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Climate-Induced Respiratory Challenges: Understanding Allergic Reactions and Asthma Caused by Pollen Allergens

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ABSTRACT

In recent years, the impact of climate change on our environment has become increasingly evident. Human activities, particularly the rise in atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases, are key contributors to this shift. These changes in climate, combined with global warming, have notable effects on weather patterns, influencing the quantity, intensity, and frequency of precipitation. Additionally, climate change is linked to a heightened occurrence of extreme events such as heatwaves, droughts, floods, and hurricanes. A significant concern is the intricate relationship between climate change and respiratory health. In this review, we highlight the association between climate change and respiratory allergies, increased prevalence and severity of asthma, and related allergic diseases. The alterations brought about by climate change significantly contribute to the development of allergic respiratory diseases and asthma. This impact extends to pollen allergies, with changes in their onset, duration, and intensity attributed to climate change. Studies indicate that plants respond to elevated atmospheric CO_2 levels with enhanced photosynthesis and reproductive effects, resulting in increased pollen production. Pollen allergies provide valuable insights into the interplay between air pollution and allergic respiratory diseases like rhinitis and asthma. Recognizing the broader health implications, it becomes crucial to address the underlying causes. Implementing measures to reduce greenhouse gas emissions emerges not only as a pivotal step in mitigating climate change but also as a proactive approach with positive health benefits. The need for a comprehensive strategy is underscored by the interconnectedness of environmental and public health concerns in the face of a changing climate.

Keywords: Climate change, Asthma, Respiratory allergy, Allergenic pollen

INTRODUCTION

Climate change has a profound impact on human health, with allergies emerging as a prominent consequence alongside infectious and cardiovascular diseases (Ayejoto et al., 2023; Tong et al., 2022) Numerous studies emphasize the influence of climate change on allergic respiratory diseases, posing a global health threat that extends to food supplies, water and air quality. Current insights are drawn from experimental and epidemiological studies exploring the correlation between allergic respiratory diseases, asthma, and environmental factors like meteorological variables, airborne allergens, and air pollution. Notably, research on respiratory allergy specifically triggered by climate change remains limited (D'Amato et al., 2016; Haines & Ebi, 2019).

The surge in respiratory allergic diseases and bronchial asthma in recent decades, especially in industrialized countries, is linked to urbanization characterized by elevated vehicle emissions and a westernized lifestyle. Climatic factors such as thunderstorms, temperature variations, humidity, and wind speed play a role in affecting both chemical and biological components of interaction. Increased carbon dioxide (CO_2) concentrations impact plant growth, leading to extended pollination periods (Crowley et al., 2021). Environmental pollutants act as irritants to skin and mucous membranes, altering allergen carriers like pollen in the atmosphere. This modification releases allergens, resulting in allergen-containing aerosols in the ambient air. Pollen, beyond its role as an allergen carrier, has been shown to release potent lipid mediators (pollen-associated

lipid mediators) with pro-inflammatory and immunomodulating effects in allergic diseases. The aim of the present article was to highlight the impact of climate change and its effects on respiratory system caused by pollen allergies.

METHOD OF LITERATURE RESEARCH

Database such as PubMed, BioMed Central, and Wiley were used to review the work done. Keywords such as “climate change”, “Asthma”, “respiratory disease”, “pollen”, “allergies” were used. Studies published in English were considered for this study.

Causes and Mechanisms of Climate Change

The regional variations in climate change patterns depend on factors such as latitude, altitude, rainfall, storms, land-use patterns, and urbanization. The impact on the prevalence of allergic diseases is intricately linked to the effectiveness of greenhouse gas mitigation strategies. Carbon dioxide (CO_2), primarily emitted from burning fossil fuels, is the dominant greenhouse gas, alongside methane (CH4), nitrous oxide (NO_2), and fluorinated gases (Watts et al., 2018).

Human activities have elevated the natural concentration of carbon dioxide, intensifying Earth's natural greenhouse effect. In 1870, before the industrial revolution, CO_2 stood at 280 parts per million (ppm). By 2018, it had risen to an average of 407.05 ppm, reaching 409.92 ppm by January 1, 2019, according to air samples analyzed by National Oceanic and Atmospheric Administration (NOAA) Global Monitoring Division (Haines & Ebi, 2019; Solomon & LaRocque, 2019).

Reducing greenhouse gas emissions can have positive health effects, but even after emission reductions, the surface air temperature is expected to rise for a century or more. This temperature increase contributes to higher concentrations of ozone and particles at ground level, driven by factors like droughts, forest fires, desertification, and increased coal energy use for cooling. The impacts of global climate change include rising temperatures, changing precipitation patterns, sea level rise, intensified extreme weather events, and the melting of glaciers, ice sheets, and Arctic sea ice (Haines & Ebi, 2019; Solomon & LaRocque, 2019).

Allergy Triggers and Pollen Allergens

Alterations in pollen allergens align with climate change, driven by the escalating concentration of CO_2 in the atmosphere. This elevated CO_2 level accelerates plant growth, intensifies pollen allergen potency, and extends both the duration and intensity of flowering. Furthermore, climate change heightens exposure and sensitivity to subtropical grasses. Early initiation and peak pollen seasons are particularly pronounced in species blooming in early spring and those responsive to warmer temperatures. Urban areas witness an earlier flourishing, with pollination occurring approximately 2 – 4 days sooner than in rural areas (Wayne et al., 2002.

Research by (Singer et al., 2005) indicates that elevated CO_2 levels directly enhance the allergenicity of ragweed pollen, potentially increasing the prevalence and severity of seasonal allergic diseases. (Wayne et al., 2002) observed a 61% increase in pollen production from ragweed per plant with a doubling of atmospheric CO_2 concentration. Additionally, Ambrosia pollen collected near high-traffic roads exhibits higher allergenicity than pollen from vegetative areas. The changing habitat patterns and species distribution of plants due to climate change further contribute to these shifts.

Studies on plant responses to elevated atmospheric CO_2 levels reveal improved photosynthesis, enhanced reproductive effects, and increased pollen production. (Anenberg et al., 2017) suggest that aeroallergens pose a significant public health burden, predicting that climate change may elevate the incidence of allergic diseases related to pollen. Mitigating climate change is proposed as a means to avoid potential health impacts associated with pollen exposure.

Relationship between Allergies, Pollution and Climate Change

The combined impact of climate change and exposure to environmental pollutants has been demonstrated to have alarming implications for human health, contributing to instances of asthma exacerbations and playing a role in the initiation and worsening of allergic rhinitis and asthma. Inhaling ozone has been associated with an abrupt decline in lung function, an increase in airway responsiveness mediated by airway injury, inflammation, and systemic oxidative stress (McConnell et al., 2002).

Gent, 2003 examined the simultaneous effects of fine particulate matter and ozone, on daily respiratory symptoms and the use of oral rescue or crisis medications in asthmatic children. Specifically, ozone was significantly linked to the occurrence of respiratory symptoms and the necessity for rescue medications in

asthmatic children already using maintenance medications. An increase of 50 parts per billion (ppb) of ozone over one hour was correlated with wheezing (35%) and chest tightness (47%). Higher ozone levels (averages of 1-8 hours) were associated with increased dyspnea and the need for rescue or emergency medication (McConnell et al., 2002).

Allergens from pollen or other plant parts that reach peripheral airways through inhaled air can induce asthma in patients. Ozone, particulate matter (PM), diesel exhaust particles (DEP), nitrogen dioxide, and sulfur dioxide in air pollution enhance the permeability of the respiratory tract. This facilitates the penetration of allergens into mucous membranes and triggers interactions with immune system cells, causing an inflammatory response in the airways of predisposed patients (D'Amato et al., 2016).

Relationship between Pollen Allergens and Allergic Reactions

The escalating prevalence of respiratory symptoms triggered by inhaling pollen and the associated rising costs underscore pollen allergy as a significant public health concern. Approximately 10 – 35% of European young adult's exhibit serum IgE antibodies to grass pollen allergens. Changes in pollen patterns can lead to allergies causing work difficulties, disabilities, increased medical consultations, and medication requirements, significantly impacting healthcare expenses (D'Amato et al., 2007).

In natural pollination, mature pollen grains undergo dehydration upon release from the anthers during dispersion. Upon contact with a wet surface, the pollen grains absorb water, undergo rapid metabolic changes, and, upon penetrating the conjunctival, nasal, or oral mucosa, release pollen allergens swiftly. This induces symptoms of pollinosis in the ocular and respiratory mucous membranes of sensitized individuals.

While it is commonly believed that rain removes pollen from the air, some studies indicate that allergens can be released from the pollen's surface within seconds of contact with water. The hypothesis suggests that during thunderstorms and precipitation, pollen releases allergens carrying particles much smaller than pollen grains, known as paucimicronic particles. These small granules, ranging from 1 – 5 μm, are developed from anther tissues and loaded with allergens, potentially playing a role in allergic asthma (Traidl-Hoffmann et al., 2003).

CONCLUSION

Climate change has significant repercussions concerning environmental pollution and the onset of hypersensitivity and pollen allergies. This leads to an escalation in pollen production and alterations in their characteristics, enhancing their allergenic properties. The future impact of climate change may modify plant growth, resulting in the production of new, modified pollens that can affect human health. Consequently, a rise in allergic diseases linked to pollens is anticipated in the medium and long term. Urgent global measures, such as public education and governmental decisions to prevent environmental pollution and address climate change, are imperative. Efforts in both adaptation and mitigation can be implemented to curb the effects of climate change on air pollution caused by chemical agents and pollens. Mitigation focuses on addressing the root causes of climate change, specifically the accumulation of greenhouse gases, while adaptation deals with the consequences of climate change. However, it's important to note that adaptation alone may not eliminate all negative impacts, emphasizing the crucial role of mitigation in limiting changes in the climate system. Individuals with pollen allergies should be educated about the risk of asthma worsening, particularly during pollen seasons. It is essential to caution them about the potential dangers of outdoor exposure without proper treatment for chronic rhinitis and asthma in such situations.

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