Climate Change, Migration, and Allergic Respiratory Diseases: An Update for the Allergist

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Abstract: Local climate changes can impact on a number of factors, including air pollution, that have been shown to influence both the development and attacks of allergic respiratory diseases, and thus, they represent an important consideration for the allergist. Migration involves exposure to a new set of pollutants and allergens as well as changes in housing conditions, diet, and accessibility to medical services, all of which are likely to affect migrants' health. This review provides an update on climate change, migration, and allergy and discusses factors for consideration when making recommendations for local allergy service provision and for assessing an individual patient's environmental exposures.

Key Words: climate change, allergy, allergic respiratory diseases, migration and allergy

(*WAO Journal* 2011; 4:120–125)

It is now widely accepted that the earth's temperature is increasing, as confirmed by warming of the oceans, rising sea levels, glacier melting, sea ice retreating in the Arctic, and diminished snow cover in the Northern Hemisphere. Moreover, changes are also occurring in the amount, intensity, frequency, and type of precipitation and the increase of extreme weather events, like heat waves, droughts, floods, and hurricanes.[1,2] The recent Working Group I Report of the Intergovernmental Panel on Climate Change states that "most of the observed increase in globally averaged temperatures since the mid 20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."[1]

Observational evidence indicates that recent regional changes in climate, particularly temperature increases, have already affected a diverse set of physical and biological systems in many parts of the world.[1,2] The Intergovernmental Panel on Climate Change, 2007,[1] reported an increase in the global average air temperature by 1.0 ± 0.3°F (0.6 ± 0.2°C) since the late 19th century. They projected a likely increase in the average surface temperature of the Earth by 2 to 11°F (1.1–6.4°C) by the end of the 21st century and estimated that the average rate of warming over each inhabited continent is very likely to be at least twice as large as that experienced during the 20th century.

A rapid increase has been observed in the number of hot days and severe meteorological events such as the 2003 heat wave, where temperatures of 35°C and greater were reached resulting in around 40,000 excess deaths across Europe.[3,4] Sea levels have also started to rise as an effect of a regression of the polar ice packs. Both events have led to water deprivation in certain areas, often associated with water degradation, which potentially could result in population migration and the effects on health that result from mass population movement.

Migration studies provide useful information on the role of environmental factors, including climate changes, on the development of atopy and asthma.[5–8] Migration involves exposure to a new set of pollutants and allergens and changes in housing conditions, diet, and accessibility to medical services, all of which are likely to affect migrants' health. Atopy and asthma are more prevalent in developed and industrialized countries as compared with undeveloped and less affluent countries, and the effect of migration is age and time dependent: early age and longer time spent in the new environment increase the likelihood of developing allergenic symptoms, such as asthma, rhinoconjunctivitis, or eczema. Therefore, migrants should be aware of the potential for developing allergies and/or asthma. Further research on possible strategies for primary prevention in high-risk atopic individuals and secondary prevention is needed with the aim of developing guidelines both for populations in developing

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countries and for immigrants from such countries to atopy-prevalent developed countries.

Climate changes will influence the development of allergic respiratory diseases.[5–18] Climate affects local and national food supplies, air and water quality, weather, economics, and many other critical health determinants. For instance, the Food and Agriculture Organization indicated that on the basis of assumed socioeconomic development, between 5 million and 170 million additional people will be at a risk of hunger by 2080. However, there are no data on the benefit of using accelerated genetically modified seeds. Thus, climate change represents a massive threat to global health that could affect many disease factors in the 21st century.

There is also a link between climate changes and air pollution, and an individual's response to air pollution depends on the source and components of the pollution, as well as on climatic agents.[9,10] Some air pollution–related episodes of rhinitis and asthma attacks are due to climatic factors that favor the accumulation of air pollutants, such as ozone, at the ground level.

Studies have demonstrated some effects of ozone over respiratory symptoms, acute decreases in lung function, increased airway responsiveness, airway injury and inflammation, and systemic oxidative stress. Gent et al[11] examined the simultaneous effects of ozone and PM2.5 at levels below EPA standards on daily respiratory symptoms and rescue medication use among children with asthma. Daily respiratory symptoms and medication use were examined prospectively for children with physician-diagnosed asthma. Ozone level (but not PM2.5) was significantly associated with respiratory symptoms and rescue medication use among children using maintenance medication. A 50-ppb increase in 1-hour ozone was associated with increased likelihood of wheeze (by 35%) and chest tightness (by 47%). The highest levels of ozone (1-hour or 8-hour averages) were associated with increased shortness of breath and rescue medication use. No significant exposure-dependent associations were observed for any outcome by any pollutant among children who did not use maintenance medication (a marker of asthma severity).

The key determinants of greenhouse gas emissions are energy production, transportation, agriculture, food production, and waste management, and attempts at mitigating climate change will need to address each of these. However, while there is some uncertainty about predicting future meteorological trends, whatever interventions may be put in place to ameliorate climate change, it is likely that the world will experience more hot days, fewer frost days, and more periods of heavy rain and consequent flooding.[12] Paradoxically, it is likely that there will be more periods of drought. A huge increase in CO_2 concentrations during the past 2 decades has been experienced (Fig. 1).

However, it is important to consider that after CO_2 emissions are reduced and atmospheric concentrations stabilize, surface air temperature continues to increase slowly for a century or more.

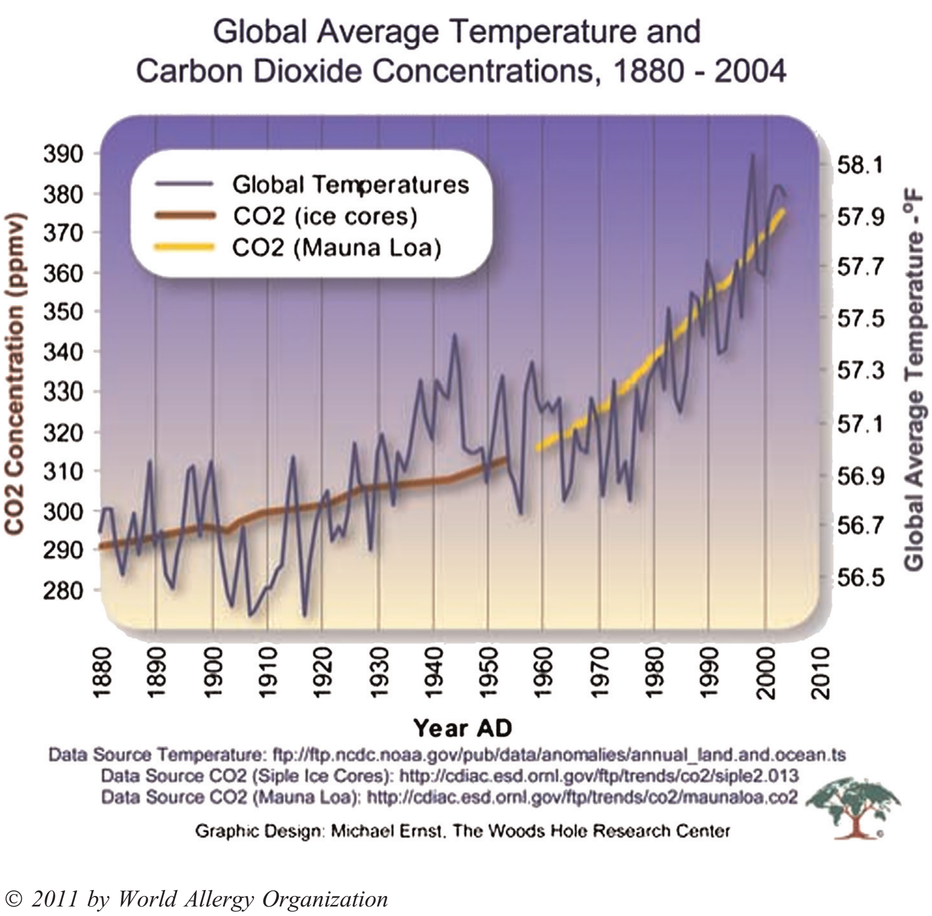

FIGURE 1. Global average temperature and carbon dioxide concentrations, 1880–2004. Graph courtesy of the Woods Hole Research Center (whrc.org).

TABLE 1. Potential Effects of Climate Change on the Prevalence of Allergic Disease

Climate Change Event	Potential Environmental Impact	Effect on Allergic Disease Prevalence
Increase in temperature	Migration of stinging and biting insects into new environments and increased population of existing insect species Change to crop patterns, with the potential to introduce new allergenic pollens into the atmosphere and new food proteins into the local diet	Sensitizations to new stinging and biting insect species and to foods, with potential increase in cases of IgE-mediated anaphylaxis
	Earlier and longer pollination seasons Increases in humidity associated with higher temperatures will lead to increased numbers of cockroaches, house dust mites, and moulds and thus allergen load	New pollen and mould sensitizations leading to increased prevalence and attacks of allergic rhinoconjunctivitis and asthma; longer pollen seasons leading to increased duration of symptoms
Increase in precipitation and drought, leading to lower crop yields, damaged crops, food shortages, and lack of work	Population migration	Development of sensitization to new allergens, leading to development of allergic respiratory and skin conditions
Increase in thunderstorms in spring and summer months	Thunderstorms cause pollen grains to rupture, increasing the levels of respirable allergens and also lead to an increase in ozone levels	Increased hospital admissions due to asthma

Sources: State of World Allergy Report 2008[19] and D'Amato et al.[20]

THE EFFECT OF CLIMATE CHANGES ON ALLERGIC AND RESPIRATORY DISEASES

A body of evidence suggests that major changes involving the atmosphere and the climate, including global warming induced by human activity, have an impact on the biosphere and human environment.[3,18]

An outline of the possible potential effects on the prevalence of allergic disease due to climate change is presented in Table 1.

Studies on the effects of climate changes on respiratory allergy are still lacking, and current knowledge is provided by epidemiological and experimental studies on the relationship between asthma and environmental factors, for example, meteorological variables, airborne allergens, and air pollution.

Climate change is correlated with allergens for several reasons:

- Increase and faster plant growth
- Increase in the amount of pollen produced by each plant
- Increase in the amount of allergenic proteins contained in pollen
- Increase in the start time of plant growth and therefore the start of pollen production and earlier and longer pollen seasons.

Climate changes affect allergenic plants and pollen distribution worldwide.[13,17,18,21] There is also considerable evidence that subjects affected by asthma are at an increased risk of developing obstructive airway attacks with exposure to gaseous and particulate components of air pollution.[11] Climate change coupled with air pollutant exposures may have potentially serious adverse consequences for human health in urban and polluted regions. Data also suggest that air pollution can lead to the development of asthma.[14–16]

It is not easy to evaluate the impact of climate changes and air pollution on the prevalence of asthma in general and on the timing of asthma attacks, but the global increase in asthma prevalence and severity indicates that air pollution and climate changes could be contributing.

EFFECT OF CLIMATE CHANGE ON POLLINOSIS

Pollen allergy is frequently used to study the interrelationship between air pollution and allergic respiratory diseases (rhinitis and asthma). Epidemiologic studies have demonstrated that urbanization, high levels of vehicle emissions, and westernized lifestyle are correlated with an increase in the frequency of pollen-induced respiratory allergy in people who live in urban areas compared with those who live in rural areas.[18]

Studies on plant responses to elevated CO_2 concentrations indicate that plants exhibit enhanced photosynthesis and reproductive effects and produce more pollen.[13,17,18] An earlier start and peak of the pollen season is more pronounced in species that start flowering early in the year (Fig. 2). Moreover, plants flower earlier in urban areas than in the corresponding rural areas with earlier pollination of approximately 2 to 4 days. Meteorological factors (temperature, wind speed, humidity, thunderstorms, etc) along with their climatic regimens (warm or cold anomalies and dry or wet periods, etc) can affect both biological and chemical components of this interaction. In addition, by inducing airway inflammation, air pollution overcomes the mucosal barrier, leading to the priming of allergen-induced responses.

Climate changes might induce negative effects on respiratory allergic diseases, favoring the increased length and severity of the pollen season, the higher occurrence of heavy precipitation events, and the increasing frequency of urban air pollution episodes.

The main diseases of concern are asthma, rhinosinusitis, chronic obstructive pulmonary disease, and respiratory tract infections, but the extent to which these are affected will vary according to the proportion of susceptible individuals

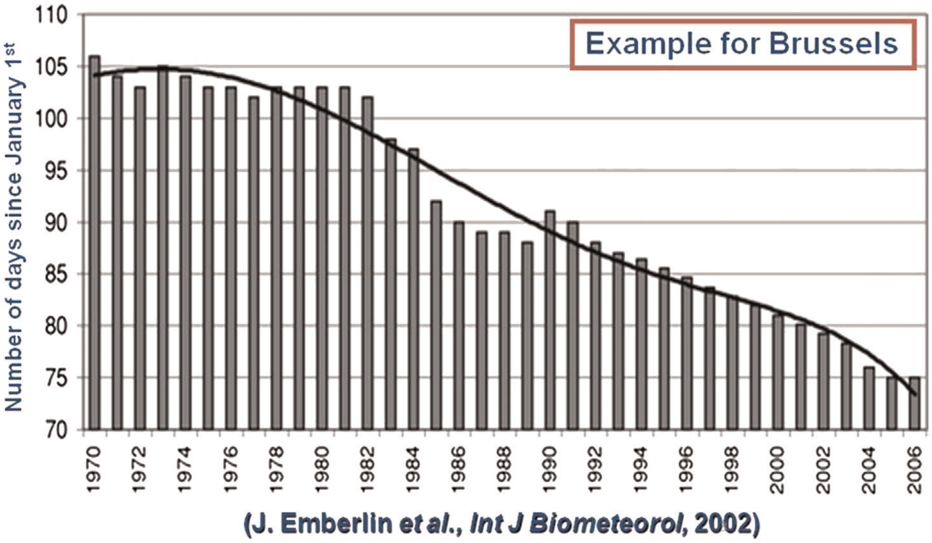

FIGURE 2. Example of earlier onset of birch pollination.

in a given population. Areas of greater poverty with limited access to medical care will experience more as will those in areas with less well-developed medical services, which are likely to include migrating populations and those with the greatest population growth.

With warming over the longer term, changing patterns of plant habitat and species density are likely, with gradual movement northward in the Northern Hemisphere and further south in the Southern Hemisphere. The change in land use might also play a relevant role, especially for some important allergenic species, such as grasses. Because most data come from the analysis of distribution of airborne pollen, these findings are potentially biased by the occurrence of long and medium distance transport episodes of allergenic pollen.[22,23]

Climatic factors (temperature, wind speed, humidity, thunderstorms, etc) can affect both components (biological and chemical) of this interaction.[21,24–29] By attaching to the surface of pollen grains and of plant-derived particles of paucimicronic size, pollutants could modify not only the morphology of these antigen-carrying agents but also their allergenic potential. In addition, by inducing airway inflammation, which increases airway permeability, pollutants overcome the mucosal barrier and could be responsible for "priming" the allergen-induced responses of pollinosis in allergic and atopic individuals. However, the relationship between air pollution, pollen exposure, and respiratory allergy is based on an individual's response to air pollution, which depends on the source and components of the pollution, as well as on climatic agents.

INTERACTION BETWEEN CLIMATE CHANGE AND URBAN AIR POLLUTION

Some air pollution–related episodes of asthma attacks are due to climatic factors that favor the accumulation of air pollutants at the ground level, and some cities are continuously affected by pollution caused by motor vehicles.[17,27,28] Air pollution can interact with allergen-carrying paucimicronic particles derived from plants.[29] The paucimicronic particles, pollen-originated or not, are able to reach peripheral airways with inhaled air, inducing asthma in sensitized subjects. Air pollution—in particular PM, DEP, ozone, nitrogen dioxide, and sulfur dioxide—have been shown to have an inflammatory effect on the airways of susceptible subjects, causing increased permeability, easier penetration of allergens into the mucus membranes, and easier interaction with cells of the immune system.[30] There is also evidence that predisposed subjects have increased airway reactivity induced by air pollution and increased bronchial responsiveness to inhaled allergens. Some pollutants seem to have an adjuvant immunologic effect on IgE synthesis in atopic subjects—in particular, DEPs, which can interact in atmosphere with pollens or paucimicronic particles.[28] It is also important to consider that in the Mediterranean area (Greece, Spain, Italy, etc), California, and other areas, hundreds of thousands of hectares of woods are destroyed each year by fire. Moreover, fire produces millions of tons of CO_2 that plays a role in the greenhouse effect.[25–27]

Thunderstorm-Related Allergic Respiratory Diseases and Bronchial Asthma in Pollinosis Subjects

Thunderstorms occurring during the pollen season have been observed to induce severe asthma attacks in pollinosis patients.[21,31] Associations between thunderstorms and asthma morbidity have been identified in multiple locations around the world.[20,32–38] The most prominent hypotheses for thunderstorm-related asthma are linked with bioaerosols and involve the role of rainwater in promoting the release of respirable particulate matter. After hydratation and rupture by osmotic shock during the beginning of a thunderstorm, pollen grains release part of their cytoplasmic content into the atmosphere, including inhalable allergen-carrying paucimicronic particles, such as starch granules and other cytoplasmic components.[21,29]

In summary, the occurrence of these epidemics is closely linked to thunderstorms; the thunderstorm-related epidemics are limited to late spring and summer when there are high levels of airborne pollen grains; there is a close temporal association among the arrival of a thunderstorm, a major increase in concentration of pollen grains, and the onset of asthma epidemics. As a consequence, subjects affected by pollen allergy should be alert to the danger of being outdoors during a thunderstorm in the pollen season.

CHANGES IN THE PROFILE OF LOCAL ALLERGENS

We urgently need to monitor changes in vegetation and airborne allergens arising from climate change so that new allergen vaccines can be available for immunotherapy. Allergists should also be alert to changes in insect, mite, fish, and animal populations that could give rise to new environmental allergen exposures, with the potential for new allergic sensitizations and a concomitant increase in allergic respiratory diseases, increased severity of asthma, and anaphylaxis.

CONCLUSIONS

Climate changes affect many physical and biological systems, including the immunologic and respiratory systems that are critical to human health, and it is foreseeable that environmental risk factors will have a stronger effect in the coming decades.[40–43] Climate changes interact with and affect air pollution and pollinosis, which in turn increases the frequency and severity of asthma, and affects the clinical expression of allergic disease. Climate change affects the timing, dispersion, quantity, and quality of aeroallergens and the distribution and severity of allergic disease. Climate change alters local weather patterns, including minimum and maximum temperature, rain precipitation, and storms, which affect the burden of allergic disease. A combined approach comprises primary prevention by greenhouse gas mitigation to stabilize the climate and secondary prevention by clinical intervention to minimize climate change–related increases in asthma and allergic disease.[39] Climate changes in the future may depend on how rapidly and successfully global mitigation and adaptation strategies are deployed. The effect of human intervention and efforts to minimize changes in vegetation and aeroallergen exposure remains to be seen.

Reducing air pollution might contribute to lessening of the impact of climate change on pollen and thus directly on patients, while recognizing that ozone, the key pollutant associated with climate change, may be the major driver of pollutant/pollen interactions. Finally, it should be taken into consideration that genetic and other types of environmental factors play a key role in the pathogenesis of allergic diseases and that these factors could not be affected by climate changes.

What can we do to decrease the effects of environmental factors affecting respiratory allergic diseases? Suggested measures are as follows: (1) encouraging policies to promote access to nonpolluting sources of energy; (2) reducing the private traffic in towns and improving public transport; (3) decreasing the use of fossil fuels and controlling vehicle emissions; and (4) planting nonallergenic trees in cities, and in this context, the proposed implantation of new trees should be evaluated by allergy specialists to avoid high allergenic species.

Many measures to reduce greenhouse gas emissions may have positive benefits for health. These cobenefits will offset at least some of the costs of climate change mitigation and should be taken into account in international negotiations.

In conclusion, strategies to reduce climatic changes and air pollution are political in nature, but citizens, and in particular health professionals and societies, must raise their voices in the decision process to give strong support for clean air policies at both national and international levels.

ACKNOWLEDGMENT

The authors acknowledge the assistance of Karen Henley and Sofia Dorsano in the preparation of the manuscript.

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