Planetary health and climate change: the effect on children with respiratory diseases around the world

PATS-ERS Webinar
March 20, 2023
Conflict of interest

• I declare no conflict of interest related to this talk
Facts about climate change

• Climate change refers to long-term shifts in temperatures and weather patterns

• 7 million premature deaths every year due to the combined effects of outdoor and household air pollution

• By 2030 onward, CC is expected to cause 250,000 additional deaths per year, from malnutrition, malaria, diarrhea and heat stress.

• The direct damage costs to health: US$ 2–4 billion per year by 2030
Important environmental exposures

• Aeroallergens
• Air pollution
• Natural disasters

European Respiratory Review Jun 2014, 23 (132) 161-169
Impact of CC in Africa region: WHO Africa

- In the last 20 years, out of 2021 public health events recorded, 56% were climate-related.
- 28% of health emergencies were vector born.
- Floods were the most frequent event (33%) of all the reported natural disasters.
- An additional 78 million people in Africa face chronic hunger by 2050.
Climate change and child health: *Lancet Planet Health* 2021
Pathophysiology

In utero: placental inflammation, developmental and epigenetic changes

Inflammation: increased inflammatory cell, epithelial barriers damage, increased susceptibility

Oxidative stress: gene activation, reactive species production

Cell death
Why are children more susceptible?

- Immature physiology and metabolism
- Incomplete development
- Higher exposure to air, food, and water per unit body weight
- Unique behavior patterns
- Dependence on caregivers

What are the respiratory impacts?

• Asthma
  ✓ Increased exacerbation of asthma
  ✓ Declining lung function
  ✓ Increased ER visits

Biomed J. 2022 Feb;45(1):88-94
• Respiratory infections and acute respiratory symptoms
  ✓ 1.8-fold increase in the risk of pneumonia in children aged under 5 years
  ✓ Cough, wheezing frequently encountered
  ✓ Increased carriage of pathogens

• Abnormal lung function

Int. J. Environ. Res. Public Health 2020, 17, 6178
Cont

• Ambient temperature change
  • Rise in allergic rhinitis
  • Increased hospitalization for respiratory infections
  • Increased mortality and morbidity of asthma

European Respiratory Review Jun 2014, 23 (132)
161-169
Challenges for Africa

• Limited diagnostic capacity

• High burden in mortality and morbidity

• Lack of cost-effective and quality assured medications

• Poor primary health care capacity

• Lack of organized health promotion programs
What are Hydrofluorocarbons?

• Hydrofluorocarbons are
  • greenhouse gases
  • short-lived climate pollutants
  • more potent global warming gas
Kigali Amendment

• The **Kigali Amendment** is an international agreement to gradually reduce the consumption and production of HFCs.

• High income countries: are committed to reducing the use of HFCs by 45% by 2024 and by 85% by 2036,

• LMIC: are committed to reducing its consumption by 80% by 2045
What is the impact for respiratory medicines?

• 2/3 of all doses prescribed use pMDI using HFC

• In 2019, 480M packs prescribed, equating to 2400 doses taken every second

• In 2014, HFC emissions from MDIs represented only 0.03% of annual global greenhouse gas emissions

Drug Des Devel Ther. 2020 Jul 29;14:3043-3055
Implementation challenge

• High price
• Difficult to coordinate the actuation of the spray with inhalation

Drug Des Devel Ther. 2020 Jul 29;14:3043-3055
A systematic review published in Lancet Global Health:

Only 10% met the 80% availability target for short-acting beta-agonists (SABAs), 6% for the inhaled corticosteroids, and very few for the combination.

SABA inhalers typically cost around 1–4 days’ wages, ICSs 2–7 days, and ICS-LABAs at least 6 days.

The Lancet Global Health, Volume 10, Issue 10, e1423 - e1442
Can Africa afford the switch of HFC to new formulations using propellants with lower GWP?

...cont
Conclusion

- CC impact on respiratory disease is a global public health.
- Asthma, COPD, respiratory infections, allergic rhinitis are the main diseases.
- Access and affordability of inhaled drugs in LMIC are challenges for LMIC.
- Emphasis have to be made to enhance access of new formulations using propellants to LMIC.
Planetary health and climate change: the effect on children with respiratory diseases around the world

A European perspective

ERS- PATS seminar, March 20th 2023

Erik Melén, MD, PhD
Professor, senior consultant pediatric allergy
Member, ERS Environmental Health Committee
## Conflict of interest disclosure

- **I have no real or perceived conflicts of interest that relate to this presentation.**

- **I have the following real or perceived conflicts of interest that relate to this presentation:**

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Outline

1. Air pollution and climate change
2. Children’s exposure
3. Across the life-course
4. Beyond air pollution exposure; allergen levels and meat allergy
5. Mitigation and what health-care professional can do
6. Conclusions
AIR POLLUTION - THE SILENT KILLER

Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce:

- Stroke
- Heart disease
- Lung cancer, chronic obstructive pulmonary disease, pneumonia and asthma

REGIONAL ESTIMATES ACCORDING TO WHO REGIONAL GROUPINGS:

- More than 2 million in South-East Asia Region
- More than 2 million in Western Pacific Region
- 1 million in Africa Region
- 500,000 deaths in Eastern Mediterranean Region
- 500,000 deaths in European Region
- More than 300,000 in the Region of the Americas

WHO Air Quality Guidelines set goals to protect millions of lives from air pollution.

CLEAN AIR FOR HEALTH #AirPollution

More than 90% of the world's children breathe toxic air every day

New WHO Global Air Quality Guidelines aim to save millions of lives from air pollution

Air pollution is one of the biggest environmental threats to human health, alongside climate change.
Air pollution and climate change intertwined

Haines et al *NEJM* 2019
A life-course perspective

Melén, Koppelman et al. *Lancet Child & Adolescent Health* 2022
Agustí, Melén et al. *Lancet Resp Med* 2022
Children are particularly vulnerable to environmental hazards:

- More time outside, physically active
- Higher rates of breathing and ventilation rates relative to body size
- Narrower airways
- Ineffective airway particle filtering
- Underdeveloped detoxification systems
- Typically don’t choose lifestyle and environment
Air quality index, March 19th 2023

World's Air Pollution: Real-time Air Quality Index
World's Air Pollution: Real-time Air Quality Index
Lung development from childhood to adulthood

Potential lung function catch-up
- Genetics and host factors
- Exposure avoidance
- Diet?
- Physical activity?
- Supplementation of beneficial factors?
- Prevention and/or treatment via precision medicine?

Normal lung function growth trajectory

Low lung function growth trajectory due to e.g.
- Genetics
- Preterm birth
- Early life environmental exposures
- LEIT
- Childhood persistent asthma

Melén and Guerra, F1000Res 2017
Air pollution exposure impairs lung function in infants

Björn Lundberg\textsuperscript{1,2}, Olena Gruzieva\textsuperscript{3,4}, Kristina Eneroth\textsuperscript{5}, Erik Melén\textsuperscript{1,2}, Åsa Persson\textsuperscript{3}, Jenny Hallberg\textsuperscript{1,2}, Göran Pershagen\textsuperscript{3,4}
Early-life events linked to lung health in young adulthood (age 21-24 y)

- **Chronic bronchitis** 5.5%
- **Irreversible airflow limitation** according to COPD-criteria 2%
- Cough, phlegm, recurrent airway infections and respiratory symptoms
- **Air pollution exposure 0-1 y strongly associated (OR 2-3)**
- RSV bronchiolitis / pneumonia 0-1 y OR 3.6 for airflow limitation
- Active smoking OR 3.8 for bronchitis
- Breastfeeding OR 0.66 for bronchitis

Wang et al, *Eur Resp J* 2021; *Thorax* 2021

![Illustration: Fuad Bahram](https://news.ki.se/early-life-events-linked-to-lung-health-in-young-adulthood)
Air pollution not only associated with lung function....

Ambient air pollution exposure linked to long COVID among young adults: a nested survey in a population-based cohort in Sweden

Zhebin Yu, Svenos Automotive, Tom Bolander, Per-Olof Johnsson, Karin Pershagen, Kristina Ewerens, Iger Kull, Anna Bergström, Antonios Georgels, Massimo Stafoggia, Olina Grezina, and Erik Melén

Growing evidence links air pollution exposure and COVID-19 risks

Dr. Alastair Chu
May 13, 2022 at 8:05 a.m. EST
Beyond air pollution

Key messages

- Allergic diseases affect millions of children and adolescents worldwide; in many regions between 5% and 30% of adolescents report rhinoconjunctivitis symptoms and up to 10% report food allergy.
- Links between climate change and allergic diseases are of increasing concern; these links include extended and altered pollen seasons, spread of allergens to new areas, along with changing and warmer climate, air pollution exposures changes, increasing exposure to heat events, and altered biodiversity.
- These new climate change aspects of allergic diseases have clinical implications for prevention, diagnostics, and treatment.
- Epigenetic changes, exemplified by DNA methylation, are associated with both environmental exposures and allergic diseases, although causality needs to be explored further.
- Use of epigenetic signatures and omics profiles has the potential to detect and monitor aspects of environmental exposures of relevance for health and disease in children and adolescents.

Melén, Koppelman et al. Lancet Child & Adolescent Health 2022
Anthropogenic climate change is worsening North American pollen seasons

William R. L. Anderegg1, John T. Abatzoglou1, Leander D. L. Anderegg2,3, Leonard Bielory4,5,6, Patrick L. Kinney4,5, and Lewis Ziska1

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Changes to Airborne Pollen Counts across Europe

Chiara Ziolò1, Tim H. Sparks1,2,4, Nicole Estrella1,2, Jordin A. Belmonte1, Karl C. Bergmann5, Edith Bucher6, Maria Antonia Brighetti1, Athanasios Damialis2,3, Monique Detandt3, Carmen Galán10, Regula Gehrig1, Lukasz Greiwling1, Adela M. Gutierrez Bustillo8, Margrét Hallsdóttir11, Marie-Claire Kockhans-Bielka12, Concepción De Linares7, Dorota Myszewska15, Anna Pályi7, Adriana Sánchez1, Matthew Smith16, Michel Thibaudon17, Alessandro Travaglino7, Agnieszka Uruska20, Rosa M. Valencia-Barrera21, Despoina Vokou1, Reinhard Wachtler22, Letty A. de Weger23, Annette Menzel1,2
Ragweed plants grown under elevated CO₂ levels produce pollen which elicit stronger allergic lung inflammation

Denise Rauer | Stefanie Gilles | Maria Wimmer | Ulrike Frank | Constanze Mueller | Stephanie Musiol | Behnam Vafadari | Lorenz Aglas | Fatima Ferreira | Philippe Schmitt-Kopplin | Jörg Durner | Jana Barbro Winkler | Dieter Ernst | Heidrun Behrendt | Carsten B. Schmidt-Weber | Claudia Traidl-Hoffmann | Francesca Alessandrini
**Alpha-Gal Syndrome**

AGS reactions can include:

- Hives or itchy rash
- Nausea or vomiting
- Heartburn or indigestion
- Diarrhea
- Cough, shortness of breath, or difficulty breathing
- Drop in blood pressure
- Swelling of the lips, throat, tongue, or eye lids
- Dizziness or faintness
- Severe stomach pain

Symptoms usually appear 2-6 hours after eating meat or dairy products, or after exposure to products containing alpha-gal (for example, gelatin-coated medications). People may not have an allergic reaction after every alpha-gal exposure.

**Factsheet**

*Allergy Healthcare Resources & Education | Allergy & Autoimmune Disease (thermofisher.com)*

**Alpha-gal Syndrome**

1-3 months IgE to alpha-Gal increases

Carrier → Tick bite → Consumes alpha-Gal containing food → 2-6 hours Reaction

**Current Opinion in Allergy and Clinical Immunology**

**Red meat allergy in children and adults**

Wilson, Jeffrey M., Platts-Mills, Thomas A.E.

**Current Opinion in Allergy and Clinical Immunology 19(3):p 229-235, June 2019. | DOI: 10.1097/ACI.0000000000000523**

**Alpha-gal syndrome initially misdiagnosed as chronic spontaneous urticaria in a pediatric patient: a case report and review of the literature**

Felicita Bellotti Enders1, Marius Ekuch1, Andreas Werner2, Kathrin Scherer Hofmeier2 and Karin Hartmann2

**Journal of Medical Case Reports**

https://doi.org/10.1186/s13256-023-0517-6
How can we mitigate climate change effects?
Asthma

Celeste Forsbärg, Erik Melén, Loun Lehtimäki, Dominick Shaw

The carbon footprint of inhalers continues to rise as global use increases. A study estimated that in 2018, 800 million hydrofluoroalkane (HFA)-propellant-based metered-dose inhalers were manufactured worldwide, using approximately 11 500 tonnes of hydrofluorocarbons, predominantly HFA-134a. Most of these HFAs are contained in salbutamol metered-dose inhalers. HFAs are strong greenhouse gases and contribute to global warming; every puff of salbutamol is estimated to be approximately equivalent to a mile travelled in a petrol car in terms of global warming. Consequently, the use of dry powder inhalers that do not contain propellants is now encouraged. Three companies have announced programmes to implement propellants with a lower global warming potential using HFA-152a or HFA-1234ze, with the first products potentially available from 2025. Disappointingly, the ability to recycle inhalers is still limited globally and the majority still end up in landfill.
In clinical practice and research we could.....

- Acknowledge and discuss with patients (also the children!) and colleagues climate change effects on respiratory health
- Improve and provide continued education of healthcare professionals on the impact of climate change
- Focus attention on high-risk and vulnerable populations, in our case children with potentially severe disease
- Promote climate-friendly activities and lifestyle among clinicians and patients that will lead to personal health and planetary co-benefits
- Raise awareness of the impacts of climate change and to boost national/international policy action
- Conduct interdisciplinary research to advance knowledge on climate change health impacts and adaptation mechanisms
- Act as an example in reducing greenhouse gas emissions in clinical practice (e.g. prescribe DPIs instead of pMDIs when possible) and in our daily activities
- DPI from age 5-6 years (depending on the child) and whenever possible
- Strive for optimal asthma control – minimize SABA overuse

DPI = dry powder inhalator    pMDI = Pressurized metered-dose inhalers
Not everything is getting worse

Associations of improved air quality with lung function growth from childhood to adulthood: the BAMSE study

Zhebin Yu1, Simon Kebede Merid2, Tom Bellander1,2,3, Anna Bergström1,2,3, Kristina Eneroth4, Antonios Georgelis1,2,3, Jenny Hallberg1,2,3, Inger Kulí2,3, Petter Ljungman1,2,4, Susanna Klevebro1,2,5, Massimo Stafoggia1,7, Gang Wang1,5, Göran Pershagen1,3, Olena Gruzieva1,5 and Erik Melén1,8

| TABLE 4 Association between improvement of air quality and differences in lung function growth from age 8 to 24 years |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Unit of improvement in exposure | Raw value | GLI z-score |
| | Difference in FEV1 growth, ml per year (95% CI) | Difference in FVC growth, ml per year (95% CI) | Difference in FEV1 growth, so per year (95% CI) | Difference in FVC growth, so per year (95% CI) |
| PM10 | 2.19 μg·m⁻³ | 4.63 (1.64–7.61) | 9.38 (4.76–14.00) | 0.03 (0.02–0.04) | 0.04 (0.03–0.05) |
| PM2.5 | 1.00 μg·m⁻³ | 0.72 (–0.91–2.35) | 2.77 (0.19–5.35) | 0.01 (0.00–0.02) | 0.01 (0.01–0.02) |
| BC | 0.26 μg·m⁻³ | 2.50 (0.60–4.93) | 5.50 (2.30–8.77) | 0.02 (0.01–0.03) | 0.02 (0.01–0.03) |
| NOx | 6.17 μg·m⁻³ | 1.70 (–0.16–3.57) | 3.29 (0.35–6.23) | 0.01 (0.01–0.02) | 0.01 (0.01–0.02) |
Conclusions

• Air pollution exposure and climate change is strongly linked
• Effects associated with respiratory health across the life-course
• Children are particularly vulnerable; lung development, asthma, respiratory infections etc
• Climate change → altered biodiversity, pollen levels, exposures
• Time to act!
• Risk mitigate is possible
Thanks!

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Thanks!

BAMSE workshop, Stockholm archipelago