

Key words

Global warming • Allergens • Ozone • Asthma

Climate change and aerobiology

E. RIDOLO, M. MONTAGNI, E. OLIVIERI

Department of Clinical and Experimental Medicine, Faculty of Medicine, University of Parma

Summary

Climate changes can be considered a major threat for global health to be faced during the next decades. Human activities and production processes are directly affecting the weather, particularly in terms of gas generation responsible for the greenhouse effect. The consequent increase of global warming, associated (and sometimes linked) to extreme weather extreme events, affects human health in different ways. Among these, we should underline the increase of allergic pathologies, and the worsening of previous diseases, since there is a strong correlation between climate changes and the pollen production, the atmosphere concentration and allergenic sensitivity, the pollens seasonality and, finally, the geographical distribution of plants and related pollens. The association of these factors with the exposure to pollution can initiate even worse disorders. The allergist is primarily involved within the process aimed at solving or at least minimizing the effects already observed and that are expected to be produced in the future by climate changes over medical diseases.

If it is plausible to think that those who are called climate change represent, in the 21st century, the greatest threat to human health¹, it is also true that the problems associated with them have always had a profound influence on human society, that has always been committed to deal with them both economically and politically.

It is generally defined as a climate change a variation, statistically significant, of the average state of the climate or of its variability, which persists for an extended period of several decades or more²; this condition implies several concomitant events and thus may not be consequent to a single event, but an increase or decrease in different events such as droughts, hurricanes, floods. Moreover, the climate has never had and does not have a static character, but it is always more or less continuous and slow changing, moving from warmer phases to colder stages and vice versa.

In these changes, the activities of man, that are the most recent of factors that can affect the environment, play a very important role and now the United Nations Framework Convention on Climate Change (UNFCCC) therefore uses the term "climate change" to indicate man-made climate change and "climate variability" for those from natural causes³.

The development of agriculture, resulting in deforestation for farmland and pastures, and the development of the industry began at the end of 1800, as well as the continuous increase in the use of cars, resulted in a progressive increase in the atmosphere

gases such as CO₂, N₂O and methane (NH₄), responsible for the so-called global warming (greenhouse effect).

The increase in the average temperature of the air has been globally estimated in $0.6 \pm 0.2^{\circ}\text{C}$ during the 19th century and it is expected that during the current century the average temperature of the soil can increase up to a value between 1.1 and 6.4 °C. This phenomenon does not affect in a uniform manner all the different parts of the globe, since the land heat up more of the oceans because of the greater heat dissipation capacity of the water and the fact that the degree of heating is directly proportional to the latitude³. Associated with global warming and humidity, that is directly proportional to the increase in CO₂, were reported: an increase in the frequency and intensity of rainfall, a change in their distribution, a rise in sea level and an increase in the frequency of so-called extreme weather events (heat waves, droughts, hurricanes, floods, etc.).

These phenomena can affect human health at different levels. For example, there has been a change in the geographical distribution of some vector-borne infectious diseases, such as malaria, dengue, Japanese encephalitis, Rift Valley fever, and an increase in diseases related to contaminated water, such as cholera, leptospirosis, schistosomiasis. In addition, the depletion of food stocks and reserves of fresh water causes the increase of certain diseases, such as malnutrition and diarrhea, as well as the forced displace-

ment of entire populations, remained locally without means of support, leading to inevitable conflicts ⁴ (Fig. 1).

Climate changes act importantly on the development of allergic diseases, as recently highlighted by the WAO Position Paper on Climate Changes (Table I). Epidemiological data show that asthma and atopy in fact have a higher prevalence in industrialized countries with a high rate of CO₂ emissions and that migration in these geographic areas, with greater development and improved living standards, of populations from areas still predominantly agricultural, induces in these subjects, for the sudden exposure to new allergens, a rapid sensitization with the onset, in a short time, of allergic manifestations ⁵.

Finally, extreme events such as intense storms and floods, in periods when the atmospheric pollen concentrations are highest, have been associated with sudden flare-ups of allergy symptoms such as bronchospasm and wheezing. In fact, during the spring and summertime storms, that have recently increased in frequency and intensity, there is a rupture, by osmotic shock, of pollen grains, at that time mainly concentrated at low levels in the atmosphere, with the sudden release of allergenic material of very small size, which, inhaled by an allergic person, causes sudden asthma attacks requiring recourse to the emergency room (Thunderstorm asthma) ⁶⁻⁸. Crisis of bronchospasm and cough can be caused, on these occasions, even by the upsurge in the atmospheric concentration of fungal spores, as observed during hurricanes (Katrina cough).

In recent years, numerous studies have been performed that have evaluated the effects of climate change on allergenic pollens, since the growth of the plants and their life cycle is closely dependent on

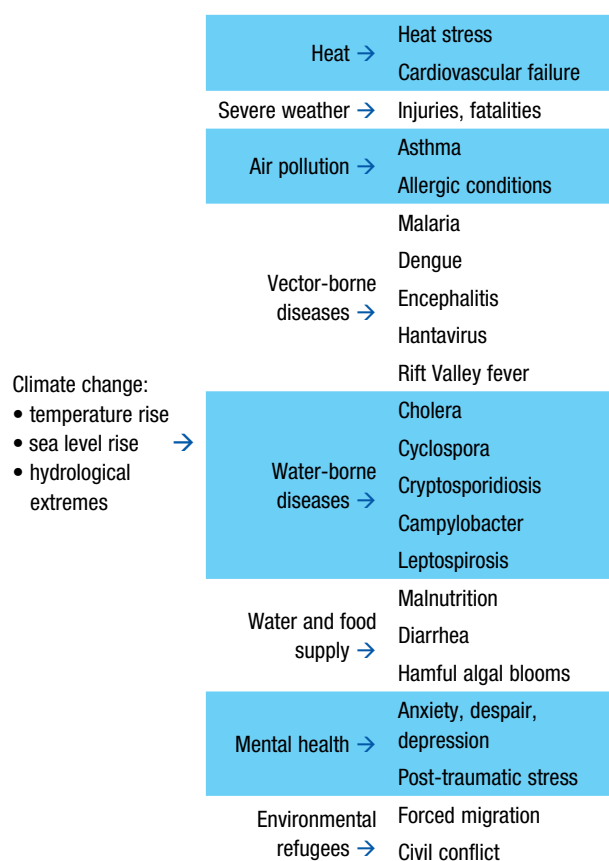


Fig. 1. Potential health effects of climate change ⁴.

Table I. Potential effects of climate change on the prevalence of allergic diseases ⁵.

Climate change	Potential impact on the environment	Effect on the prevalence of allergic diseases
Rise in temperature	Migration of stinging and biting insects into new environments and increase of the population of the existing species of insects. Changing patterns of culture, with the possibility of introducing new allergenic pollens in the atmosphere and new food proteins in the local diet. Pollination seasons longer and earlier. Increases of humidity associated with higher temperatures favoring a greater number of cockroaches, dust mites, molda, and then higher load of allergens.	New sensitization to species of stinging and biting insect and to foods, with potential increase of cases of IgE-mediated anaphylaxis. New sensitizations to pollens and molds, with and increase in prevalence and acute attacks of allergic rhinoconjunctivitis and asthma; longer pollen seasons with prolonged duration of symptoms.
Increase in rainfall and drought, resulting in lower crop yields, damage to crops, shortage of food and lack of work.	Migration of population.	Development of sensitization to new allergens and consequent onset of allergic respiratory and cutaneous diseases.
Increase of storms during spring and summer	Storms cause the rupture of pollen grains, increasing the load of inhalant allergens; storms also increase the levels of ozone	Increase of need of emergency room or hospitalization for asthma

the temperature of the air, as well as by other factors such as the availability of water and nutrients and sunlight. Climate change affects therefore the production of pollen, its atmospheric concentration and allergenicity, the duration of the pollen season, and finally the spatial distribution of the various plants and their pollen⁹⁻¹².

In particular, in the case of important allergenic species such as birch, alder and Japanese cedar, has been demonstrated an increased production of pollen in response to the rise of CO₂ in the air, because of an increase in photosynthesis and reproductive phenomena¹³⁻¹⁶.

Already in 2002, Wan had demonstrated in an experimental study, that ragweed plants grown in soil warmer than their usual, show an increase in the number of stamens, pollen diameter and total pollen production¹⁷. Subsequently, other studies have shown, also experimentally, that the doubling of the current CO₂ levels, as might happen in the near future, it is likely to cause an increase of 30-90% in the production of ragweed pollen. The relationship between CO₂ concentration and pollen production was confirmed by a subsequent study of Ziska et al. that evaluated the effects of urbanization on ragweed pollen¹⁸.

There are also numerous observations concerning the changes in the pollen seasons. For several years it has been observed for a number of species, particularly those with early flowering as birch, mugwort, *Parietaria*, grasses and oak, a tendency to anticipate the start of the pollen season, and at the same time an increase in the total duration of the pollen season in the late-flowering species⁹⁻²⁰. Currently, the phenological advance is about 3 days for several pollens of plants, while it is quantified in 5 days per decade for the other pollen species.

Ariano et al.⁹, in 2010 evaluated in Liguria the influence of climate change on variations in pollen seasons and sensitization in the previous 27 years, showing a progressive increase in the duration of the pollen season for *Parietaria* (85 days), olive and cypress (18 days) with an advance, in the period under review, of the start of the stage of pollination of *Parietaria* of about 2 months. Moreover, a progressive increase in pollen concentration of about 25%, except for grasses, was also observed in the Po valley by Ridolo et al.¹⁰. At the same time it has been observed, in subjects examined, an increased sensitization to these pollens⁹⁻²¹. Other studies have also shown that in the presence of higher concentration of atmospheric CO₂ are produced pollens, for example by ragweed and birch, with an increased content of major allergens.

Aerobiological and allergological studies show that the European pollen map¹⁵ is changing both in relation to climate change and cultural factors, such as the importation of new ornamental plants for urban green spaces and greater frequency of travel and international trade; this seems to have been behind the colonization of northern Italy by ragweed.

The increase in average temperature and atmospheric CO₂, as

a result of global warming, also tends to favor the spread in areas to the north and in areas with higher altitude species pollen (grass, ragweed and olive) characteristics of temperate climates. Consequently, the vegetation of the mountains is changing, with a progressive reduction of species resistant to cold and a parallel increase of the species best suited to warmer climates²². There are also extensive evidence that pollens, especially the light ones, can be carried by wind for long distances and cause, therefore, allergic reactions in areas they are not present because of the lack of native plants, as happened central Italy for ragweed^{23 24}.

On allergic diseases, in addition to global warming and consequent climate changes, also frequent exposure to environmental pollutants act in a synergistic way, as occurs with CO₂, NO₂, PM10 and ozone (O₃), a potent oxidant that increases proportionally to the temperature. Fifty percent of ozone inhaled reaches the lower airways where it produces an increase in the permeability of the epithelium, also to allergens, and inflammation associated with increased oxidative stress. In patients with asthma this results in an increase in bronchial hyperresponsiveness, reduced lung function and, in general, in acute respiratory symptoms, and a consequent increase in need of emergency room and hospital admissions. It was also demonstrated an immunomodulatory effect of ozone, which seems to be able to cause an inflammation of neutrophilic type at the level of the respiratory mucosa of asthmatics with increased production of IL-8, IL-6, ICAM-1, GM-CSF^{25 26}. Even the particulate, especially the exhaust of diesel engines, has proved capable of inducing, in studies with controlled exposure, an inflammation at the level of the respiratory tract in healthy subjects, with increase of cytokines and chemokines and reduction of macrophage function, while in asthmatics causes, above all, an increase in bronchial hyperresponsiveness. By nasal provocation test, the Diesel Exhaust Particles (DEPS) seem to cause, within a few minutes, an increase of allergen-induced histamine release and rhinitis symptoms, while in the next few hours, in the presence of the allergen, a Th2 cytokine milieu is produced with increased synthesis in the following days of total and specific IgE with emphasis of the allergen sensitization^{27 28}. Pollutants may also modify the effects of inhalant allergens in respiratory diseases, either by increasing the release of antigens by pollen grains, or favoring the absorption of those inhaled prolonging their permanence in the respiratory tract and facilitating by the inflammatory effect the penetration through the epithelium of pollen allergens. If it is true that the climate changes represent a global emergency, it is clear that some impacts are inevitable. However, urgent interventions aimed at reducing the growth of CO₂ produced by man, and its negative influences on the climate are possible^{29 30}. The strategy is based on reducing the emission of gases that cause the greenhouse effect, decreasing the use of fossil fuels, in favor of alternative energies, tending the traditional vehicular transportation and increasing the

reforestation intended to facilitate the reabsorption of CO₂ and the production of O₂. Finally, mechanisms are needed to adapt the response to the impact of current and future climate scenario. In the field of allergology and aerobiology is necessary, in particular, to implement a careful monitoring of pollen species, both known and emerging, and of new sensitivities, thereby improving the forecasts on annual pollen calendar and also providing appropriate education to allergic patients to deal with the effects that climate change is having and will increasingly have on allergic

disease, in order to minimize their effects; it is also desirable a greater collaboration between aerobiologists and the media for the dissemination of data and with the city authorities for a more careful and targeted design of public parks.

Therefore, the allergist must play an important role both in education and in scientific research, working to improve air quality and supporting governments in initiatives that reduce the negative consequences of human activities on the climate, as recently pointed out by the WAO Position Paper of 2011³¹.

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