Climate change, pollen and allergic diseases

CERH / WHO –CC
Doctoral training course
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Public health significance of allergic diseases

• Global prevalence of current asthma (wheeze)
  – 0.8 - 37.6% among children (mean 14.1%; Lai et al. 2009)

• Global prevalence of current rhinoconjunctivitis
  – 1.0 - 45.1% among children (mean 14.6%; Ait-Khaled et al. 2009)
Pollen grains

www.e-calyptus.fr

www.pharmallerga.com
Main sources of allergenic pollen

• In Europe
  – Northern: Birch, grasses
  – Central: Deciduous forest trees, birch, grasses
  – Eastern: Grasses, mugwort, ragweed
  – Mountainous: Grasses, trees
  – Mediterranean: Grasses, Parietaria, olive, cypress

• In other countries
  – USA: Ragweed
  – Japan: Japanese cedar (Sugi)
  – South-Africa: Bermuda grass and other grasses
  – Australia: Rye grass and other grasses, plantain and cypress
Japanese cedar
Impacts of Climate Change on Pollen

• Pollen/allergen production
  – Pollen production of ragweed increased 60% to 90% from pre-industrial to current and further to expected future CO$_2$ concentrations in the US (Ziska & Gaulfield 2000; Wayne et al. 2002)
  – Increased ragweed pollen diameter from 21.2 μm to 23.9 μm resulted in a prairie experiment when temperature was elevated by 1.2°C in the US (Wan et al. 2002)
  ➔ Negative impact on dispersion capacity
Ragweed
Impacts of climate change on pollen

- Pollen/allergen concentration
  - Rising trends of annual sums of daily concentration of birch pollen were observed at five monitoring stations in Europe between 1961-1993 (Spieksma et al. 1995)
  - Total pollen load linked to warming progressively increased approximately 25% on average for birch, cypress, olive and pellitory species in Italy between 1981 and 2007 (Ariano et al. 2010)

→ Pollen release in short period of time?
Climate change and its impact on birch pollen quantities and the start of the pollen season an example from Switzerland for the period 1969–2006 (Frei & Gassner 2008)

Fig. 1 Annual mean temperature 1864–2006. Basel and Switzerland (average of 12 meteorological stations;
Climate change and its impact on birch pollen quantities and the start of the pollen season an example from Switzerland for the period 1969–2006 (Frei & Gassner 2008)

Fig. 3 Birch pollen: annual count and highest daily mean count Basel, 1969–2006
Pellitory of the wall
Impacts of climate change on pollen

• Pollen/allergen season
  – An advance of pollen initiation of 1 to 3 weeks for olive and up to 4 weeks for oak species is projected (Garcia-Mozo et al. 2006)
  – Birch flowering has projected to occur in earlier in London, Brussels, Zurich and Vienna; has variable onset in Turku; and is later in Kevo (Emberlin et al. 2002)
  – Between 1995 and 2009, the ragweed pollen season linked to warming lengthened from 13 to 27 days, above 44°N in the US (Ziska et al. 2011)
  → There is a risk that pollen seasons are more often interrupted/mitigated by adverse weather conditions
Impacts of climate change on pollen

• Spatial distribution
  – Extension of northern limit of birch, olive and ragweed is predicted to occur in Europe (Emberlin 1994)
  • Ragweed has colonized extensive areas in Southern and Central Europe during the last decades and it is rapidly expanding northward (Kiss & Béres 2006)
  – Recent warming is resulting in poleward and upward shifts in ranges in plant species (IPCC 2007)
→ Invasive plants can disappear/decline from their original habitats
Current distribution of ragweed in Europe (According to Cunze et al. 2013)
Predicted habitat suitability for ragweed in Europe (According to Cunze et al. 2013)
Impacts of climate change on pollen

• Allergenicity
  – Interaction with air pollutants and other allergens
    • Timothy grass released more allergens when exposed to high concentrations of NO$_2$ and O$_3$ (Motta et al. 2006)
    • Inducing mucosal damage and impaired mucociliary clearance, facilitating access of inhaled allergens (Shea et al. 2008)
  – Increased content of the major allergen and higher allergenicity was found in the pollen from birch trees grown at the higher temperatures and CO$_2$ concentrations (Ahlholm et al. 1998; Hjelmroos et al. 1995)
Impacts of climate change on pollen

• Other plant effects
  – Increased shoot growth of ryegrass on average by 17%
  – Correspondingly, root biomass of ryegrass ranged between -4% and +107% at elevated CO₂ concentration (690 ppm; Schenk et al. 1995)
  – Increased germination percentage (89.3 vs. 92.2%) and seedling size in plantain (675 ppm; P. lanceolata; Wulff & Alexander 1985)
  → Changing plant species density and diversity
Impacts of pollen exposure on allergic diseases (According to Beggs & Bambrick 2005)
Factors affecting the reproduction of plants

- Genotype
- Carbon dioxide
- Temperature
- Biotic factors: competition, diseases, parasites, herbivory, symbiosis, disturbance, phenology, phase of life cycle
- Other abiotic factors: water, nutrients, sunlight, wind, precipitation, soil structure
Impacts of pollen exposure on allergic diseases

• Symptoms
  – Seasonal exacerbations of allergic diseases
    • Increase in the number and severity of asthma attacks (D’Amato et al. 2005)
    • 10-15% increase in asthma- and wheeze-related emergency department visits during the highest pollen concentration days (Darrow et al. 2012)
    • A rise of 60 grass pollen / m³ increased the risk of suffering from a severe seasonal allergic rhinitis by 8% (Annesi-Maesano et al. 2012)
Impacts of pollen exposure on allergic diseases

- Allergic diseases
  - Role of pollen on the development of asthma/allergies?
    - Pollen counts of pellitory species (Parietaria) has increased during the last decades, but not any clear effects on pollen sensitivity in the population was found in Italy (Voltolini et al. 2000)
    - Exposure to more intense pollen season in early infancy increased the risk of development of pollen allergy later in life (Björksten & Suoniemi 1981)
    - Infants exposed to high pollen concentrations during the first 3 months of life had an increased prevalence of pollen induced asthma at age 4-5 years (Kihlström et al. 2002)
Future scenarios

• Vulnerable subjects
  – Individuals in countries where society does not work due to corruption, political and social instability, conflicts and environmental devastation
  – Individuals in areas of greater poverty with limited access to medical services
  – Individuals in areas with less-developed medical services
Future scenarios

• Exposure to pollen and allergic diseases
  – Up to 50% more olive pollen with projected warming in Europe (Garcia-Mozo et al. 2006)
  – Lower numbers of days with a grass pollen count above the clinical threshold was observed in Spain (Jato et al. 2009)
  – An increase in mean temperature of 1°C was associated with an increase in asthma prevalence of almost 1% in New Zealand (Hales et al. 1998)
  – Based on current trends, there is a predicted 70% increase in the prevalence of allergic disease in Australia by 2050 (ASCIA 2007)
  – Temporal and spatial variation in growth conditions
    → Intra- and interspecific variation in pollen production
Future scenarios (According to D’Amato & Cecchi 2008)

Table 2. Expected changes in airborne allergenic pollen levels and allergenic plants distribution in Europe

<table>
<thead>
<tr>
<th>Effects of climate change</th>
<th>Pollen involved</th>
<th>Expected impact on atopic patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earlier start of pollen season (western and Baltic Europe)</td>
<td>Mugworth [87], pellitory [88], grass [89, 90], birch [85, 86]</td>
<td>Negative</td>
</tr>
<tr>
<td>Extended duration of pollen season</td>
<td>Summer and late flowering species [92]</td>
<td>Negative</td>
</tr>
<tr>
<td>Increase of long-distance episodes</td>
<td>Ragweed [102, 103]</td>
<td>Negative</td>
</tr>
<tr>
<td>Increased pollen allergenicity</td>
<td>Ragweed [100]</td>
<td>Negative</td>
</tr>
<tr>
<td>Increased pollen production</td>
<td>Ragweed [95–98]</td>
<td>Negative</td>
</tr>
<tr>
<td>Effects of socio-economic factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in land use</td>
<td>Grass [89, 105]</td>
<td>Unchanged*</td>
</tr>
<tr>
<td>Socio-economic transitions</td>
<td>Ragweed [106]</td>
<td>Negative</td>
</tr>
</tbody>
</table>

*See text.
Future scenarios (According to Thompson et al. 2012)
Future scenarios (According to Thompson et al. 2012)
Primary prevention - Mitigation

• Actions that limit, stop or reverse the magnitude and/or rate of long-term climate change
• Reduce dependence on carbon-based energy production
  – Enhancing greenhouse gas sinks
  – Decreasing greenhouse gas emissions
• Management of allergenic plants in residential areas
  – Planting non-allergenic plants
  – Eradication of allergenic plants from the neighbourhood (Beggs 2010, Reid & Gamble 2009)
Secondary prevention - Adaptation

• Actions designed to reduce the impacts of already established climate change on individuals / communities
• Protect the public from adverse exposures
  – Pollen monitoring, forecasting and warning system
  – Preventive building and ventilation solutions
• Improved patient counselling, medical management and enhanced access to medical care (Beggs 2010, Reid & Gamble 2009)
Management (According to Reid & Gamble 2009)

Modified from Bernard et al. 2001

* Moderating Factors are non-climate factors that may affect health outcomes, such as standards of living, health care access, and public health infrastructure.
Co-benefits

- Decreased greenhouse gas emissions
  - Decreased exposure to air pollutants
  - Decreased allergenicity of pollen
  - Decreased health risks
  - Improved health and wellbeing
In summary

• It is quite probable that pollen load will be increased in future due to more favourable growth condition
→ However, year to year and place to place variation / fluctuation are expected
→ Impacts of increased pollen load on human health will be seen during the next decades