Review paper

The position paper of the Polish Society of Allergology on climate changes, natural disasters and allergy and asthma

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Abstract

The observed global climate change is an indisputable cause of the increased frequency of extreme weather events and related natural disasters. This phenomenon is observed all over the world including Poland. Moreover, Polish citizens as tourists are also exposed to climate phenomena that do not occur in our climate zone. Extreme weather events and related disasters can have a significant impact on people with allergic diseases, including asthma. These effects may be associated with the exposure to air pollution, allergens, and specific microclimate conditions. Under the auspices of the Polish Society of Allergology, experts in the field of environmental allergy prepared a statement on climate changes, natural disasters and allergy and asthma to reduce the risk of adverse health events provoked by climate and weather factors. The guidelines contain the description of the factors related to climate changes and natural disasters affecting the course of allergic diseases, the specific microclimate conditions and the recommendations of the Polish Society of Allergology for vulnerable population, patients suffering from asthma and allergy diseases, allergologists and authorities in the event of climate and weather hazards.

Key words: allergy, asthma, climate changes, natural disasters.

Introduction

The observed global climate change is an indisputable cause of the increased frequency of extreme weather events and related natural disasters. In the last century, the mean air temperature on Earth increased by 0.7°C. According to estimates by the Intergovernmental Panel on Climate Change (IPCC), the global mean surface air temperature in 2090–2099 will reach values higher by 1.8–4°C as compared to those recorded between 1980 and 1999. The alleged cause of the observed change in climate, i.e. an increase in the concentration of greenhouse gases in the atmosphere, is largely due to the anthropogenic effect, being the result of burning fossil fuels and deforestation (decrease in the forest area) [1]. The report on the Global Climate Change Impacts in the United States prepared within the US Global Change Research Program reveals that the frequency and intensity of heavy rainfalls in the United States have increased by 20% and the frequency and strength of Atlantic hurricanes have also increased together with warming of oceans [2]. The negative consequences of climate changes are also observed in Europe, including Poland. As results from the monograph “Natural Disasters and Internal Security of the Country”, published in 2013 by the Institute of Meteorology and Water Management, the frequency of heavy rainfall-related floods has significantly increased for the last 40 years. Moreover, there are whirlwinds found in Poland, which have not appeared in our country before [3]. Polish citizens are also occasionally exposed to climate phenomena not occurring in our climate zone (foreign tourism).

Heat waves, forest fires, and droughts are more frequent in Southern and Central Europe, while Northern and North Eastern Europe is afflicted by floods and erosion of coasts [1].

The results of numerous studies indicate that the health of both individuals and entire societies is largely dependent on a variety of environmental factors, including weather. These factors are direct and indirect. The former involve the impact of individual elements of climate and

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weather phenomena on humans. Some meteorological factors exert a significant effect on the human organism, and their fluctuations in the short time exacerbate clinical symptoms of diseases. Extreme weather events and related disasters can have a significant impact on people with allergic diseases, including asthma. These effects may be associated with the exposure to air pollution, allergens, and specific microclimate conditions [4–8].

Due to a relatively small number of multi-centre long-term studies concerning climatology and aerobiology as well as the impact of phenomena occurring in these fields on the prevalence of allergic diseases, especially among children, there is a need to create appropriate international and intercontinental research networks. It is necessary to reduce the degree of air pollution and carefully plan vegetation cover in urban areas in cooperation with experts and specialists in aerobiology and allergology [4].

The development and distribution of appropriate prophylactic guidelines for populations living in the areas in which the described natural hazards occur have become very important. These guidelines must take into account prevention of the most important threats encountered at the national or local level. Following these recommendations can help reduce the risk of adverse health effects.

Since 1991, the European Commission (publication of the first program on the reduction of carbon dioxide emissions) has been developing strategies aimed at reducing the negative consequences of climate changes. The most important documents concerning this issue in relation to Europe include:
- "European Climate Change Programme" (ECCP) – 2000/2005 [9],
- "Adaptation to Climate Change in Europe – Options for EU Action" (2007) [10],
- "Impacts of Europe's Changing Climate" (WHO document – 2008) [11],
- "Adapting to Climate Change: Towards a European Framework for Action" (2009) [12].

Measures taken are to raise awareness of the importance of the problem as well as coordinate actions of all EU countries in response to the impact of climate change on local communities.

If the current approach based on voluntary action is not effective by 2017, the Commission will consider the need to issue a legislative proposal to the European Parliament, which would impose an obligation on Member States to develop and implement appropriate plans [12].

Due to the need for planning measures to reduce the risk of adverse health effects associated with climate change, the Polish Society of Allergology has developed the present statement, whose recommendations, being its integral part, are addressed to allergologists, primary care physicians, public administration managers, and asthmatic patients and their families.

Factors related to climate changes and natural disasters affecting the course of allergic diseases

Atmospheric pollution

Particulate matter

The observed climate change exerts an effect on the movement and distribution of pollutant particulates. Particulates suspended in the atmosphere are derived from both natural and anthropogenic sources, the latter from urban areas, being mainly the products of liquid fuel combustion. They remain for a long time in the atmosphere and can be transported over very long distances. The effects of exposure to particle pollution to a large extent depend on the type and diameter of the dust particles.

Atmospheric aerosols (particulate matter – PM) are particles of natural origin or those constituting municipal pollutants. They can be classified according to the origin, phase (liquid/solid), physical and chemical properties and size (ultrafine particles – particles of 100 nm aerodynamic diameter or less, fine particles, PM2.5 – particles of 2.5 μm aerodynamic diameter or less, PM10 particles of 10 μm aerodynamic diameter or less, total suspended particulates (TSP) i.e. all aerosols, even the larger ones, with particle aerodynamic diameter exceeding 10 μm) [13].

Exposure to air pollution particulate matter deteriorates lung function and the course of asthma in both children and adults. Anthropogenic particulates are a mixture of various components surrounding the particle nucleus, which is composed of carbon. They comprise, inter alia, volatile organic substances (VOCs), including aromatic hydrocarbons, such as benzene, toluene and xylene; metals (iron, vanadium, copper, nickel, zinc, manganese); pollen; fungal spores; bacteria, and endotoxins [14, 15]. PM10 particles reach the upper respiratory tract and lungs. PM2.5 are absorbed in the upper and lower respiratory tract, and may also penetrate into the bloodstream. Inhalation of PM can induce coughing and shortness of breath, especially while performing physical activity. Moreover, the exposure to PM increases the risk of respiratory infections and exacerbations of allergic diseases, e.g. asthma, allergic rhinitis, and conjunctivitis. Severity of symptoms depends largely on the concentration of particulates in the air, exposure time, additional exposure to the environment-related factors and increased individual susceptibility [16, 17].

This fraction includes ultrafine particles, i.e. 100 nm particles generated through engineering. Similarly to PM, ultrafine particles can cause coughing and breathing difficulties, especially on exertion. The role of these particles in the pathogenesis and formation of the clinical picture of allergic diseases remains unclear. However, from the point of view of allergy and asthma prevention, it is appropriate to minimize the exposure of a particularly vulnerable population, i.e. children to ultrafine particles by avoiding the sources of emission such as biomass combustion, fireplaces, and stoves [18].

Particular importance in allergic diseases is attributed to diesel-exhaust particles (DEP), solid particles of the gases emitted by diesel engines. Exposure to these particles is a known risk factor for the development of asthma and allergic rhinitis. Free allergens and adjuvants can bind to DEP carrying them into peripheral and deep airways [19–22]. The DEP are pro-inflammatory for the respiratory system, can increase Th2 sensitization to coinhaled allergens, induce reactive oxygen species production, supress alveolar macrophage function, induce permeability of epithelial cells, increase the expression of costimulatory molecules on dendritic cells, and activate complement proteins [23–35]. The DEP can also induce epigenetic effects: DNA methylation in genes associated with Th2 polarization [36–38].

Biomass combustion/forest fires

The effects of climate phenomena such as forest fires, droughts and desertification of the Earth land areas are important sources of atmospheric dust. Natural disasters in the form of huge forest fires are moreover related to the emission of a variety of toxic compounds, herbicides, pesticides, and combustion products of polymers.

Exposure to dust and fumes from forest fires and combustion of other types of biomass can be a very serious threat to the respiratory system and exert a negative impact on the course of allergic diseases. Dust and fumes consist of carbon monoxide, nitrogen oxides, and a number of irritant and carcinogenic substances, such as hydrocarbons, including polycyclic aromatic hydrocarbons. Irritants from biomass combustion present in the smoke irritate the mucous membranes (conjunctival problems, sore throat, cough), and increase hyperreactivity of nasal and bronchial mucous membrane, inducing asthma attacks and resulting in deterioration of the clinical course of allergic diseases. Moreover, they increase susceptibility to respiratory infections. Volatile organic compounds can facilitate allergic sensitisation to common environmental allergens, acting as adjuvants. In Polish conditions, due to the widespread custom of making bonfires and burning waste at the garden plots, limitation of this type of exposure especially in relation to children seems to be extremely important.

Significant contamination of forests with municipal waste commonly encountered in Poland (including plastics, e.g. pet bottles, packets and car tires) and illegal storage of toxic waste increase, in the case of forest fire, the exposure not only to the dust originating from the biomass combustion but also to a number of chemical factors with significant toxic potential. In populations living in agricultural regions, in which fires are widely prevalent over large areas (Canada, Australia, Iran), the deterioration of disease control and the increased incidence of medical interventions and hospitalizations due to respiratory diseases were observed among patients with asthma, particularly among children [39–41].

Ozone and nitrogen oxides

Ozone (O_3) is a component of photochemical smog produced by the effect of sunlight on the products of the combustion of fossil fuels present in the lower layer of the atmosphere (troposphere). Its synthesis is increased at higher temperatures, which can predict the rise in its concentration in the troposphere along with the observed increase in temperature. The ozone concentration in the troposphere has been estimated to increase more than twofold by 2100 [42].

Exposure to ozone exacerbates asthma, which has been reflected in the results of numerous epidemiological studies [43–46]. An increase in the number of asthma-related emergency department visits and hospitalization rates and in the use of anti-asthmatic rescue medications was observed [45]. Moreover, exposure to ozone exerts also adjuvant effects [47–49]. In people with asthma exposed to ozone concentrations of 0.16 to 0.25 ppm, a higher degree of bronchospasm has been found during allergen inhalation provocation tests [48]. It has been also shown that the exposure to ozone is a factor that primarily induces asthma. A prospective study conducted among 3535 children with initially negative history of asthma, indicated the relationship between outdoor physical activity performed in the areas with a high concentration of atmospheric ozone and the development of asthma [43]. Furthermore, the exposure to ozone has been proven to be a risk factor for asthma in non-smoking adult males [50]. Nitrogen oxides (NOx) are generated by the combustion of hydrocarbons at high temperatures, especially in internal combustion engines. Exposure to NOx results in inducing both acute and chronic changes in lung functions, neutrophilic infiltration in the bronchial mucosa, higher production of proinflammatory cytokines and increased response to inhaled allergens [51–56].

Pollution related to volcanic activity

Exposure to volcanic dust found its direct reflection in the increased morbidity due to respiratory diseases (as observed in some studies) – asthma and chronic obstructive pulmonary disease (COPD), however remote effects of exposure are still unknown. Analysis of the reports on the effects of volcanic ash on human lungs indicates that the following factors should be taken into account while predicting health effects within the respiratory system:

- the concentration and size of the inhaled volcanic ash particles and in particular the percentage of smaller particles (below 4 and 2.5 μm), able to penetrate the bronchi and lungs, and larger of 4–10 μm diameter, affecting mainly the upper airways;

- the mineral content – especially the content of crystalline silica (inducing silicosis, asbestosis, and endothelioma of the pleura);
- properties of the surface, containing divalent iron ions, whose content results in a higher production of free oxygen radicals, thus increasing toxicity [40, 57–59].

The electrical charge of inhaled ash particles can also exert deleterious effects on the respiratory tract [60]. Numerous compounds including hydrocarbons, sulphuric and other acids as well as heavy metals can be adsorbed on the particle surfaces.

The investigations of volcanic ash concerning its toxicity and impact on health have shown its irritating and inflammatory action [40, 57–59].

Epidemiological studies of exposed populations reported a 2–3-fold increase in the number of hospital admissions and a 3–5-fold increase in the number of visits to emergency centres because of respiratory problems during a volcanic eruption [40, 57–61]. A prospective study conducted in a group of people who suffered from obstructive diseases of the respiratory system before the eruption and were later exposed professionally to the volcanic ash in the area of the eruption indicated a short-term exacerbation of symptoms, lasting some days beyond exposure to ash, which was reflected in the results of clinical spirometry tests. However, in some patients, exacerbation of symptoms persisted for several months [62]. Deleterious volatile substances are released through the volcano crater and diffusion from the soil both at the time of volcanic eruption and between eruptions. The emitted substances are gases, CO, CO_2, SO_2, HCl, H_2S, HF, radon; sulphate aerosols and heavy metals, such as mercury and lead in the solid and gaseous form. People severely affected may develop non-allergic asthma, reactive airways dysfunction syndrome (RADS). Chronic exposure to e.g. sulphur dioxide released during the eruption and in the geothermal areas increases morbidity and mortality associated with respiratory diseases and the deterioration in lung function values. Serious health disorders and deaths have been connected with the exposure to SO_2 and H_2S and mainly concerned patients with asthma and COPD [40, 57–59].

Tourists visiting the areas of volcanic exhalations (fumaroles, solfataras, mofette – the latter being found in Poland) are exposed to substances emitted by volcanic eruption. The exposure may also take place during exploitation of geothermal water (high concentration of CO_2 and H_2S) [63].

Sandstorms

Sandstorms are a special variety of risks related to the effects of dust on the respiratory system. As a result of such weather events, large amounts of dust are transferred to long distances.

The dust, besides the mineral particles, consists of combustion residues of petroleum products, and microorganisms (bacteria – including *Bacillus, Pseudomonas, Staphylococcus*; moulds – *Aspergillus*, *Fusarium*, *Mucor*, *Penicillium*, *Phoma*, *Stachybotrys* and viruses) [64–68]. Other allergenic agents (pollen), microbes and air pollutants (ozone, nitrogen oxides), whose role in exacerbation of allergic diseases has been proven, are also transferred this way [69–71]. This exposure may lead to the occurrence of respiratory complications both acute and chronic (cough and other symptoms resulting from irritation, exacerbation of asthma, and an accelerated decline in pulmonary function values associated with aging). Many reports from the Middle East confirm the increase in the frequency of emergency department visits and hospitalizations of patients with asthma, COPD, and other respiratory diseases (e.g. allergic rhinitis, allergic pulmonary alveolitis resulting from sensitivity to pigeon droppings – Al Eskan disease) during the occurrence of sandstorms [72–76].

Specific microclimate conditions

Consequences of global warming are associated with the occurrence of extreme temperatures manifested among others as heat waves, and extreme weather events.

The urban heat island phenomenon

The so-called urban heat island (UHI) is a model of ecological consequences of global warming, being a manifestation of a particular climate of the city through an increase in air temperature in the ground layer of the atmosphere in relation to the air temperature in non-urban areas. The origin of the word "island" is associated with the image of isotherms, which plotted on the city map take the shape of an island surrounded by the sea of cooler air. The urban heat island is a dynamic phenomenon characterized by a very high daily and annual temperature fluctuation [77]. In large American cities with favourable weather conditions, temperature differences between the city and the area outside the city can exceed 12°C, while in European cities they frequently reach 10°C. In Poland, for example in Lodz, the observed temperature differences between the city centre and its suburbs remain at the level of 2–4°C most of the time, periodically reach 8°C, with 12°C being the maximum recorded difference [77, 78].

The form and intensity of the urban heat island are a result of many physical processes, such as specific radiation balance of cities, large heat capacity of building materials, anthropogenic heat flux, reduced evapotranspiration, and reduced turbulent heat transfer. Additionally, air pollution, especially particulate matter specific for urban areas, increases the effect of heat accumulation through blocking and radiating the city-generated heat back in the direction of the Earth's surface [79]. The enhancement of the urban heat island effect may increase some secondary pollutants (i.e. ozone), and it can indirectly increase natural sources of air pollutant emissions (e.g. decomposition of vegetation, soil erosion) [4]. Urban heat island phenomenon increases hospital respiratory admissions in the warm centre of the urban area [80].

Storms/hurricanes

Intense gusts of wind during a storm can cause accumulation and movement of dust and gases. As some reports show, the concentrations of certain pollutants are distinctly elevated in these specific weather situations. According to the WHO Air Quality Guidelines 2006, the most important pollutants include sulphur and nitrogen oxides and ozone produced during storms. The health effects of dust inhalation affect people with hyperreactivity of the mucous membrane of the upper and lower respiratory tract (especially in asthma patients), the elderly, and children, who breathe 50% more air (per kg of body weight) than adults [81].

Thunderstorm asthma

Thunderstorm asthma is an epidemiological phenomenon, whose prevalence rises with an increase in global climate changes. This term defines epidemics of asthma exacerbations during violent storms with numerous lightning strikes [4]. The phenomenon is related to osmotic lysis of pollen and fungal spores in the atmosphere, resulting in the release of allergens into the air. Storm front causes precipitation of a large amount of allergenic material (pollen) and mixing them in the air masses. High atmospheric humidity makes the airborne pollen grains swell, crack and release chipped fragments loaded with allergens of respirable size [82].

Droughts/frost

Due to prolonged droughts, accumulation of dust pollution may occur in certain areas, which can then be carried by wind over long distances. Extreme temperatures (e.g. frosty air) may be a factor inducing hyperreactivity and bronchospasm. Droughts and frost can also cause persistent significant changes in plants and animals (e.g. rodent invasion), which may result in a new allergen exposure [4].

Impact of microclimate changes on the distribution and composition of aeroallergens

Climate changes affect the distribution, quantity, and quality of pollen and induce alterations in the range and duration of the pollen season of many species. The potential impact on epidemiology and clinical course of allergic diseases and asthma is also exerted by interactions between aeroallergens and air pollution. Such meteorological factors as temperature, sunshine, humidity, rainfalls and snowfalls, wind strength and direction have an impact on pollen emission and dispersion [4].

Impact of atmospheric air temperature and humidity on the concentration and distribution of aeroallergens

The elevated temperature with a concomitant increase in the carbon dioxide level in the air increases e.g. the content of a major allergen (*Amb a 1*) in ragweed pollen [83]. This can result in both an increase in the prevalence of sensitization to the allergen as well as exacerbation of clinical signs of allergy. It has been also shown that birches growing in higher temperatures produce pollen with a higher content of the main allergen *Bet 1* and higher allergenic potential [84].

High temperature also enhances the expansion of new species of plants that have not appeared in the area before, or increase the chances of survival of exotic plants, which are often planted in urban areas, without realizing the serious consequences they can provide. Such a change in the natural environment also causes the appearance of new, previously unrecorded allergies [8].

A number of studies indicate that global warming also induces an earlier beginning of pollination (including plants that are significant in allergies such as mugwort, oak, birch, nettle, grass) [5–7, 85–92]. Additionally, extended duration of the pollen season for plants flowering in summer and autumn as well as for nettle plants was observed in Italy [85]. Earlier beginning of the pollination season, as well as the extended time and intensity of pollination were noted within the urban heat islands [93].

Global warming has had a distinct impact on the type of vegetation, its diversity and density, the geographical distribution of plant species (both horizontal and vertical, e.g. appearance of species in the upper parts of the mountains, which have not been previously encountered there or which grow sporadically). Moreover, changes in wind direction and intensity may affect the prevalence of allergic diseases induced by aeroallergens, the severity of their clinical course and the profile of allergen sensitization [5–7, 85–92].

The results of many studies confirm the impact of climate changes on the intensity of pollination, although it is not reflected in all species and in the prevalence of pollinosis. Hence, careful planning of vegetation cover in large gatherings of people, such as urban areas is a challenge not only for architects of urban green areas but also for public health professionals [93].

Furthermore, changes in humidity, rains, and storms affect the course of allergic diseases and asthma. Hydration and fragmentation of pollen grains and mould spores at the time of changes in humidity and air pressure result in the formation of biologically active sensitizing aerosols [82]. During storms, they lead to severe exacerbations of asthma in people allergic to pollen and mould spores [4].

Climate changes can affect the exposure to allergens in the home environment. Increased indoor humidity and temperature have a positive effect on the growth of microflora [94, 95].

Interactions between pollen and air pollution

Chemical pollution may increase the pollen allergen potential by enhancing the synthesis of pathogenesis-related proteins (PRP). In response to a chemical stressor plants synthesize these proteins [96]. A three-fold higher content of allergen Cup a (thaumatin-like protein belonging to the PRP family) has been found in *Cupressus arizonica* pollen derived from plants growing in the city compared to the pollen of plants from non-urban areas [97]. In addition, experimental studies have shown that pollen exposed to contaminants undergoes morphological changes that increase its bioavailability [98]. In the Japanese study, the prevalence of pollinosis was higher in people living near highways, although the concentration of cedar pollen in the atmosphere was similar in the studied areas [14]. An increase in the carbon dioxide concentration in the atmosphere increases plant biomass and a number of blooming flowers, resulting in increased pollination. This phenomenon has been confirmed with respect to ragweed [99]. It has been also shown that exposure of timothy to higher concentrations of nitrogen dioxide and ozone increases the release of its pollen grains containing allergens [100].

The dust particles, being an important component of urban air pollution, constitute a carrier for multiple allergens including plant pollen, increasing bioavailability and the risk in the case of inhalation exposure [19–22].

In addition, the mechanism of harmful action of air pollutants involves the damage to the epithelial barrier of the airways and impairment of mucociliary clearance. This facilitates the penetration of allergens and their contact with the immune system and induces inflammation in the airways, increasing in this way the risk of asthma [8].

Changes in fauna

The observed climate changes also lead to persistent significant alterations in fauna, which can result in the allergen exposure that is unprecedented in the given area (e.g. animal migrations, invasions of rodents, transmissions of fiery ant colonies (*Solenopsis invicta*), whose stings are known to cause anaphylactic reactions), or the emergence of new infectious diseases through the expansion of the adequate vectors of transmission (e.g. tiger mosquito – *Aedes albopictus*) [101–103].

Floods

Floodwaters are a significant threat to health associated with an increase in humidity in living quarters, contributing to the development of bacteria and fungi, and also deterioration of water quality. This creates a number of problems often concerning thousands of people living in floodplains and favours the development of various diseases, including respiratory ones. Residual floodwater becomes a reservoir for the development of different types of microorganisms, which leach out of household septic tanks, outbuildings (barns) and dead animals. Bacteria, viruses, and fungi undergo multiplication and eggs of parasites are transmitted under such conditions. When entering the human body, they can induce severe infectious, parasitic, and allergic diseases. In people who have experienced flood disaster, an increase in the prevalence of peripheral blood eosinophilia and non-specific respiratory symptoms as well as related diagnostic difficulties in differentiating between invasive and allergic diseases have been observed. In children living in floodplains, the symptoms initially regarded as allergic appeared to be a consequence of parasitic infections [104–107]. The phenomenon of more frequent parasitic infections in areas affected by floods is worth highlighting, because of the common presence of septic tanks in Poland.

Exposure to products of microbial metabolism results in the possibility of developing specific allergies, enhancing sensitization to other allergens (adjuvant effect) and also toxic and carcinogenic (mycotoxins) action [104–113]. Even after the withdrawal of the flood wave, an increased risk of respiratory diseases and a higher prevalence of infectious diseases, such as influenza, pneumonia and tuberculosis, were reported. Flooding of living quarters and household facilities even after drying promotes the development of house dust mites, mould, and insects (cockroaches) [104–106]. This increases the risk of developing allergic diseases, including asthma, extrinsic allergic alveolitis and exacerbating pre-existing allergic diseases. In the case of flood, it is necessary to take immediate action to remove the damp household appliances and furniture, clean contaminated surfaces and dry rooms. It should be kept in mind that physical activity associated with the removal of flood effects improves ventilation of the lungs and promotes inhalation of metabolic products of the above-mentioned organisms, which increases the risk of developing respiratory diseases [104].

Numerous studies have been devoted to negative effects on the health of people staying in the indoor environment (homes, schools, educational institutions) contaminated by moulds [104, 105, 107, 108, 112, 113]. These effects involved increased prevalence of allergies, infectious diseases, irritation of the conjunctiva and respiratory tract, headaches, dizziness, fatigue, concentration problems, and joint pain. Mould-exposure-related medical conditions may be diagnosed as atopic dermatitis, urticaria, rhinitis, bronchitis, asthma, extrinsic allergic alveolitis, organic dust toxic syndrome (toxic alveolitis), and irritant effects of the skin and respiratory tract [104].

Concluding remarks

The impact of air pollution and climate changes on the prevalence of allergic diseases and their course has not been completely elucidated until now. This is related to the lack of multicentre multidisciplinary research and imperfection of research methods, especially perceived in individual multifactorial monitoring of exposure to air pollution. However, the formulation and popularization of prophylactic recommendations resulting from the present state of knowledge at the state level, taking into account vulnerable local populations at particular risk of health are highly indicated. In Poland, the prevention of health effects of flooding and biomass combustion/forest fires and appropriate, from the allergologist's point of view, design of green urban infrastructure seem to be very important.

Recommendations of the Polish Society of Allergology

Recommendations for residents at risk of the inhalation exposure to particulate matter

- Allergologists must have knowledge of the potential risks arising from sudden climatic events and natural disasters, and be able to formulate appropriate prophylactic and therapeutic recommendations in the case of their occurrence.
- They should know which populations are most vulnerable to the harmful health effects of inhalation exposure to particulate matter (children, the elderly, people with chronic respiratory diseases – asthma, emphysema, bronchial inflammation and chronic cardiovascular diseases).
- These people should have their state of health constantly monitored during increased exposure to particulate matter.
- People at risk of adverse health effects should be informed that in the case of health problems or exacerbation of symptoms such as wheezing, tightness and heavy feeling in the chest, dyspnoea, dizziness, and headache, they should immediately contact their doctor. The occurrence of respiratory diseases after a latency period (24–48 h after the exposure) also requires urgent consultation with the doctor.
- When the people suffering from respiratory diseases (asthma) experience an exacerbation of symptoms and are not able to contact their doctor, they should take the action according to the individual treatment plan previously developed by the doctor (e.g. increase doses of asthma medications).
- People living in close proximity to sources of dust emission, in the case of greater intensity of the emission, should stay at home and avoid inhalation of fumes and dust.

  Standard dust masks retaining large particles may be insufficient protection against more dangerous particles of smaller size. More effective are masks with the HEPA filter – or in extreme situations – respirators. However, HEPA filters or respirator masks can be difficult to use for people with respiratory diseases, therefore, they should consult the doctor in order to select an appropriate mask.
- If a dust mask is not available while staying in a dusty/smoky area, the airways should be covered with a moistened piece of cloth, which will prevent the inhalation of at least part of contaminants.
- People should refrain from performing activities outside the home if they smell smoke or experience eye and/or throat irritation. Physical exertion should be reduced not to increase ventilation.
- Particular attention should be paid to children, who are more susceptible to the harmful effects of dust and fumes; their respiratory system is developing and lung ventilation is increased as compared to adults, based on body weight, therefore more pollution is inhaled.
- When driving through the threatened areas, the windows should be closed and the closed circuit of the air should be turned on.
- For people at high risk (e.g. suffering from respiratory diseases) actions should be taken to limit the access of harmful agents into the house by sealing doors, windows, chimneys and using air conditioners with filters cleansing the air.
- Persons subject to home oxygen therapy should not modify the administered amount of oxygen without consulting the doctor.
- Persons involved in rescue or clean-up operations in the area where there has been a massive emission of particulate matter should be equipped with personal protective equipment, including adequate protective masks; people suffering from respiratory and circulatory diseases should not participate in such operations.
- People planning to stay in the areas of volcanic activity, or areas with sandstorms, should be informed about the related health risks. This particularly concerns patients with asthma and COPD.

Polish Society of Allergology recommendations for people allergic to pollen and fungal spores with regard to thunderstorm asthma

- People who are allergic to pollen and fungal spores should be informed of the health risks associated with the occurrence of the phenomenon of thunderstorm asthma and stay in a residential area with the windows closed during the storm.
- They should also be necessarily provided with an individual treatment plan in the case of asthma exacerbation.

Recommendations for asthmatic patients exposed to very cold air

- Asthmatic patients should be informed of the potential negative effects of exposure to very cold air, which may require modification of doses of asthma medications.
- These patients should avoid exposure to extremely low temperatures reducing the time of outdoor activities, in particular intensive physical exertion.

Recommendations in relation to the phenomenon of urban heat islands

- As one of the most important measures reducing the intensity of the phenomenon of urban heat islands is to increase green areas and the number of water reservoirs in urban infrastructure, the actions supporting the development of these types of urban infrastructure should be undertaken at different levels.
- Vegetation cover of cities should be planned with special care in order to avoid species with high allergenic potential. It is worth emphasizing that the allergenic potential of plants growing in the city is increased due to higher air temperature and chemical stress associated with exposure to air pollution.
- Planning vegetation cover in cities should be absolutely consulted with experts in the field of allergology.

Recommendations for residents of the areas affected by flood

- One should be aware of the increased likelihood of the transmission of infectious diseases (including influenza, pneumonia, tuberculosis) after flooding and in large populations, and take measures to prevent the spread of infections.
- Caution should be advised while using floodwater (it may be contaminated by many organisms – bacteria, viruses, moulds and toxins); only water from a safe source should be used for drinking and food preparation as well as for sanitary purposes.
- One should be aware that after the floodwaters have receded, biological and chemical contaminants remain in the flooded area.
- Damp furniture and equipment should be advised to be promptly removed from the living quarters due to the possibility of the development of harmful microorganisms; their drying is not sufficient.
- During cleaning-up, protective measures including wearing masks should be advised; inhalation of fumes must be avoided as dirt and microorganisms can be inhaled especially during increased physical activity.
- During cleaning-up, devices that emit ozone cannot be used.
- Stress induced by the difficult situation may exert adverse effects especially on asthma and COPD patients as well as older people, causing exacerbation of symptoms and predisposing to respiratory infections.
- Gas stoves and burners, as well as devices powered by liquid fuels must not be used to dry rooms.
- In the case of patients with allergic diseases, it is necessary to constantly monitor their state of health; if symptoms such as shortness of breath, wheezing, tightness, and heavy feeling in the chest occur, the person should immediately contact his/her doctor.
- When the people with diagnosed and treated respiratory diseases (asthma) and exacerbation of symptoms are not able to contact their doctor, action should be taken according to the treatment plan previously developed by the doctor (e.g. increased doses of asthma medications). People living in floodplains should always have a supply of essential medicines in the home medicine cabinet.
- People with food allergies should have access to adequate and safe food for them.
- Children with allergies should be able to stay in safe areas without the presence of animals.

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Conflict of interest

The authors declare no conflict of interest.

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