headaches, nasal congestion, difficulty in nasal breathing, and a decreased sense of smell and taste.[13]

Allergic conjunctivitis often coexists with allergic reactions in the upper respiratory tract due to the anatomical proximity of the nasal and ocular canals. This condition occurs when airborne allergens, such as pollen or dust, come into contact with the eyes, resulting in symptoms that include itching, stinging, redness and swelling.[14]

Diagnosis, treatment, and management of allergic reactions

Diagnosis typically involves a combination of clinical history, physical examination, and allergy testing (skin prick tests or blood serum IgE levels tests). [15,16]

Skin tests represent the most prevalent and effective approach, particularly for identifying allergies to environmental allergens, including pollen, dust mites, mold, and pet dander. Conversely, blood tests assess the concentration of immunoglobulin E (IgE) antibodies, which are generated by the immune system in reaction to allergens.[17]

Management of allergic reactions affecting the upper respiratory tract requires a multifaceted approach that includes pharmacological interventions, lifestyle modifications, and immunotherapy (desensitization). Medicines that relieve allergy symptoms, such as antihistamines, work by blocking the action of histamine, while corticosteroids are used to reduce inflammation. For individuals who experience chronic allergies, the option of immunotherapy - specifically desensitization.[18]

Desensitization represents a sophisticated method for the treatment of allergies, which involves the subcutaneous administration of minimal quantities of allergens. This process aims to facilitate the immune system's development of tolerance to particular allergens.[19]

In relation to pharmacological interventions, it is recommended to take the prescribed therapy regularly(antihistamines, corticosteroids, nasal sprays) and in a timely manner together with preparations to improve immunity, especially in the seasons when the symptoms are most prominent.[20]

While lifestyle modifications can significantly reduce exposure to allergens. Implementing practical strategies such as using air purifiers equipped with HEPA filters, changing bedding routinely, and refraining from outdoor activities during elevated levels of particulate matter and pollen in the air can significantly reduce exposure to allergens.

Materials and methods

The research was conducted in the "Dr. Trifun Panovski" Clinical Hospital in Bitola, at the department of Otorhinolaryngology.The survey uses a self-administered survey questionnaire to collect data on 26 individuals representing different demographics (gender, age, residence, and occupation).A questionnaire with structured questions on demographics, air quality perception, pollution exposure and symptoms. Questions addressed frequency of exposure to outdoor and indoor air pollution, severity of allergic symptoms, and perceived air quality.Symptoms examined included sneezing and runny nose, sore throat, itching and redness of the eyes, cough, difficulty breathing (choking).

The frequency distribution was analyzed for variables such as gender, age, place of residence and occupation.Correlations between exposure and symptoms were investigated.

Dataanalysis

The study, which explores the relationship between air pollution and allergic reactions of the upper respiratory tract, provides critical insights through the analysis of data collected from 26 respondents. By examining variables such as gender, age, place of residence, occupation, and exposure to pollution, the study highlights the prevalence and patterns of allergic reactions within the population.

Table number 1. Number of respondents by gender

Gender	Number of respondents	Percentage (%)
Male	10	38.5%
Female	16	61.5%

The findings of the study indicate a higher representation of female respondents (61.5%) compared to male participants (38.5%). This gender difference provides an opportunity to investigate whether women are more likely to report or experience allergic reactions to air pollution or if their greater participation reflects other factors, such as a willingness to engage in health-related research. Sex-specific differences in allergic response patterns, such as hormonal influences or differences in occupational exposure, may further influence as a significant factor. Future studies could focus on gender-based comparative analyzes to better understand these dynamics and their implications for air pollution prevention strategies and the emergence of respiratory allergies as a significant public health issue.

Table number 2. Representation of respondents by age

Age	Number of respondents	Percentage (%)
Under 18 years old	4	15.4%
18 – 30 years old	9	34.6%
31-45 years old	6	23.1%
46 - 60 years old	5	19.2%
Over 60 years old	2	7.7%

Regarding age, individualssmallest group consists of people under 18 years old (15.4%), the largest group consists of people aged 18-30 years (34.6%), followed by those aged 31-45 years (23.1%). The youngest group, under 18, made up 15.4%, while only 7.7% of participants were over 60. This age distribution highlights the need to investigate how age affects vulnerability and symptom severity, particularly among younger and able-bodied individuals.

Table number 3. Sorting respondents by place of residence

Place of residence	Number of respondents	Percentage (%)
Urban area	13	52%
Suburban area	8	32%
Rural area	4	16%

Urban residents represented the majority (52%), followed by suburban (32%) and rural participants (16%). These results reflect the environmental disparities in exposure to air pollution, with urban areas often experiencing higher levels of outdoor pollutants such as vehicle emissions and industrial discharge. Comparisons between rural, suburban, and urban respondents could shed light on the differential impact of air pollution on allergic reactions.

Table number 4. Number of respondents by occupation

Occupation	Number of respondents	Percentage (%)
Student in primary education	4	15.4%
College student	5	19.2%
Employee	15	57.7%
Unemployed	2	7.7%

The occupational distribution revealed that the majority of respondents were employed (57.7%), while students and unemployed individuals made up smaller portions. Employees likely face regular exposure to workplace-related pollution, making this a key factor in their respiratory health.

Table number 5. Air quality assessment

Air quality	Number of respondents	Percentage (%)
High level	2	7.7%
Average level	11	42.3%
Low level	13	50%

Furthermore, the perception of air quality in the respondents' living environments was concerning. Half (50%) rated their air quality as low, and only 7.7% considered it high. This suggests widespread dissatisfaction with environmental conditions and a potential link to the prevalence of allergic reactions.

Table 6. Exposure to outdoor air pollution (e.g. traffic, industrial emissions)

Exposed to outdoor air pollution	Number of respondents	Percentage (%)
Rarely (1-2 times a week)	2	7.7%
Often (3-5 times a week)	6	23.1%
Everyday	18	69.2%

The data on outdoor air pollution exposure highlights that a majority of respondents (69.2%) reported daily exposure. This is a striking result that emphasizes the pervasive nature of outdoor pollutants in the environments where participants reside, particularly in urban and suburban settings. A smaller proportion, 23.1%, indicated exposure often (3–5 times per week), while only 7.7% reported rare exposure (1–2 times per week).This distribution underscores the critical role of outdoor air pollution as a constant health risk. The prevalence of daily exposure suggests that many participants likely live or work in areas with high traffic

emissions, industrial activities, or other sources of air pollutants. Such frequent exposure has well-documented effects on respiratory health, including exacerbating allergic conditions.

Table 7. Exposure to indoor air pollution(eg, smoking, dust, mold)

Exposed to indoor air pollution	**Number of respondents**	**Percentage (%)**
Rarely (1-2 times a week)	11	42.3%
Often (3-5 times a week)	9	34.6%
Everyday	6	23.1%

The data on indoor air pollution exposure presents a more balanced distribution compared to outdoor exposure. A significant portion of respondents (42.3%) reported rare exposure to indoor pollution, while 34.6% experienced it often (3–5 times per week), and 23.1% faced daily exposure.This variation reflects differing levels of indoor pollution sources, such as smoking, mold, dust, and inadequate ventilation, which may be more manageable than outdoor pollutants. The relatively lower frequency of daily exposure suggests that indoor environments might provide some respite from the harsher conditions outside. However, the notable proportion of respondents with frequent exposure points to the need for targeted interventions.

Table number 8. The most common symptom of allergic reaction

Symptom	**Number of Responses**	**Percentage (%)**
Sneezing and runny nose	10	38.46%
Pain in the throat	5	19.23%
Itching and redness of the eyes	7	26.92%
A cough	3	11.54%
Difficulty breathing (choking)	1	3.85%

According to the analysis of the symptoms most often associated with allergic reactions include sneezing and runny nose (38.46%), followed by itching and red eyes (26.92%). Less common symptoms include sore throat (19.23%), cough (11.54%) and shortness of breath (3.85%). These findings are consistent with conditions such as allergic rhinitis, which is caused by airborne allergens.

Table number 9. Time of year you notice the greatest increase in allergic reactions

Time of Year	**Number of Responses**	**Percentage (%)**
Spring	15	57.69%
Summer	3	11.54%
Autumn	6	23.08%
Winter	2	7.69%

Analyzing seasonal patterns further revealed that spring was the peak season for allergic reactions (57.69%), most likely due to high pollen levels, while autumn (23.08%) was the second most frequent case. This highlights the role of environmental changes in the exacerbation of symptoms.

Table number 10. The type of polluted air that influences the occurrence of allergic symptoms

Type of air pollution	**Number of respondents**	**Percentage (%)**

Outdoor pollution	8	30.8%
Indoor pollution	3	11.5%
in both situations	15	57.7%

When asked about the type of pollution most associated with their symptoms, 57.7% of respondents identified both indoor and outdoor sources, while 30.8% pinpointed outdoor pollution alone. This dual attribution underscores the complex interplay between external environmental factors and indoor conditions, such as dust and mold. It also highlights the need for integrated strategies targeting multiple pollution sources to mitigate allergic reactions effectively.

CONCLUSION

The findings of this study highlight the pervasive and detrimental impact of air pollution on respiratory health, particularly in the upper respiratory tract, where allergic reactions are common and debilitating. The evidence highlights a clear and consistent correlation between exposure to outdoor and indoor air pollution and the frequency and severity of allergic symptoms. These results highlight that environmental factors play a key role in shaping health outcomes in vulnerable populations.

The analysis reveals that urban populations are disproportionately affected, largely due to higher exposure to pollutants from vehicles and industries. Similarly, indoor environmental factors, such as dust, mold, and smoke, contribute significantly to the burden of allergic reactions, highlighting the dual importance of addressing both outdoor and indoor sources of pollution. Seasonal variations, particularly the prevalence of symptoms in spring and autumn, further emphasize the role of environmental triggers in allergic conditions.

This study also highlights demographic differences, including variations by gender, age, and occupation, suggesting that biological, behavioral, and situational factors influence susceptibility and severity of allergic reactions. These findings call for targeted interventions that take into account the unique needs of different population groups. Ultimately, combating air pollution is not just about reducing allergic reactions, but also about protecting long-term respiratory health and improving overall quality of life. By fostering collaboration among scientists, health professionals, policymakers, and communities, it is possible to create environments that support healthier lives and mitigate the far-reaching public health consequences of air pollution.

IMPLICATIONS AND RECOMMENDATIONS

The most important implication would be to recognize air quality as a critical public health priority. The strong correlation between exposure to pollutants and the prevalence of respiratory allergies underscores the urgency for action. Seasonal patterns, such as the onset of symptoms in spring and autumn, highlight the ecological sensitivity of individuals to both natural and man-made air pollution. Urban populations, given their exposure to vehicle emissions and industrial pollutants, are particularly vulnerable, highlighting the differences between urban and rural areas. [21] Furthermore, indoor pollutants such as dust, mold, and smoke, open criticism, should emphasize the need for a comprehensive approach to the impact of pollution. [22]

Policymakers should consider stricter emissions regulations and promote greener urban planning as green and clean energy transitions increase. Improved air quality monitoring will help inform. Public awareness is crucial, with education about the risks of air pollution and preventive measures, such as the use of HEPA filters and air quality

monitoring. Health services should focus on routine screening for respiratory diseases, especially in high-risk populations, and promote personalized treatment.[23] At the individual level, limiting outdoor activities in high-pollution areas, using masks, and improving indoor air quality should reduce exposure to pollutants.

Future research should extend these findings to investigate the long-term effects of air pollution on the environment of digestive products. Observational and more diverse family studies are needed to document and elucidate the underlying mechanisms of demographic differences in symptom prevalence. Integrating environmental data with clinical outcomes will also improve our understanding of how pollution affects allergic conditions.

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