Effect of external exposome on respiratory health

Isabella Annesi-Maesano

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COIs

- ERS Ethics and Integrity Committee (Member)
- EAACI ROC
- EAACI Environmental Guidelines
- AAAAI Environmental Exposures and Respiratory Health Committee
- ATS Health Policy Committee

- IRD Ethics Committee (President)
- Comité prévention et protection (CPP) MEDD
- SFA Scientific Committee (Member)
- CSTB Scientific Committee (Member)
- RNSA Scientific Committee (Member)
- Météo France (Commission Santé)
- Société de Pneumologie de Langue Française: GT PAPPEI

- Section Editor for Environmental Health of ERJ and IJTLID
Chronic respiratory diseases (CRDs)

- CRDs include chronic obstructive pulmonary disease (COPD), asthma, and other chronic respiratory diseases such as occupational lung diseases, and pulmonary hypertension.

- In the world:
  - 212.3 million prevalent cases of COPD were reported globally, with COPD accounting for 3.3 million deaths and 74.4 million DALYs → 3rd cause of mortality
  - 300 million prevalent cases of asthma

Leading causes of death and disability in the Region of the Americas

05/12/2022

IAM-XI.2022
Age standardised point prevalence of chronic obstructive pulmonary disease per 100,000 population in 2019, by country (generated from data available at https://ghdx.healthdata.org/gbd-results-tool).

Saeid Safiri et al. BMJ 2022;378:bmj-2021-069679
Chronic diseases evolution

Rapid increase in immunological, autoimmune / inflammatory diseases
In the past decades

D’après Bach J-F et al. NEJM 2002
Major role of the environment/exposome

- The environment is more important than genetics (it explains 70-90% of diseases).
- The known exposures are few (air pollution, smoking, nutrition, alcohol, lead...)
- The number of environmental factors is increasing dramatically.

Lim et al., Lancet 2012; Rappaport & Smith, Science 2010
Respiratory exposome assessments

**Questionnaires**
- Residential, occupational, smoking history, etc.

**GIS-based environmental model**
- Air pollution
- Green space
- Noise, etc.

**Mobile devices**
- Smartphone
- Accelerometre
- Environmental sensor, etc.

**Pictures**
- Cosmetic use
- Food
- Cleaning products, etc.

**Biomarkers in different tissues**
- Urine
- Blood
- Exhaled breath condensate, etc.

**High-throughput omics technologies**
- Epigenomics
- Transcriptomics
- Proteomics
- Metabolomics, etc.

**Integrated tools and technologies for exposome assessment**
Exposome and respiratory diseases: **external and internal exposome**

- **Specific external environment**
  - In utero smoking
  - Chemical air pollutants
  - Biocontaminants (viruses...)
  - Allergens (pollen, molds, pets, hymenoptera...)
  - Diet
  - Drug
  - Consumer products

- **Non specific external environment**
  - Climate
  - External biodiversity (greenspaces...)
  - Urban environment
    - Mobility, exercise
  - Social dimension

- **Epigenome**
- **Genome**
- **Gene-Environment interactions**
- **« Omics »**
  - Transcriptomics
  - Metabolomics
  - Adductomics
  - Proteomics
  - Microbiomics

- **INTERNAL EXPOSOME**
- **EXTERNAL EXPOSOME**

Respiratory diseases

**Exposome and respiratory diseases:**

- **External and internal exposome**

**Data for health**

Cecchi, D'Amato, Annesi-Maesano JACI 2018

05/12/2022 IAM-XI.2022
Exposome and respiratory diseases: 

**Interactions in the external exposome**

**Call to action: Air pollution, asthma, and allergy in the exposome era**

Isabella Annesi-Maesano, MD, PhD, DSc, Cara Nichole Maesano, PhD, Benedetta Biagioni, MD, Gennaro D'Amato, MD, Lorenzo Cecchi, MD, PhD

Journal of Allergy and Clinical Immunology 2021 14870-72DOI: (10.1016/j.jaci.2021.05.026)
Climate change interactions
The increase in the average temperature of the atmosphere and the oceans causes the melting of snow and ice, the acidification of the oceans and the rise in sea level. This modifies the water cycle and leads to an increase in the intensity and frequency of extreme climatic phenomena: heat waves, drought, floods, cyclones.

**DIRECTS**
- Temperature, UV, humidity, rain, storms, atmospheric pressure

**INDIRECTS**
- Air pollution, soil, water
- Mold, pollen

**Biodiversity**
- Loss

**AUGMENTATION IN PREVALENCE, PHENOTYPIC EXPRESSION AND SEVERITY**

Through the action of climate change on the determinants of these factors.

IAM-XI.2022
Main pollutants and sources

- Particulate matter (primary and secondary)
- Nitrogen dioxide
- Sulphur dioxide
- Volatile organic compounds
- Ammonia
- Tropospheric ozone, formed by reactions of other pollutants
CLIMATE CHANGE: TRENDS OF AIR POLLUTION

• Virtually certain
  – Increased outdoor ozone level due to
    • Increasing temperatures
    • Windiness and stagnant air conditions
    • Urbanization
    • Natural sources of air pollutant emissions (→ biogenic VOCs)
  – Increased outdoor PM level due to
    • Increasing emissions from
      – fossil fuel-fired power plants due to demand for electricity for cooling (due to temperature increase)
      – Urbanization and traffic
    • Increasing natural sources of air pollutant emissions
      – Wildfire smoke induced by drought and heat
      – Desertification → Sand storm

• To be further confirmed
  – Increase of indoor air pollutants
Air pollution and asthma exacerbations

**O₃ (8-h or 24-h)**

**NO₂ (24-h)**

<table>
<thead>
<tr>
<th>Article</th>
<th>Relative risk (RR)</th>
<th>RR</th>
<th>95%-CI Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babin, 2008</td>
<td>1.0045 [1.0005; 1.0085]</td>
<td>7.3%</td>
<td></td>
</tr>
<tr>
<td>Botten-Forszne, 2004</td>
<td>1.0062 [0.9867; 1.0158]</td>
<td>4.4%</td>
<td></td>
</tr>
<tr>
<td>Cirera, 2012</td>
<td>0.9770 [0.9372; 1.0189]</td>
<td>0.6%</td>
<td></td>
</tr>
<tr>
<td>Fuso, 2001</td>
<td>1.0157 [0.9867; 1.0446]</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>Galen, 2003</td>
<td>1.0390 [1.0108; 1.0680]</td>
<td>1.0%</td>
<td></td>
</tr>
<tr>
<td>Jaffe, 2003 - Cincinnati (USA)</td>
<td>1.0247 [0.9966; 1.0530]</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>Jaffe, 2003 - Cleveland (USA)</td>
<td>1.0500 [0.9857; 1.0247]</td>
<td>1.7%</td>
<td></td>
</tr>
<tr>
<td>Jaffe, 2003 - Columbus (USA)</td>
<td>1.0347 [0.9886; 1.0030]</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>Ko, 2007</td>
<td>1.0100 [1.0060; 1.0140]</td>
<td>7.3%</td>
<td></td>
</tr>
<tr>
<td>Kwon, 2016</td>
<td>1.0089 [0.9682; 1.0581]</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>Laurent, 2008</td>
<td>0.9680 [0.9651; 1.0020]</td>
<td>0.7%</td>
<td></td>
</tr>
<tr>
<td>Lavigne, 2012</td>
<td>1.0060 [1.0021; 1.0100]</td>
<td>0.7%</td>
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</tr>
<tr>
<td>Medina, 1997</td>
<td>1.0114 [0.9942; 1.0389]</td>
<td>2.1%</td>
<td></td>
</tr>
<tr>
<td>Petroeschensvalsky, 2001</td>
<td>1.0440 [1.0224; 1.0662]</td>
<td>1.3%</td>
<td></td>
</tr>
<tr>
<td>Rau, 2014</td>
<td>1.0039 [1.0027; 1.0171]</td>
<td>5.6%</td>
<td></td>
</tr>
<tr>
<td>Sacks, 2014</td>
<td>1.0047 [0.9996; 1.0099]</td>
<td>6.7%</td>
<td></td>
</tr>
<tr>
<td>Schoulen, 1996</td>
<td>1.0087 [0.9932; 1.0244]</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td>Son, 2013</td>
<td>1.0227 [1.0149; 1.0305]</td>
<td>4.8%</td>
<td></td>
</tr>
<tr>
<td>Stieb, 2005 - Portland (USA)</td>
<td>1.0035 [0.9804; 1.0281]</td>
<td>3.8%</td>
<td></td>
</tr>
<tr>
<td>Wilson, 2005 - Manchester (UK)</td>
<td>1.0100 [0.9950; 1.0250]</td>
<td>6.8%</td>
<td></td>
</tr>
<tr>
<td>Woll, 1999</td>
<td>0.9850 [0.9815; 1.0000]</td>
<td>4.2%</td>
<td></td>
</tr>
<tr>
<td>Goodman, 2017</td>
<td>1.0310 [1.0162; 1.0460]</td>
<td>2.7%</td>
<td></td>
</tr>
<tr>
<td>Zu, 2017</td>
<td>1.0003 [0.9994; 1.0007]</td>
<td>7.3%</td>
<td></td>
</tr>
<tr>
<td>Guo, 2018</td>
<td>1.0023 [0.9958; 1.0088]</td>
<td>6.5%</td>
<td></td>
</tr>
<tr>
<td>Atkinson, 1999</td>
<td>1.0031 [0.9867; 1.0136]</td>
<td>4.9%</td>
<td></td>
</tr>
<tr>
<td>Villesenoue, 2007</td>
<td>1.0055 [1.0001; 1.0110]</td>
<td>6.5%</td>
<td></td>
</tr>
</tbody>
</table>

**Random effects model**

| Prediction interval (68%-P90) | Heterogeneity: $I^2 = 64%$, $Q = 0.0001$, $p = 0.01$ |

| Relative risk (RR) | 1.0062 [1.0055; 1.0111] 100.0% |

Urbanization and traffic

To be submitted
Air pollution and asthma exacerbations

SO$_2$ (24-h)
Air pollution and asthma drugs

Table 3a. Relationship between ATC R03 and R06* drug sales and air pollutants in metropolitan France in 2013.

<table>
<thead>
<tr>
<th></th>
<th>RR</th>
<th>CI</th>
<th>p-value</th>
<th></th>
<th>RRa</th>
<th>CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM_{2.5}</td>
<td>1.033</td>
<td>1.024–1.042</td>
<td>&lt;0.001</td>
<td></td>
<td>1.046</td>
<td>1.034–1.058</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NO{2}</td>
<td>1.039</td>
<td>1.035–1.043</td>
<td>&lt;0.001</td>
<td></td>
<td>1.041</td>
<td>1.036–1.047</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PM_{10}</td>
<td>1.043</td>
<td>1.036–1.051</td>
<td>&lt;0.001</td>
<td></td>
<td>1.056</td>
<td>1.046–1.065</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>R06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM_{2.5}</td>
<td>1.027</td>
<td>1.019–1.036</td>
<td>&lt;0.001</td>
<td></td>
<td>1.039</td>
<td>1.029–1.050</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NO_{2}</td>
<td>1.032</td>
<td>1.028–1.036</td>
<td>&lt;0.001</td>
<td></td>
<td>1.034</td>
<td>1.028–1.039</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PM_{10}</td>
<td>1.036</td>
<td>1.028–1.043</td>
<td>&lt;0.001</td>
<td></td>
<td>1.043</td>
<td>1.034–1.051</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Unadjusted and adjusted** relative risks (RR and RRa) and 95% confidence intervals (CI) in one-pollutant models.

*Drugs are classified according to the Anatomical Therapeutic Chemical (ATC) Classification System: R03 (Drugs for obstructive airway diseases, overall for asthma) and R06 (Antihistamines for systemic use).

**Models are fitted to mean temperature, relative humidity and crude lung cancer rate.
Air pollution and asthma development

AMERICAN THORACIC SOCIETY DOCUMENTS

Outdoor Air Pollution and New-Onset Airway Disease
An Official American Thoracic Society Workshop Report


The official workshop report of the American Thoracic Society was approved December 2019.

Abstract

Although it is well accepted that air pollution exposure exerts a detrimental effect on lung health, many factors contribute to asthma development and bronchial hyperreactivity. The large burden of mortality and morbidity associated with asthma and bronchial hyperreactivity can largely be attributed to environment, such as indoor pollution, socioeconomic status, and dietary patterns, but is also influenced by genetic factors. The environment plays a major role in asthma development, and this is particularly true in children, as demonstrated by the increased risk of asthma and bronchial hyperreactivity seen in children living in areas with higher levels of air pollution. This review focuses on the role of outdoor air pollution in asthma development, with a particular emphasis on the role of air pollution in the development of asthma in children. The review also highlights the need for further research to better understand the mechanisms by which air pollution affects asthma development and to identify potential interventions to reduce the risk of asthma development.

Keywords: Air pollution, asthma, COPD, new-onset airway disease

Figure 1. Meta-analysis of studies of long-term exposure to air pollution and new-onset asthma. The prevalence of asthma in children living in areas with higher levels of air pollution is significantly increased, compared to children living in areas with lower levels of air pollution. This association is consistent across different studies and populations, suggesting a strong and consistent relationship between air pollution and asthma development. The findings highlight the need for further research to better understand the mechanisms by which air pollution affects asthma development and to identify potential interventions to reduce the risk of asthma development.

Urbanization and traffic
Outdoor air pollution and the burden of childhood asthma across Europe

Haneen Khreis1,2,3,4,9, Marta Cirach2,3,4, Natalie Mueller2,3,4, Kees de Hoogh5,6, Gerard Hoek7, Mark J. Nieuwenhuijsen2,3,4 and David Rojas-Rueda2,3,8,9

66 600 (11% of total cases) and 2400 (0.4%) childhood asthma cases per year could be prevented by complying with the World Health Organization (WHO) air quality guideline for PM2.5 and NO2, respectively.
When can a relationship between an exposure and a disease be considered “causal”?

• In the case of multifactorial diseases, for example asthma, a causal factor can be any major contributor that, if eliminated, would have either prevented the occurrence of the outcome or reduced its severity or frequency.

• Proving the contribution of one factor in the development and/or aggravation of the disease is essential to give directions for promoting preventive measures or remedial actions.
Dust Storms & the Risk of Asthma Exacerbations

<table>
<thead>
<tr>
<th>Age group</th>
<th>Lag</th>
<th>R</th>
<th>RR*</th>
<th>95 %CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust &gt;200</td>
<td>0</td>
<td>1.137</td>
<td>0.536–1.737</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.233</td>
<td>0.643–1.824</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.372</td>
<td>0.783–1.961</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.993</td>
<td>0.376–1.609</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.855</td>
<td>0.236–1.473</td>
<td></td>
</tr>
</tbody>
</table>

Association between Dust storm events (lag of 0-5 days) and respiratory disease in less than 15 yrs with dust at PM$_{10}$ > 200 ug/m$^3$

Introduction: Wildfires—There are no boundaries

Areas with significant trends in fire weather season length from 1979 to 2013; red=↑; blue=↓

Wildfires in California are associated with increased Asthma Exacerbations

Reid, et al, Environ Health Persp, 2016
Reid, Merritt, Tager, Mann, Balmes Environmental Research 2016

N=12.7 million; 112,000 hospital visits
WILDFIRES RELATED MORBIDITY

Youssouf and Annesi-Maesano IJERPH (2014)
At the population level

- Wildfires related to asthma exacerbation (Reid, Environ Int. 2019)
Total and anthropogenic PM$_{2.5}$ were found to have immediate effect on all-cause consultations and cardiovascular cause while PM$_{2.5}$ from wildfire showed a delayed pattern on respiratory cause consultations.
Climate change and air pollution have an effect on the release and dispersion of airborne pollen and thereby on allergic diseases.
Climate change and pollen
HEALTH IMPACT OF ALLERGENS VARIATIONS
Cecchi, D’Amato, Annesi-Maesano

In the case of pollen
✓ Shift of vegetation zones
✓ Changes in onset and duration of the pollen season
✓ Increase of airborne pollen concentration
✓ Immigration and spread of neophytes (e.g., Ambrosia artemisiifolia)
✓ Increase of pollen allergenicity: changes in allergenic proteins and adjuvant substances in pollen (e.g. pollen-associated lipid mediators (PALMs), lipopolysaccharide (LPS))
✓ Thunderstorm asthma: increased exposure to small allergen fragments during thunderstorms

Observed (solid arrows) and projected (dotted arrows) effects of climate change on pollen allergy
SHIFT OF VEGETATION ZONES

In response to climate change, plants can

- Moving - to the right climate
- Adapt - to the new climate
- Go extinct

→ Unexpected distribution of plants, pollen and allergens
When we replace, in the MétéoFrance model, the current climate variables with those estimated for the end of the 21st century, we see a clear extension of the area of the holm oak, which is currently emblematic of the Mediterranean region. In 2100, its climatic niche could exceed the Loire. The same is true for the majority of Mediterranean species: Olea, Pinus halepensis, Pinus pinea, Cupressus sempervirens... Translated with www.DeepL.com/Translator (free version)
Climate change and pollens

Longer pollen seasons, even earlier, increase of airborne pollen concentration, more pollen allergens and increased allergenicity
Anticipation and duration of pollen season

**Anticipation**

The average first flowering date of 385 British plant species has advanced by 4.5 days during the past decade compared with the previous four decades:

16% of species flowered significantly earlier in the 1990s than previously, with an average advancement of 15 days in a decade.

**Durations**

International Phenological Gardens in Europe (69-42 ° N, 10 ° W-27 ° E):

- Flowering season longer of 10.8 days in average

Fitter AH & Fitter RSR. *Science*. 2002 May 31;296(5573):1689-91


Increased Duration of Pollen and Mold Exposure are Linked to Climate Change

Objective

Summary- Pollen exposure in the Bay Area of California is increasing

When using time-series regression models between 2002 and 2019, the annual average number of weeks with pollen concentrations higher than zero increased over time.

- For tree pollens, the average increase in this duration was 8 weeks in 17 yrs
- For mold spores, the average increase in this duration was 9 weeks in 17 yrs
Ambrosia artemisiifolia L.: Effect of CO₂ on pollen and allergen production

Interaction of the Onset of Spring and Elevated Atmospheric CO₂ on Ragweed (Ambrosia artemisiifolia L.) Pollen Production

Christina A. Rogers,1 Peter M. Wayne2 Eric A. Mocko,3 Michael L. Huntenberg,1 Christopher J. Wagner1, Paul R. Epstein1, and Fatimi A. Bazzi2

1Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts, USA; 2New England School of Agriculture, Amherst, Massachusetts, USA; 3New England Research Institute, Watertown, Massachusetts, USA; 4Center for Health and the Global Environment, Harvard Medical School, Boston, Massachusetts, USA; 5Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, USA

Research Note:
Increasing Amb a 1 content in common ragweed (Ambrosia artemisiifolia) pollen as a function of rising atmospheric CO₂ concentration

Ben D. Singer, Lewis H. Ziska, David A. Frenz, Dennis E. Gebhard and James G. Straka

Functional Plant Biology 2005;32:267-70

CO₂ concentration (µmol mol⁻¹)

Estimated Amb a 1 exposure (mg plant⁻¹)

05/12/2022

Greenhouse conditions!
EXTREME EVENTS

Long distance transport of birch pollen

EUMETSAT pictures first time a pollen (and ash) cloud

10 May 2006 © EUMETSAT MEDIA
Thunderstorm Asthma: An Example of Climate Change

Whole pollen grains get swept up into cloud as storm matures. Flowery grasses. Whole grain fragments. Moisture in the cloud fragments the pollen into smaller pieces. Dry, cold outflows carry pollen fragments to ground level, where people breathe them into their lungs. Pollen fragments.

N=230 ER visits/hour/Melbourne

Is exposure to pollen during thunderstorms a risk factor for moderate and severe asthma exacerbations?

Severe asthma exacerbations in the general population exposed to grass pollen during thunderstorms

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Age</th>
<th>Outcome Definition</th>
<th>Grass pollen concentration</th>
<th>Lag</th>
<th>EE</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newson 1997</td>
<td>&gt;15 years</td>
<td>Asthma-Related ED Admissions</td>
<td>Pollen count &gt;50 grains/m³</td>
<td>0</td>
<td>1.47</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>all ages</td>
<td></td>
<td>with sferics *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pollen count &gt;50 grains/m³</td>
<td></td>
<td>1.06</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>without sferics *</td>
<td></td>
<td>1.31</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with sferics *</td>
<td></td>
<td>1.03</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pollen count &gt;50 grains/m³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lewis 2000</td>
<td>&gt;14 years</td>
<td>Asthma-Related ED Visits</td>
<td>Pollen count &gt;50 grains/m³</td>
<td>0</td>
<td>2.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Celenza 1996</td>
<td>&gt;16 years</td>
<td>Asthma-Related ED Visits</td>
<td>&gt;30 grains/l increase</td>
<td>9 hours before</td>
<td>0.83</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;30 grains/l fall</td>
<td></td>
<td>2.50</td>
<td>1.36</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;10 grains/l increase</td>
<td>2</td>
<td>2.15</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;10 grains/l fall</td>
<td></td>
<td>1.89</td>
<td>1.24</td>
</tr>
<tr>
<td>Hajat 1997</td>
<td>All ages</td>
<td>Asthma-Related Visits</td>
<td>258 grains/m³</td>
<td>3</td>
<td>1.17</td>
<td>1.06</td>
</tr>
<tr>
<td>Silver 2018</td>
<td>0-64 years</td>
<td>&quot;High levels of grass pollen over the three days preceding the thunderstorm were associated with increased admissions (roughly 3-5 additional admissions). When average grass pollen concentration of the previous three days exceeded 70 grains/m³, the exacerbation became significant, plateauing at around 4 additional admissions per day for mean concentrations of 100 grains/m³ or more.&quot;</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

D’Amato, Annesi-Maesano et al. CEA 2016
Still about climate change and pollen

• Ambrosia

Fig. 1 Habitat suitability in Europe for Ambrosia artemisiifolia under current climate conditions and the future IPCC climate scenarios RCP 6.0 and RCP 8.5 for the years 2070–2099. Translation figure legend: Derzeitiges Klima current climate. (Modified from Rasmussen et al. [17], Creative Commons CC-BY 4.0)

• Pollen and Sars-Cov2
  • Exposure to pollen weakens the immune response to certain rhinoviruses by reducing the interferon response, regardless of the presence of allergy (Damialis 2021 Proceedings of the National Academy of Sciences [2021], Gilles Allergy [2021]).

• Increased prevalence of oak processionary moth
Air pollution and pollen
Step 1. Agglomeration induced by organic substances

Step 2. Local preactivation of pollen + humidity

Step 3. Allergen release

Allergenic extrusions < 1 µm
Adsorption of allergens to pollen bound particles

Step 4. Allergenic aerosol
Particulate matter as allergen carrier

Behrendt and Becker, Curr Opin Immunol 2001; 13(6):709-715

IAM-XI.2022
Ambient Aerosol: Interaction between pollen, molds and pollutants

1. PM may transport allergens

Allergens from pollens, latex and also beta-glucans may be bound to and, hence, transported by the combustion particles in ambient air as shown by the immunogold labelling visualised in the backscatter electron imaging mode.

IAM Paris 2020
Interaction between pollen, molds and air pollutants

Traffic-related pollutants can trigger the release of allergen-containing granules from grass pollen, and increase the bioavailability of airborne pollen allergens. (Motta et al 2006)

- Modifications of the pollen morphology following exposure to pollutants
- Modifications of PCG release following exposure to pollutants

Fig. 1. Examples of damaged pollen grains. Treatment of pollen samples to air or pollutants can induce structural damage of the grains. a. Intact pollen. ×2,540. b. Pollen damaged following treatment to 50 ppm NO₂. ×2,000. c. Pollen damaged following treatment to 0.7 ppm O₃. PCG can be seen inside the broken grain. ×6,000.

Fig. 2. Release of PCG following contact of pollen grains with water. PCG are expelled from the grain via the pore (a, b). Only a small proportion of the grains release their cytoplasm, and the remaining grains stay intact (b: intact grain on the right). However, in the fragile pollen, PCG release can also occur through breaks of the exine (e). ×400.

PCG: Pollen cytoplasmic granules PCG

IAM Paris 2020 05/12/2022
Is exposure to pollen a risk factor for moderate and severe asthma exacerbations?


*: equal contribution

Allergy 2022 in press
Is exposure to pollen a risk factor for moderate and severe asthma exacerbations?

Asthma exacerbations defined:

- **directly:**
  - exacerbations (Moderate = temporary change in treatment (rescue or controller), Severe = Emergency Department (ED)/hospitalisation with systemic steroid use or systemic steroid for at least 3 days)
  - asthma symptoms/well days

- **indirectly:**
  - asthma medication
  - lung function
  - quality of life and mortality.
Severe asthma exacerbations associated with an increase of grass pollen (lag >2)

Severe asthma exacerbations associated with an increase of 0 to 50 grains/m3 of grass pollen (lag 0) in patients

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>log(Odds Ratio)</th>
<th>SE</th>
<th>Weight</th>
<th>Odds Ratio IV, Random, 95% CI</th>
<th>Odds Ratio IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1 Lag 0</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Batra 2021</td>
<td>-0.0101</td>
<td>0.0157</td>
<td>5.3%</td>
<td>0.99 [0.96, 1.02]</td>
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<tr>
<td>Lee 2019</td>
<td>0.0129</td>
<td>0.0081</td>
<td>18.0%</td>
<td>1.01 [1.00, 1.03]</td>
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<tr>
<td>Shrestha 2017</td>
<td>0.0065</td>
<td>0.0051</td>
<td>37.9%</td>
<td>1.01 [1.00, 1.02]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td>61.2% [1.00, 1.01]</td>
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<tr>
<td>Heterogeneity: Tau² = 0.00; Chi² = 1.82, df = 2 (P = 0.40); I² = 0%</td>
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<tr>
<td>Test for overall effect: Z = 1.45 (P = 0.15)</td>
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<tr>
<td>1.1.2 Lag 0–2</td>
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<tr>
<td>De Roos 2020</td>
<td>-0.0513</td>
<td>0.0319</td>
<td>0.9%</td>
<td>0.95 [0.88, 1.03]</td>
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<tr>
<td>Gleason 2014</td>
<td>0.0051</td>
<td>0.0051</td>
<td>37.9%</td>
<td>1.00 [0.99, 1.01]</td>
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<tr>
<td>Subtotal (95% CI)</td>
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<td>38.8% [0.95, 1.03]</td>
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<tr>
<td>Heterogeneity: Tau² = 0.00; Chi² = 1.69, df = 1 (P = 0.19); I² = 41%</td>
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<tr>
<td>Test for overall effect: Z = 0.52 (P = 0.60)</td>
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<tr>
<td>Total (95% CI)</td>
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<td>100.0% [1.00, 1.01]</td>
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<tr>
<td>Heterogeneity: Tau² = 0.00; Chi² = 4.61, df = 4 (P = 0.033); I² = 13%</td>
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<tr>
<td>Test for overall effect: Z = 0.88 (P = 0.38)</td>
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<tr>
<td>Test for subgroup differences: Chi² = 0.63, df = 1 (P = 0.43); I² = 0%</td>
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</tbody>
</table>

Severe asthma exacerbations associated with an increase of 0 to 50 grains/m3 of grass pollen (lag >2) in patients from general population
What can be done?
Climate change related factors plotted along axes to include their relevance in asthma and allergy (minor to major) and the ability to control these factors at the individual, community and population levels through (in red) mitigation or adaptation.

*: HDM, pets, pest that depend on climate
What "good practice" strategies can be used successfully?

• **Population level**
  • Reducing air pollution
  • Monitoring heat, air pollution, pollen, molds... → maps
  • Informing and educating about climate change issues
  • Almost 5% of all green house gas emissions in Europe come from the healthcare sector. Need for a central responsibility for a climate-neutral and sustainable transformation
  • ...

• **Individual level**
  • Advice on climate adaptation and resilience and the benefits of CO₂ reduction—for their own and the planet’s health.
  • Ventilation, Filtration systems, personal masks, avoidance, behaviours
Short-lived climate pollutants (SLCP)

- Beyond CO₂ there are many other equally dangerous gases - short-lived climate pollutants (SLCP): black carbon, methane, tropospheric ozone, and hydrofluorocarbons responsible for up to 45% of current global warming.
- Widespread and fast action to reduce SLCP emissions has the potential to reduce warming by as much as 0.6°C over the next few decades.
- Immediate implementation of SLCP control measures could reduce the rate of sea-level rise by ~20% in the first half of this century.
- By 2100, full mitigation of CO₂ and short-lived climate pollutants could reduce the rate of sea-level rise by up to 50%, which would give coastal communities and low-lying states time to adapt.
Quoting Bradford Hill:

“All scientific work is incomplete – whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge.

That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time.”
Climate change and respiratory disease: European Respiratory Society position statement

Projections of the effects of climate change on allergic asthma: the contribution of aerobiology

Climate change and respiratory diseases

Meteorological conditions, climate change, new emerging factors, and asthma and related allergic disorders. A statement of the World Allergy Organization

Allergy, 2010
WAO journal, 2011
JACI, 2018
MERCI