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Climate Change and Allergic Respiratory Disease: an Overview of Effects on Children's Health

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Abstract

Allergic respiratory disease and asthma, which each impact an estimated 20% of the population, are increasing in prevalence with the influence of climate change. Changing weather patterns resulting in stronger storms and worsening air pollution contribute to the threat that climate change poses to public respiratory health, increasing disease incidence and strengthening harmful exacerbations. Since children spend more time outdoors and have less resistance to air pollutants and aeroallergens, they are more susceptible to diseases like asthma and allergic rhinitis. Allergic respiratory disease has significant damaging effects on quality of life, causing physical health problems and hindering social and academic aspects of daily life. A systematic review was conducted to discuss the impacts of climate change on respiratory health, especially in children and adolescents. Action can and must be taken to prevent further health complications in the future—more widespread treatment methods, awareness of climate issues, and policy changes will go a long way.

Keywords: climate change, allergic respiratory disease, children's health, asthma, allergic rhinitis

Introduction

The impact of climate change, commonly recognized as the 21st century's most significant health threat, is ever increasing in severity as human activities generate atmospheric greenhouse gases. The widespread consequences of climate change include rising temperatures and increased frequency and intensity of extreme weather such as thunderstorms, floods, heatwaves, and hurricanes (D'Amato & Akdis 2020). Adverse environmental changes such as air pollution associated with ground-level ozone are also related to climate change (D'Amato et al. 2015), while particulate matter and other air pollution related to urbanization further contribute to respiratory allergic disease (D'Amato & Akdis 2020).

Asthma, the most common chronic disease in children and adolescents worldwide, develops from complex interactions between genetic factors, environmental exposures (Sheffield et al. 2011), and gene-environment interactions (Xu et al. 2018). In individuals affected by asthma or allergic rhinitis, the immune system mistakenly identifies environmental triggers such as allergens as dangerous to the body, releasing chemicals that can cause symptoms which include sneezing and congestion. An estimated 300 million individuals worldwide suffer from asthma and over 400 million from allergic rhinitis (Lake et al. 2017), costing tens of billions of dollars annually. Additionally, past literature has established that higher CO2 levels due to climate change have a clear effect on bringing about earlier pollen seasons and higher pollen densities (Beggs 2015), enhancing photosynthesis, reproduction (D'Amato et al. 2015; Lake 2017), and plant

growth (Pawankar et al. 2020). Increased production of mold, pollen, and other aeroallergens will impact human health by increasing exposure to aeroallergens and worsening symptoms of allergic disease in affected individuals (Ziska et al. 2011). This will increase the risk of allergic respiratory diseases such as asthma and allergic rhinitis, the prevalence of which have been increasing in the past decades.

Moreover, thunderstorms strengthened by climate change have been shown to exacerbate asthma and allergic symptoms (D'Amato et al. 2015). Air pollution from traffic-related emissions and fossil fuels can further intensify the effects of aeroallergens on asthma exacerbation and allergic disease (Poole et al. 2019). Effects of climate change pose an increasing danger to respiratory health, especially in children, and more attention must be brought to this issue to improve future healthcare methods and reduce the burden of climate change on health. This paper systematically reviews existing papers and studies about the effects of climate change on allergic respiratory diseases and summarizes the implications those effects have on pediatric health. This review also aims to highlight research gaps and potential solutions for issues presented relating to children's health in the future.

Methods

Due to the relevance of climate change, there has been a rapid rise in the quantity of literature relating to this topic in the last several years. A systematic review was conducted using Pubmed, Google Scholar, and Proquest. Keywords used in the search include "climate change", "pollen allergy", "asthma", "asthma in children", and "childhood health". 440 records were screened for titles and 78 were fully assessed for eligibility. Papers published after 2009 examining the effects of climate change on asthma or allergic respiratory disease or identifying impacts of asthma or allergic respiratory disease on children's health and quality of life were included. Records describing food allergy were excluded unless a significant mention of climate change or respiratory allergy was included. Articles focusing on air pollution were included if there was sufficient mention of climate change. 40 records that followed the inclusion criteria were included in the final review.

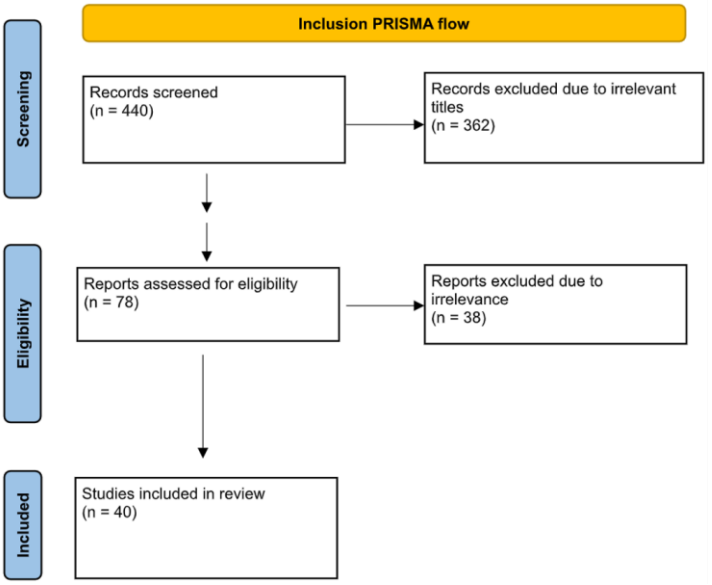

FIGURE 1: PRISMA flow diagram of the systematic review conducted for this study

Results

Climate change and allergic disease

Various studies examined the effects of climate change on pollen prevalence using ragweed pollen. One such study used the recent ragweed invasion in Europe to demonstrate the effects of climate change on the development of the rather novel allergen to the region (Lake et al. 2017). They estimated that sensitization to ragweed will more than double from 33 million to 77 million by 2041-2060, with the greatest proportional increases occurring where ragweed sensitization is not yet common. This analysis shows that ragweed pollen may become a common health problem in the future without ample control of its spread in response to climate change (Lake et al. 2017). Another study on ragweed pollen in Europe determined an approximately fourfold increase in pollen concentrations by 2050 (Hamaoui-Laguel et al. 2015). Stinson et al.

(2016) grew ragweed plants at three latitudes in the northeastern United States, analyzing the effects of increased CO2 levels on flowering periods. They found that elevated CO2 resulted in flowering an average of 2-3 days earlier. Furthermore, plants from higher latitudes flowered for an average of 5 days longer than those from lower latitudes. These results provide evidence for a correlation between higher CO2 levels and flower production, duration, and potential pollen output (Cecchi 2018), with a possibility of more drastic effects in latitudes further north. Above 44° North, the ragweed pollen season may have been prolonged by as much as 13-27 days since 1995 (Ziska et al 2011). Pollen-counting stations in the United States have also shown an earlier start in the pollen season in the most recent decade (Zhang et al. 2015). Additionally, a 27-year-long study using extensive pollen monitoring data in Italy found a progressive increase in pollen season length and sensitization to pollen throughout the period (Ariano et al. 2010), correlating with the increase in temperature due to climate change.

Climate change will also increase the frequency and severity of thunderstorms, impacting respiratory health. A number of studies assessed the effects of thunderstorms on asthma and respiratory allergy. It has been shown that the first phase (20-30 minutes) of a thunderstorm can cause increases in the number of allergens in the air (D'Amato et. al 2016) as wet conditions rupture pollen grains, possibly resulting in severe asthma attacks or even death in susceptible individuals (Pawankar et al. 2020; D'Amato et al. 2020). One particular study showed that the occurrence of asthma epidemics is linked to thunderstorms and is limited to late spring and summer when there are high levels of airborne pollen grains (D'Amato et al. 2014). Additionally, 2016, the warmest year on record before 2020, witnessed the most severe thunderstorm asthma event ever recorded (Katelaris et al 2018), with an estimated 3365 more respiratory-related hospital emergencies than expected. A questionnaire study of this event showed that 57% of patients did not have prior asthma diagnoses and that rhinitis, found in 88% of subjects, was highly prevalent, with 71% reporting moderate to severe symptoms (Pawankar et al. 2020). Thunderstorms pose a real danger to susceptible individuals and staying indoors when they occur should be recognized as an important precaution to avoid health complications.

Furthermore, air pollution and climate change are closely associated. For example, burning fossil fuels generates significant amounts of greenhouse gas, including CO2, which contributes to climate change (Eguiluz-Gracia et al. 2020). Acute ground-level ozone exposure resulting from climate change is linked to childhood respiratory illness and increased emergency department visits related to asthma (Sheffield et al. 2011), and may even cause new cases of asthma in the long term. Studies have demonstrated that ozone increases asthma morbidity by enhancing airway inflammation and hyper-responsiveness (Guarnieri & Balmes 2014; D'Amato et al. 2014; Sheffield et al. 2011). In addition, as many individuals spend much of their time inside in westernized countries, high exposure to indoor allergens such as dust mites, tobacco smoke, and other pollutants can be expected (D'Amato et al. 2016), harming respiratory health. Outdoor air pollution from sources such as traffic has similar effects, but can also enhance the allergenicity of certain plants and contribute to global warming (Eguiluz-Gracia et al. 2020). Further, air pollution can harm children's lung development, adding to the adverse effects of respiratory disease. Epidemiological studies have demonstrated that urbanization and high levels of vehicle emissions correlate with a greater frequency of respiratory allergy in urban populations, especially in children living near traffic (D'Amato et al. 2015; D'Amato et al. 2016). The risk of epidemic rise in allergic diseases is more severe in the Asia-Pacific region due to its rising urbanization in recent decades (Pawankar et al. 2020). These developing consequences of climate change necessitate

consideration of potential health impacts on children in particular.

Allergic disease and children's health

The increasing prevalence of respiratory disease due to climate change disproportionately affects children's health as a result of their cognitive and physical immaturity (Anderko et al. 2020). The World Health Organization states that 88% of the global burden of disease attributed to climate change occurs in children less than five years old, particularly those in low-income countries. Children may also be at a higher risk of developing asthma or allergic disease by spending more time outdoors and being exposed to outdoor pollutants and allergens (Sly & Holt 2018; D'Amato et al. 2014).

The prevalence of allergic disease in children has various studied causes. For instance, exposure to harmful environmental factors may be able to affect the health of a child even in the fetal stage of development (Anderko et al. 2020; Gern 2010); there is accumulating evidence establishing a link between prenatal and early-life stress and the development of asthma in children (Rosa et al. 2018; Lam et al. 2014). Exposure to mold, moisture, and maternal smoking in the first year of life (Lam et al. 2014) have also been shown to increase the risk of asthma and rhinitis (Cecchi et al. 2018). Furthermore, an analysis of the 2016–2017 US National Survey of Children's Health found that adverse childhood experiences, such as household economic hardship, an incarcerated parent or guardian, and household and neighborhood violence were all associated with higher odds of reported moderate or severe asthma (Ross et al. 2021).

A study of common diseases in children took place in South Africa, where decadal warming rates of 0.1°C to 0.3 °C were observed. The most prevalent diseases found in the study group were diarrhea (42.4%), respiratory infection (31.3%), asthma (6.6%), and malaria (6.5%) (Thompson et al. 2012). These diseases correlate with climatic variations due to climate change and are the leading causes of death among children. Male children were more susceptible to the prevalent diseases that were observed, possibly a result of their greater interaction with the outdoor environment. Similarly, older children are more susceptible to asthma and rhinitis (Yamamoto-Hanada et al. 2020), while younger children experience a greater incidence of respiratory infection—likely due to lower immunity against airborne allergens (Thompson et al. 2012). There is also evidence of an increasing incidence of pollen-food allergy syndrome, particularly in adolescents, which may be related to the rising prevalence of allergic rhinitis and pollen allergy (Kiguchi et al. 2021; Cudowska et al. 2021).

Several studies demonstrated the implications of respiratory diseases such as allergic rhinitis and asthma on quality of life for children and adolescents. In the United States, the prevalence of allergic rhinitis in individuals aged 14 to 17 was estimated to be 24.8%, and this number will likely continue increasing. Furthermore, adolescents with allergic rhinitis or asthma were found to have a lower quality of life, affecting daily function, sleep, school productivity, and academic performance (Blaiss et al. 2018; Proctor et al. 2020; Kiotseridis et al. 2013); higher levels of anxiety, depression, and hostility, along with shorter durations of nighttime sleep were also noted (Blaiss et al. 2018). Interestingly, the negative impact on quality of life was more severe in adolescents than younger children and adults. This difference is likely due to common lifestyles focused on school, in which these symptoms more strongly interfere with patients' ability to complete daily activities, achieve goals, and maintain family relationships (Blaiss et al. 2018). In young children, wheeze is the most common symptom of asthma, and it has been shown to disrupt sleep one or more times a week until age 3 (Yamamoto-Hanada et al. 2020). At ages 2 and 3, rhinitis caused disturbances to the daily activities of about 5% of children. Similarly, a study of grass pollen allergy symptoms in children found a strong association between pollen count, symptom severity, and health-related quality of life during the pollen season (Kiotseridis et al. 2013).

Discussion

These results show that climate change is worsening respiratory allergy and disease through increased air pollution, lengthened pollen season, greater production of aeroallergens, and changing weather patterns. Consequently, severe impacts on children's respiratory health must be considered to prevent future health implications as climate change progresses and the population continues to grow. Children have lower immunity to airborne pathogens and spend more time outside; therefore, their age group is more vulnerable and requires particular attention. In addition, pollen allergy and asthma have far-reaching effects: financially, with medication expenses, and socially, by interfering with daily activities such as work and school. Improved management of allergic respiratory diseases could help reduce disease burden on daily functioning, quality of life, sleep, and academic performance, especially in children and adolescents (Blaiss et al. 2018).

Addressing and finding solutions to specific health issues will be essential. For cases related to severe asthma, which includes about 5% of populations with asthma, close therapeutic relationships between medical practitioners and patients can effectively manage the disease (Ahmed & Turner 2019). Adaptation measures to climate change that work to reduce ozone levels, such as cleaner-burning fuels and vehicle emission limits, may be able to synergize with efforts to manage asthma (Sheffield et al. 2011). In regards to pollen-food allergy syndrome, a significant danger to adolescents that is often linked to rhinitis, poor knowledge of the subject in patients can be mitigated by early intervention and more thorough education (Kiguchi et al. 2021). Of course, capturing epidemiological signatures will continue to be essential to document burdens of disease and to design health care services, including prevention measures, clinical interventions, and policies (Yamamoto-Hanada et al. 2020).

Action can be taken to address issues raised by climate change. Effective training and preparation of future healthcare providers will be essential. Moreover, proper education of individuals with respiratory allergy and asthma may help patients avoid unnecessary risks such as staying outdoors during thunderstorms. Additionally, it will be important to coordinate efforts between legislatures, administrators, and the public to take steps to combat air pollution and slow global warming (Pawankar et al. 2020). Parents can ensure that their children are not exposed to a contaminated environment and stay safe with advice from healthcare professionals. Further, increased awareness of climate change may allow for stronger environmental conservation programs, enforcement of safety precautions, and more readily available treatment.

A very promising method of allergy treatment is allergen-specific immunotherapy, the only clinically effective treatment capable of modifying IgE-mediated allergic diseases (Arasi et al. 2018). It is helpful as a therapeutic option to intervene during the early phases of respiratory allergic diseases in childhood, when disease progression can be more easily influenced. Growing evidence supports allergy immunotherapy as a way to treat allergy; one study showed a 50% improvement in quality of life after 3 years of therapy (Proctor et al. 2020). This strategy may even work to prevent the development of new allergic diseases in patients. However, the methodologies of its administration are not standardized, and more study must be done surrounding its long-term benefits.

Some limitations to this study include a lack of access to some sources of relevant data. For example, various topics explored in the review such as thunderstorm asthma would have benefited from more detailed source material; a greater database pool could resolve this issue. Additionally, although significant progress has been made in this field in recent years, there are still many areas where further research is necessary. For one, the majority of pollen studies were completed in the northern hemisphere and

often focused on ragweed and tree pollen. As notable trends may vary in different regions, research in the southern hemisphere is warranted (Beggs 2015). Furthermore, knowledge about treatments for allergic disease is lacking and should be a focus of future research to combat climate change.

In conclusion, climate change is heightening the danger of allergic respiratory diseases, with children at the highest risk of allergen exposure. Moderation of the main risk factors for respiratory disease such as air pollution and better management of asthma and rhinitis are necessary and will have significant long-term health benefits.

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