ERJ Express. Published on February 27, 2009 as doi: 10.1183/09031936.00003409

Climate change and respiratory disease: a position statement

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Key Words: Climate change, respiratory disease, advocacy

Abstract

Climate change will affect individuals with pre-existing respiratory disease but to what extent remains unclear. This position statement was developed on behalf of the European Respiratory Society to identify areas of concern arising from climate change for individuals with respiratory disease, health care workers in the respiratory sector and for policy makers. The statement was developed following a two day workshop held in Leuven in March 2008. Key areas of concern for the respiratory community arising from climate change are discussed and recommendations made to address knowledge gaps. The most important recommendation was the development of more accurate predictive models to predict the impact of climate change on respiratory health. Respiratory health care workers also have an advocacy role in persuading governments and the EU to maintain awareness and appropriate actions with respect to climate change and these areas are also discussed in the position statement.

Background

It is now widely accepted that climate change is occurring as a result of anthropogenic factors, in particular fossil fuel combustion and greenhouse gas (GHG) emissions from energy supply, transport, agriculture, industry, forestry, waste, commercial and residential buildings. While global approaches are needed to mitigate the increase in global temperatures, climate change is likely to have many, mostly adverse effects on health, particularly in low-income countries which require attention and action. These findings have been well described by the Intergovernmental Panel on Climate Change (IPCC)[1] and the WHO[2].

Climate change, and its driver GHG emissions, will thus affect human health[1] and for respiratory medicine through:

- Increased number of deaths and acute morbidity due to heat waves;
- Increased frequency of cardio-respiratory events due to higher concentrations of ground-level ozone
- Changes in frequency of respiratory diseases from trans-boundary long-range air pollution (e.g. related to fires, aerosols)
- Altered spatial and temporal distribution of allergens and some infectious disease vectors.

These impacts will affect not only those with existing respiratory disease but also may influence the incidence and thus prevalence of respiratory conditions.

The impact of climate change on individuals with respiratory disease will vary depending on the degree to which ambient temperatures will rise relative to today, changes in short term transboundary long range air pollutants, the risk of heat-waves and the risk of flooding and excessive rainfall as well as the impact of those changes on other health-relevant factors such as air pollution, allergens and moulds. Adaptive capacity must be expanded beyond simply responding to extreme events as planning for the longer term is needed. Consequently, diagnostic tools and clinical treatments may need to be adjusted with time and clinicians will need to be made aware of changing patterns of disease that will occur in response to changing environmental conditions. This requires better disease surveillance and warning systems.

The Environment and Health committee of the European Respiratory Society (ERS) held a workshop in Leuven, Belgium, in March 2008 to explore the specific health issues of climate change in relation to respiratory disease. This position statement arose from that workshop. While climate change and health has been addressed in the general medical literature[3,4] this statement is the first from a specialist medical society and runs in parallel with the interest of the American Thoracic Society in climate change[5]. The statement highlights the broad issues facing the medical profession, those pertinent to respiratory disease, how approaches to the likely change in pattern of disease can be managed, gaps in our knowledge and how this can be used in advocacy, in particular to Governments. The statement reflects the Environment & Health Committee's role to advise both the ERS and the European Lung Foundation on matters of environment and health, providing information to these and other relevant bodies as well as the general public.

Within this statement we have addressed two main themes:

Adaptation: Actions designed to reduce the impact of already established climate change on patients with respiratory - disease and to protect the public from related exposures known to adversely affect lung health.

Mitigation: Responsibilities of health care professionals and organizations such as the ERS to lead by example in reducing dependence on carbon and hence contributing to reducing the influence of climate change and its impact on future generations.

Climate change

Global temperature has risen markedly over the last 30 years due to increases in greenhouse gas emissions, largely from anthropogenic sources[1]. For example, mean annual central England temperatures have continued to rise and are now over 2°C higher than in the coldest period of the 'Little Ice Age' in the late 17th century with half of this increase occurring in the last 40 years[6]. The increase in temperature has also seen a rapid rise in the number of hot days and severe meteorological events such as the 2003 heatwave where temperatures of 35°C and greater were reached[6] resulting in around forty thousand excess deaths across Europe. Sea levels have also started to rise as a consequence with clear regression of the polar ice packs. The combination has 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. Changes in biodiversity, land use, crop yields and soil degradation could lead to problems with malnutrition through reduced food availability and thus potentially increasing the incidence of respiratory infections.

The key determinants of greenhouse gas emissions are energy production, consumption and efficiency, transport, agriculture and food production and waste management[7] and attempts at mitigating climate change will need to address each of these. However, it is likely that the world will experience more hot days, fewer frost days and more periods of heavy rain and consequent flooding[1]. Paradoxically it is likely that there will be more periods of drought.[1]

Climate change and respiratory disease

The key climate change factors which could potentially influence respiratory disease are extreme temperature events (both heat and cold), changes in air pollution, flooding, damp housing, thunderstorms, changes in allergen disposition and consequent allergies, forest fires and dust storms effects either being short- or long-term.

The main disease areas of concern are asthma, rhino-sinusitis, COPD and respiratory tract infections but the extent to which these will be impacted will vary according to the proportion of susceptible individuals in a given population. Areas of greater poverty with limited access to medical services will suffer more as will those areas with less well developed medical services which will include migrating populations and those where population growth is greatest.

Extreme temperature events.

In Europe, an increase in the frequency and intensity of summer heat waves is expected, especially in Central, Eastern and Southern countries[1]. These changes will contribute to the burden of diseases and premature deaths, particularly in population subgroups with limited adaptive capacity such as the elderly and patients with COPD. In the 2003 summer in Italy those over the age of 65 experienced a 34% greater risk of dying during hot days with higher risks for respiratory disease[8] although effects vary with different heat waves[9]. Heat-related mortality is higher in women[8.] and in COPD patients in hospital without appropriate climate control at the time of the heat-wave[10]. In a multi-city European study, the estimated overall change in all cause mortality for a $1^{O}C$ increase in maximum apparent temperature above the city-specific threshold was 3.1% in the Mediterranean region and 1.8% in the north continental region with a higher effect on respiratory mortality [6.7% and 6.1%, respectively][10].advancing the date of death by months. Hospital admissions for respiratory diseases follow the same pattern, especially in the very elderly[11].

In addition cold spells will reduce which may result in a fall in winter respiratory deaths especially in the more northerly countries.

Adaptation Such increased exposure to heat could be reduced by modifications to indoor living such as changes in building design, particularly for the susceptible elderly, both for personal and communal housing. While increased use of air conditioning can be considered (where feasible), this is a significant contributor to global warming and alternative approaches to cooling indoor spaces are needed. Behavioural change will be critical as people learn the appropriate response to a period of high temperature. The WHO Regional Office for Europe[2] has prepared a list of short-term and long-term measures to deal with the health effects of heat-waves. Reducing air pollution during heat-waves will be critical in the success of preparedness for heat-waves. Respiratory physicians should pay attention to vulnerable patients, make pre-summer medical assessments and advise on routine care, including fluid intake and adjustment of medications during hot weather.

Air pollution

Ozone

The concentration of air pollutants in the atmosphere is highly dependent on the weather, particularly for those pollutants that result from photochemical reactions e.g. tropospheric ozone[12] itself a potent greenhouse gas. Climate change is expected to alter the concentration and distribution of pollutants in the atmosphere, but the magnitude and direction of the change is unclear[13]. Most projections have focussed on ozone levels and assume that precursor emissions are held constant. These models predict an overall increase in ozone concentrations for high-income countries but with wide regional differences[14]. This could have important health consequences, especially for those suffering from chronic respiratory diseases. Ozone is a powerful oxidant that has been associated with reduced lung function[15], exacerbation of chronic respiratory diseases[16] and increases in respiratory hospital admissions[17] [18] and mortality[19] [20] both in Europe and the United States. It has been estimated that in the UK there will be 1500 more ozone-associated deaths annually by the year 2020.[21] However, modelling of future health impacts from ozone do not include reductions of precursor emissions that are in the pipeline or expected from regulations in place. Such reductions may decrease exposure to ozone, even in rising temperatures and should reduce the risk below those shown in the current models.

Particles

The impact of climate change on ambient particle concentrations is uncertain[14]. While mitigation policies may result in reductions in particle emissions at the local scale, desertification and a higher frequency of forest fires may increase trans-boundary transport of particles[13 22]. Long-term exposure to particles has been associated with increased symptoms and reduced lung function in asthmatic children[23] and higher mortality in adults, including lung cancer deaths[24 25 26]. Similarly, short-term increases in ambient particles have been related to increases in cardiopulmonary hospital admissions and mortality[27 28 29]. If significant increases in particle levels are seen with climate change this could thus have significant public health consequences.

Synergy between air pollution and temperature

Even with stable levels of ozone and particles, climate change may enhance the adverse effects of these pollutants because of warmer conditions. Adverse effects of ozone have been observed specifically during the warm season[19 30 31] with some evidence of a synergistic effect between high temperature and ozone[32 33]. Similarly, larger particle effects during the summer and/or the presence of a synergistic effect between particles and temperature have been reported[31 34] although the possibility of reduced exposure to outdoor air pollutants in winter months has not been investigated Recent experimental work confirms that the redox activity of particles is amplified by ozone[35] raising the possibility of a three-way interaction between particles, ozone and temperature in the future.

Adaptation

Actions taken towards adaptation to climate change should be aimed at reducing emissions and instituting ways of coping with higher temperatures. These may involve changes in activity patterns that could ultimately affect human exposure to air pollution (e.g., minimizing time spent outdoors to avoid heat). Conversely, some strategies may lead to higher air pollution levels, for instance, growth in energy demand due to increased use of air conditioning in the summer. Similarly, a switch from gasoline to diesel cars, potentially more energy efficient, could result in additional exposure to diesel particles. Thus, climate change mitigation and adaptation strategies need to be carefully evaluated with regard to their impact on air quality.

Effects of flooding and damp

It is likely that climate change will be associated with more episodes of extreme precipitation[1] potentially leading to severe flooding, consequent population dislocation, poor living conditions and worsening water quality, poor nutrition and inadequate access to medical care. This will affect respiratory infections, in particular pneumonia.

Lesser degrees of flooding will also lead to housing remaining habitable but being damp. Damp housing has for long been recognised as a cause of respiratory ill health[36 37 38] being consistently associated with cough and wheeze (and to a lesser extent asthma) in both children and adults. In the USA damp and mould exposure have been estimated to contribute to around one fifth of all cases of asthma potentially with a high economic impact[39]. While a role for allergic sensitisation associated with fungal exposure is plausible[40] the evidence is less strong and the reasons for damp affecting respiratory symptoms are unclear as most studies have been cross sectional in nature, few having used objective measures of exposure. Changes in indoor conditions with climate change may allow house dust mites to become established in regions where cold winters and heating have prevented colonisation before[41].

The potential for exposure to other bioactive molecules associated with damp housing such as endotoxin, volatile organic compounds and mycotoxins may also be relevant.

Adaptation

There is some evidence to suggest that better insulated homes improves indoor temperatures and is associated with improved markers of health[42 43] while there is some evidence that house mite populations can be controlled by improved house design incorporating environmental control.

Effects on allergens and allergic responses

Increased temperatures in more northerly latitudes will allow the spread of certain plant species to larger areas, thus exposing new populations to, for them, novel allergens[44] while levels of recognised outdoor moulds (*Alternaria, Cladosporium*) may also increase. To what extent this will result in more individuals with respiratory allergies is conjectural but any increase in allergen load in conjunction with rising ozone levels will result in more exacerbations of asthma and allergic rhinitis as ozone potentiates the effects of allergen exposure[45] while exposure to higher concentrations of dust mite allergen in households is associated with an increased incidence of asthma. It is likely that there will be an increase in thunderstorms with climate change which are known to be associated with outbreaks of asthma mediated through allergen exposure, notably pollens and wet air fungal spora[46 47 48 49 50].

Adaptation

Because of the uncertainty as to the extent of changes in pollen distribution and consequent allergen sensitisation with climate change, we cannot recommend specific adaptations other than to limit exposure through avoidance and to press for prospective collection of data relevant to this phenomenon through collaborative research.

Effects of indoor air pollution

Indoor air pollution from burning of solid fuels largely from biomass for cooking and heating is the fourth leading cause of morbidity and mortality in the developing world, particularly acute respiratory infection in children under the age of 5 (with an estimated 1.5 million deaths per year)[51] and COPD in non-smoking women. Recent scientific data indicates that black carbon (soot) from indoor air pollution is the second leading air emission contributing to the greenhouse effect and global warming[52]. Black carbon has a half life in the atmosphere of weeks as opposed to hundreds of years for carbon dioxide so interventions targeting a reduction in biomass emissions may have benefit within the foreseeable future.

Adaptation

Adaptation must be considered on a country by country basis but should aim to reduce indoor air pollution by introducing more efficient cooking stoves that reduce both emissions (combustion efficiency) and fuel use (fuel efficiency). The latter also has major benefits for the environment by reducing the impact of deforestation from unregulated felling of trees for fuel which contributes to soil erosion and loses an important natural source for CO_2 sequestration.

Changes in respiratory infections.

It is likely that climate change will alter the frequency of some infections, in particular, tuberculosis and respiratory syncytial virus (RSV). The timing and duration of the RSV season has changed over the last decade, the season ending earlier as temperatures have increased, attacks also being less severe. Tuberculosis may increase in some circumstances, especially with migrating populations potentially finding themselves in situations associated with more crowding.[53]

The effect of seasonality will likely also impact beneficially on other respiratory infections due to warmer winters. Seasonality of respiratory infections is poorly understood although temperature is thought to play an important part, along with patterns of transmissibility due to population behaviour such as spending more time outdoors in the milder winters. In general, respiratory infections increase in winter months[54] so warmer winters may well reduce their frequency. It is possible that some respiratory infections currently limited geographically, may increase in range. Chikungunya virus infection has been identified until now only in tropical areas but recent outbreaks in Italy could have been influenced by higher temperatures, allowing the vector (*Aedes albopictus)* to thrive[55] although provision of environmental niches, notably water pools in rubber tyres, trade in which has increased globally, may also contribute. Climate change might affect the ecology of avian influenza (AI) viruses through alteration of bird migration, influence on AI virus transmission cycle and virus survival outside the host. The joint, net effects of these changes are rather unpredictable, but it is likely that AI virus circulation in water bird populations will continue with persistent adaptation and evolution[56].

Consequently the overall effect of climate change on respiratory infections is likely to be modest and may even be beneficial. However, as increases in air pollution will occur, increasing susceptibility to infections may result.

Knowledge gaps and recommendations for research

Our knowledge in the area of climate change and respiratory heath is based on limited information and substantial, but informed speculation. There are many gaps in our knowledge much of which will only truly become clear as climate change advances which may be too late for some situations. Consequently, much research is needed into improvement of predictive models supplemented by continuous prospective measurement and assessment of the key outcomes and exposures which determine the impact of climate change on respiratory health. The complexity of the issues involved requires coordination and collaboration across research disciplines.

Increase understanding of the current and projected impacts of climate change on respiratory health

1 There is limited information on how changes in temperature, precipitation, and other weather variables could affect the geographic range and incidence of, mortality and morbidity from respiratory diseases. For example:

- formation of ground-level ozone is for the most part temperature-dependent so, while this is not always a clear positive association, and if precursor emissions are not reduced, increasing temperatures will increase ozone concentrations, which would adversely affect susceptible groups (particularly children, the elderly, people with asthma and COPD). It is not known to what extent this will occur.
- plants are flowering earlier in the spring, lengthening the allergy season. There is limited evidence that increased temperatures and carbon dioxide concentrations could increase pollen allergenicity. Systems need to be put in place to monitor changes in aeroallergen concentrations and how this might match to changes in sensitization.
- Increasing heavy precipitation events, with subsequent flooding, could increase exposure to indoor damp and moulds.

2 Effective research requires development of long-term data sets on the incidence and prevalence of respiratory diseases, as well as of the environmental and social factors with which they are associated. This will require construction of datasets which are spatially linked at a suitable level of resolution. Currently, environmental and health datasets only cohere geographically at a high level except in some local circumstances. Appropriate statistical methods, such as multilevel regression models to estimate associations between contextual factors and respiratory health

outcomes, and path analysis to investigate possible mediators of these associations, need to be applied.

3 Projections of future health impacts need to take into account the key factors that determine the geographic range and incidence of respiratory diseases, including effectiveness of treatment with respect to population, age, and gender.

4 This information can be used to identify indicators for monitoring the respiratory health impacts of climate change, to modify current and planned programs to address respiratory health issues and thus increase preparedness for projected climate change impacts.

5 These projections should not be limited to the European region, as changes in other regions, such as desertification leading to increased long-range transport of dust, viruses, and other particles, or the spread of respiratory diseases due to warmer temperatures and changing precipitation patterns, could affect the health of European populations.

Augment basic research on the etiology and treatment of respiratory diseases

1 Any disease with a strong seasonal signal, such as respiratory syncytial virus, may be affected by temperature. However, limited research has been conducted on what role, if any, weather patterns play in their appearance or intensity of transmission.

2 Greater understanding is needed of the biological mechanisms that increase the risk of initiating and exacerbating respiratory diseases both in general and in the context of climate change. Areas which should be investigated include early programming of and impacts of drugs on thermo–regulation and acclimatization and adaptation of susceptible populations.

Identify effective approaches to prevent and reduce possible impacts

1 Research is needed on the clinical efficacy of interventions and treatments in the context of climate change. This should include research on factors, such as nutritional status, that can increase sensitivity as well as the efficacy of treatments.

2 Evidence is emerging that increasing temperature can amplify the adverse effects of poor air quality. This suggests that advance warnings of adverse conditions should be developed to strengthen the capacity of the health system to prepare for the increase in extreme weather events.

3 Development of the methodology for and evaluation of the effectiveness of warning systems.

4 Greater education of health professionals on the respiratory health risks of climate change, to ensure that patients are adequately informed of how changing weather patterns could affect their health and how medications could affect their sensitivity to heatwaves.

5 Research is needed on the role of housing and indoor climate control systems in respiratory diseases.

Evaluate the health impacts of policy options to reduce greenhouse gas emissions

1 It is critical for public health for the ERS to have a strong voice in the evaluation of options to reduce greenhouse gas emissions, and to advocate for policies on issues including the built environment, transport, energy generation, energy efficiency and agriculture.

2 The health costs and benefits of various policy choices are needed to inform policy evaluations.

Research should focus on particularly vulnerable populations and regions

1 Children and those with chronic respiratory diseases may be particularly sensitive to the impacts of climate change. Research should focus on identifying those most at risk and implementing effective programs and activities to reduce their vulnerability. This research should evaluate sensitivity in the broadest sense, including biological, environmental, and social factors. This refers to the fact that sensitivity is a complex entity including either susceptibility i.e. the likelihood of producing a significantly larger-than-average response to climate changes effect or vulnerability, i.e. the likelihood of being unusually severely affected by climate change effects either as a result of susceptibility to the effects of these substances or as a result of a greater than average exposure.

2 Research also should take into account that climate change may alter the geographical spread of regions at risk.

The role of the ERS in Advocacy

In view of the complexity and magnitude of the challenge there is a general misconception that climate change can only be addressed at a national or supranational level. Immediate governmental action is indeed required but action by health care professionals at an individual level may bring about significant incremental effects not least in protecting the health of their patients.

Respiratory health care professionals have a distinguished history of combating major public health concerns such as air pollution, tuberculosis, tobacco use/exposure and asbestos exposure and are well placed to play a role in combating climate change and the related adverse effects on health.

As a trusted source, physicians can disseminate information about the health consequences of climate change, the ways to counteract the adverse effects and the co-benefits associated with such actions. Setting an example to their patients, families, communities and organisations by taking steps to reduce the carbon footprint of their homes, practices, and encouraging their organisations to do the same is a powerful method of engaging others in similar behavioural changes.

Many of the actions that mitigate GHG emissions yield co-benefits for both health and the environment. Energy efficiency saves money on energy bills, besides curbing emissions. Reducing automobile dependence promotes physical activity, helps fight obesity and reducing traffic-related injuries. Carbon dioxide reductions will improve air quality and subsequently respiratory health.

Consequently, the ERS's approach to advocacy with respect to climate change embraces:

i Policies to promote access to non-polluting and sustainable sources of energy, recognising the need to develop policies that prevent dangerous anthropogenic emissions while addressing the energy needs of disadvantaged populations.

ii Encouragement of the development of new technological options, policy choices and economic instruments for power generation, transport, agriculture and the built environment. This could incorporate the development of a comprehensive programme for clean energy which optimises mitigation and allows adaptation to climate change.

This needs to be undertaken while appreciating the potential barriers to change, which include vested interests, political inertia, inability to take meaningful action, global inequalities and weak technology transfer mechanisms. Equally importantly the approach to climate change needs to incorporate inter-sectoral research with concerted action being taken both at national and international levels.

iii Education of health care professionals and patients on the impact of climate change on respiratory health.

ERS advocacy actions with regard to climate change-related impacts on respiratory and lung health

Although regulatory changes to improve air quality are required, the maintenance of respiratory health also largely rests upon changes at a societal level. The EU needs more stringent standards to limit emissions from industry and vehicles as well as more effective enforcement. On the other hand, lifestyle changes centred on reducing energy consumption, e.g. the use of vehicles are also required. The proposed advocacy actions can be summarised in the two main areas of adaptation and mitigation.

1 Advocacy at European level:

- Ensure that the respiratory health effects of Climate Change are considered in all discussions and recommended actions at EU level through the society and by supporting the efforts of public interest organisations such as the European Health and Environment Alliance, HEAL[57].

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- Emphasise the links between emissions Climate Change and indoor and outdoor air quality and advocate for ongoing review of the current outdoor air quality standards.
- Identify areas of research need both in health effect assessment and policy and press for calls to support these

- Advocate for policy changes that introduce cost-effective measures to reduce emissions that contribute to climate change

2 Advocacy for practicing respiratory health care professionals:

- Encourage local public health authorities to develop early warning schemes similar to those already existing for smog, ground-level ozone and air-borne allergens and heat waves known to adversely affect individuals with chronic lung disease. (Adaptation)
- Promote health care institutions to register with the EU's Eco-Management and Audit Scheme (EMAS) or equivalent body (Mitigation).
- Advocate for policy changes that could reduce emissions that contribute to climate change

3 Advocacy steps by ERS:

- Disseminate knowledge of best practice in tackling the effects of extreme weather events on respiratory health; (Adaptation)
- Establish a set of sustainability criteria to add to existing metrics when choosing meetings venues and convention centres. [58] (Mitigation)

- Continue developing the ERS initiatives in exploring and developing alternative approaches to face meetings and consider use of carbon offset [59] where possible (Mitigation)
- Consider registering for the EU's Eco-Management and Audit Scheme (EMAS) [60]. EMAS is a voluntary instrument which acknowledges organisations that are improving their environmental performance continuously on the basis of environmental reviews and reports. (Mitigation)

Acknowledgements

This report resulted from a workshop organised by the Environment and Health Committee of the European Respiratory Society whose members are:

Isabella Annesi-Maesano, Jon Ayres, Bert Brunekreef, Bertil Forsberg, Francesco Forastiere (Chair), Peter Helms, Nino Kuenzli, Juha Pekkanen, Torben Sigsgaard.

Those attending the workshop were:

Ross Anderson, Isabella Annesi-Maesano, Jon Ayres, Alena Bartonova, Roberto Bertollini, Lennart Braback, Bert Brunekreef, Kai-Haken Carlsen, Gennaro D’Amato, Richard Dey, Jeroen Douwes, Kristie Ebi, Eliann Egaas, Jean-Luc Eiselé, Gary Ewart, Christian Farrar-Hockley, Francesco Forastiere, Bertil Forsberg, Trond Sundby Halstensen, Hans Cristian Hansson, Peter Helms, Anna-Karin Hurtig, Vessela Karloukovska, Klea Katsouyanni, Sari Kovats, Martin Krayer von Krauss, Maaike Maayor, Davide Mannisero, William Martin, Robert Maynard, Mercedes Medina-Ramón, Bettina Menne, Paola Michelozzi, Ben Nemery, Juha Pekkanen, Carlo Perucci, Torben Sigsgaard, Robin Stott, Jenny Versnel, Giovanni Viegi, Paul Wilkinson, Mark Windt, Denis Zmirou.

We thank Nicoletta Muzio,from the ERS office in Brussels for organizing the workshop

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