MINISTERO della SALUTE
Workshop “Clima e Salute”
Roma 16 giugno 2016
Piano nazionale per la prevenzione degli effetti del caldo sulla salute, Estate 2016”

Cambiamenti climatici, Esposizioni Ambientali e Malattie Respiratorie

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SCENARIOS

Major natural and anthropogenic processes and influences on the climate system addressed in scenarios
Why the trend to increased allergy and asthma in the population?

- Hereditary
- “Hygiene” hypothesis
  - Rates of immunization; early antibiotic use
- Indoor pollution-changes in air exchange
- Dietary factors
- Exposure to allergens in early life
- Outdoor air pollution and global warming.

D’Amato G “Respiratory allergy, Aeroallergens and other trigger factors (climate change ad air pollution).” Publ Momento Medico 2016
“Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely [at least 90%] due to the observed increase in anthropogenic greenhouse gas concentrations.”

**CO2 is the most important anthropogenic greenhouse gas and about 75% of CO2 emissions during the past 20 years resulted from fossil fuel burning**

*Source: IPCC, 2007 (Working group I)*
Increased atmospheric concentrations of CO₂ and other greenhouse gases:

- increases in temperature (global warming) and humidity
- changes in the amount, distribution, and intensity of precipitation events
- increases in the intensity and frequency of certain extreme weather events (heat waves, floods, thunderstorms and hurricanes)

Anthropogenic activities play a key role

Solomon et al., 2007, Fourth Assessment Report of the IPCC,
Anthropogenic CO$_2$ input

![Graph showing CO$_2$ concentration over years](image1.png)

**CO2: six degrees of freedom**

\[
259.67 + 53.887 \times \exp(0.01684 \times (\text{YEAR} - 1958)) + 2.797 \times \sin(-0.463 + ((\text{YEAR} - 1958) \times 2\pi) / 1)
\]

![Photography](image2.png)

Mauna Loa CO$_2$ ppmv

![Photography](image3.png)
Long-term effects of CO$_2$: time to stabilization
After CO2 emissions are reduced and atmospheric concentrations stabilize, surface air temperature continues to rise slowly for a century or more

<table>
<thead>
<tr>
<th>CO$_2$ concentration, temperature, and sea level continue to rise long after emissions are reduced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time taken to reach equilibrium</strong></td>
</tr>
<tr>
<td>Sea-level rise due to ice melting: several millennia</td>
</tr>
<tr>
<td>Sea-level rise due to thermal expansion: centuries to millennia</td>
</tr>
<tr>
<td>Temperature stabilization: a few centuries</td>
</tr>
<tr>
<td>CO$_2$ stabilization: 100 to 300 years</td>
</tr>
</tbody>
</table>
Potential Health Effects of Climate Change

Climate change:
- Temperature rise
- Sea level rise
- Hydrologic extremes

Adapted from J. Patz

Source: Dr. Howard Frumkin
Fig. 1. Possible effects of climate change on patients affected by respiratory allergy (see text).

- Earlier start, increase of length and intensity of pollen season
- Increase of pollutants levels
- Increase of heavy precipitation events (e.g. thunderstorms)
- Increased occurrence of episodes of long distance transport of pollen and pollutants

- Reduced susceptibility to upper respiratory infections (due to increase in winter temperature)
EFFECTS ON ASTHMA AND RESPIRATORY ALLERGY OF CLIMATE CHANGE AND AIR POLLUTION.
Meteorological Conditions, Climate Change, New Emerging Factors and Asthma. A Statement of the World Allergy Organization


WAO Journal 2015
PM can affect both the respiratory and cardiac systems.

Pyramid of Health Effects of PM

- mortality
- hospital admissions
- emergency room visits
- physician office visits
- reduced physical performance
- medication use
- symptoms
- impaired pulmonary function
- subclinical (subtle) effects

**short-term vs. long-term effects**

although there is probably a continuum of effects in the time scale, which are not yet fully understood
Ozone is a colorless, odorless gas formed when nitrogen oxides and volatile organic compounds react in the presence of intense sunlight.

**OZONE FORMATION**
Ozone is formed when nitrogen oxides (from fuel burning sources like utilities and automobiles) and volatile organic compounds (from sources such as gasoline, paints, inks and solvents) react in the presence of sunlight. The formation of ozone is dependent on the volume of air available for dilution, air temperature and the amount of sunlight.
Ozone Increases with Higher Temperatures

Ozone versus Temperature

Riverside, 2003-2005

Fresno, 2003-2005

$R^2 = 0.60$

$R^2 = 0.82$
Acute Effects of Ozone

- Respiratory symptoms
- Acute decreases in lung function
- Increased airway responsiveness
- Airway injury and inflammation
- Systemic oxidative stress
Health Effects of Exposure to Ozone and PM$_{2.5}$

- coughing
- nose and throat irritation
- chest pain
- reduced lung function
- increased susceptibility to respiratory illness
- aggravation of asthma
- children with chronic lung disease are particularly at risk

- increased risk of cardiac arrest and premature death
- aggravation of asthma
- respiratory related hospital visits
- reduced lung function and chronic bronchitis
- work and school absences
- children with chronic lung disease are particularly at risk

WHO: More than 7 million air pollution deaths each year.
Hospital Admissions and ED visits for Asthma due to Ozone

- Brisbane, Australia
  - Petroeschevsky et al; 13,246 hospital admissions for asthma showed a strong association between O$_3$ exposure and asthma exacerbations

- Atlanta
  - White et al 1994 showed that among black children from low-income families, asthma may be exacerbated following periods of high ozone pollution
  - Tolbert et al 2000 looked at pediatric emergency room visits from 1993-1995 and found ozone (>100 ppb vs. <50 ppb: odds ratio = 1.23, p = 0.003) with pediatric asthma exacerbations

- Toronto
  - Thurston et al-Correlation in admissions to the hospital during the summer and ozone levels

- Sydney
  - Jalaludin et al 2008-Increased ED visits from air pollution including ozone in children
Climate Change and Allergens

• Increase plant growth
• Increase the amount of pollen produced by each plant
• Increase the amount of allergenic proteins contained in pollen
• Increase the start time of plant growth and therefore the start of pollen production

• D’Amato G et al Position paper of EAACI “Allergenic pollen and pollinosis” Allergy 2007
The Possible Ways by which Atmospheric Pollution may Increase Allergy

- Genetic Predisposition
  - Enhancement of Sensitization
  - Enhancement of Organ Hyper-responsiveness
  - Triggering Episodes of Disease

- Allergic Sensitisation

- Organ Hyper-responsiveness

- Enhanced Pollen Production and Antigenicity

Disease
A doubling of the atmospheric CO2 concentration stimulated ragweed-pollen production by 61%
Elevated Atmospheric Carbon Dioxide Concentrations Amplify *Alternaria alternata* Sporulation and Total Antigen Production

*Wolf J, et al Environ. Health Perspect 2010*

At 500 and 600 mol/mol CO2 concentrations, *A. alternata* produced nearly 3 times the number of spores and more than twice the total antigenic protein per plant than at lower concentrations.

Effect of increasing leaf C:N on the natural log of *A. alternata* spores

Effect of increasing *P. pratense* leaf C:N on the *A. alternata* spore antigen content
Due to climate change, changes are also occurring in the amount, intensity, frequency and type of precipitation as well as the increase of extreme events, like heat waves, droughts, floods and hurricanes.
Weather changes with Climate Change

• More extreme weather patterns, such as increase in thunderstorms
• High number of thunderstorms in spring and summer as same time at high pollen counts
• Pollen grain rupture with thunderstorms with higher levels of respirable allergens; also increase in ozone
• More asthma outbreaks
  – UK, Australia, and Italy

(Michael Blaiss in WAO  J 2015)
Meteorological conditions, climate change, new emerging factors, and asthma and related allergic disorders. A statement of the World Allergy Organization

Fig. 3 Possible effects of climate change on respiratory allergy. Source: Lorenzo Cecchi, original drawing.

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

Meteorological Conditions, Climate Change, New Emerging Factors and Asthma.
A Statement of the World Allergy Organization


WAO
World Allergy Organization

EAACI
European Academy of Allergy and Clinical Immunology

EAACI 2015 Barcelona
Thunderstorm related asthma: what happens and why.

Possible mechanisms for thunderstorm-related asthma.

Is there a causal link between thunderstorm and asthma attacks?

Is it possible to predict thunderstorm related asthma?

Thames Regions Accident and Emergency Trainer Association. A major outbreak of asthma associated with a thunderstorm: experience of accident and emergency departments and patients characteristics BMJ 1996;312:601-4
6 patients received treatment in emergency departments for severe asthma and one was admitted to an intensive care unit for acute respiratory insufficiency.
All patients were allergic to Parietaria pollen with symptoms during Spring-Summer months. The extraordinarily long persistence in the atmosphere of *Parietaria* pollen in southern Mediterranean area is responsible for a multiseasonal symptomatology.
Thunderstorm - associated asthma epidemics: observational evidence

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>UK</td>
<td>26 sudden cases of asthma attacks in relation to thunderstorms</td>
</tr>
<tr>
<td>1992</td>
<td>Australia</td>
<td>Late spring thunderstorms in Melbourne can trigger epidemics of asthma attacks (five to 10-fold rise)</td>
</tr>
<tr>
<td>1997</td>
<td>UK</td>
<td>Asthma or other airways disease hospital visits. 640 cases who attended during a 30-h period on June 1994, nearly 10 times expected number</td>
</tr>
<tr>
<td>1992–2000</td>
<td>Canada</td>
<td>18,970 hospital ED asthma visits among children 2–15 years of age. Summer thunderstorm activity was associated with an OR of 1.35 (95% CI 1.02–1.77) relative to summer periods with no activity</td>
</tr>
<tr>
<td>1993–2004</td>
<td>USA</td>
<td>215,832 asthma ED visits; 24,350 of these visits occurred on days following thunderstorms. Significant association between daily counts of asthma ED visits and thunderstorm occurrence. Asthma visits were 3% higher on days following thunderstorms.</td>
</tr>
<tr>
<td>2000</td>
<td>Australia</td>
<td>Asthma visits during thunderstorms History of hayfever and allergy to ryegrass are strong predictors for asthma exacerbation during thunderstorms in spring</td>
</tr>
<tr>
<td>2001</td>
<td>Australia</td>
<td>The incidence of excess hospital attendances for asthma during late spring and summer was strongly linked to the occurrence of thunderstorm outflows</td>
</tr>
<tr>
<td>2002</td>
<td>UK</td>
<td>A case–control study of 26 patients presenting to Cambridge University Hospital with asthma after the thunderstorm Alternaria alternata sensitivity is a compelling predictor of epidemic asthma in patients with seasonal asthma and grass pollen allergy and is likely to be the important factor in thunderstorm-related asthma</td>
</tr>
<tr>
<td>2004</td>
<td>Italy</td>
<td>Six cases of thunderstorm-related asthma because of pollen (Parietaria)</td>
</tr>
<tr>
<td>2010</td>
<td>Italy</td>
<td>20 cases of thunderstorm-related asthma because of pollen (olive tree)</td>
</tr>
<tr>
<td>2010</td>
<td>Australia</td>
<td>Epidemics of ‘thunderstorm asthma’ that occurred in Melbourne during spring 2010 The approach of spring, together with high winter rainfall in and around Melbourne that heralds another severe pollen season, raises the risk of allergic rhinitis and asthma in pollen-sensitive individuals</td>
</tr>
</tbody>
</table>
The pollinic allergens are located in the walls or in the cytoplasm.
Hydrated pollen on a wet surface

- Lipid drops
- Starch
- Proteins
Submicronic and/or paucimicronic particles in atmosphere

Pollen grains fragmented and dispersed in atmosphere
Pollen fragments

Starch granules and other cytoplasmic granules

Non-pollen plant parts (from inflorescences, leaves or Ubisch bodies)

Non-plant particulate matter (allergens transferred through physical contact or by leaching from the surface of the pollen grain to other airborne small particles).

Climate Changes favour production also of Airborne Small Allergen-carrying Particles


Pollen grains fragmented and dispersed in atmosphere during Thunderstorms
The potential role of orbicules (Ubish bodies) as vector of allergens.

D’Amato G - Z Erkrank Atm Org 1981
Pacini E Franchi GG - Plant Syst Evol 1993
Vinckier S Smets E - Allergy 2001
D’Amato G - Allergy 2001
D’Amato G et al Clin Exp Allergy 2005
D’Amato G et al Allergy 2007; JIACI 2010; ERR 2014; CEA 2016
Under wet conditions or during thunderstorms pollen grains may, after rupture by osmotic shock, release part of their cytoplasmic content into the atmosphere.


Climate change and respiratory diseases

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@ERSpublications
Climate change represents a threat to respiratory health by acting on respiratory diseases or their risk factors http://ow.ly/v6JEl
Weather changes with climate change:
- High number of thunderstorms in spring and summer at the same time at high pollen counts
- Pollen grain rupture with thunderstorms with higher levels of respirable allergens;
- More asthma outbreaks
Thunderstorm–associated asthma epidemics: evidence based-knowledge

There is a close temporal association between the start of the thunderstorm and the onset of asthma epidemics. Asthma epidemics related to thunderstorms are limited to pollen (and outdoor mould) seasons. There are not high levels of gaseous and particulate components of air pollution during thunderstorm-related asthma outbreaks. Subjects with pollen allergy who stay indoors with the window closed during thunderstorms are not involved. There is a major risk for subjects who are not receiving antiasthma treatment but subjects with allergic rhinitis and without previous asthma can experience severe bronchoconstriction. Non-allergic subjects are not involved in thunderstorm-related asthma outbreaks.
Is there a causal link between thunderstorms and asthma attacks?

<table>
<thead>
<tr>
<th>Hill’s criteria</th>
<th>Application to the thunderstorm-related asthma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
<td>Increased risk of asthma attacks in relation to thunderstorms</td>
</tr>
<tr>
<td>The stronger the relationship between the independent variable and the dependent variable, the less likely it is that the relationship is due to an extraneous variable.</td>
<td></td>
</tr>
<tr>
<td><strong>Consistency</strong></td>
<td>Association between thunderstorm and asthma found in different studies and different populations</td>
</tr>
<tr>
<td>Multiple observations, of an association, with different people under different circumstances and with different measurement instruments increase the credibility of a finding.</td>
<td></td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>Scantily demonstrated by experimental data (also sparse and heterogeneous)</td>
</tr>
<tr>
<td>Causation is likely if a very specific population at a specific site and disease with no other likely explanation. The more specific an association between a factor and an effect is, the bigger the probability of a causal relationship is [1].</td>
<td></td>
</tr>
<tr>
<td><strong>Temporality</strong></td>
<td>Thunderstorms always precede asthma attacks</td>
</tr>
<tr>
<td>The effect has to occur after the cause.</td>
<td></td>
</tr>
<tr>
<td><strong>Dose–response relationship</strong></td>
<td>Increased amount of pollen and mould spores at the beginning of the thunderstorm associated with increased probability of asthma attacks in pollen patients and other allergic patients</td>
</tr>
<tr>
<td>There should be a direct relationship between the risk factor (i.e. the independent variable) and people’s status on the disease variable (i.e. the dependent variable).</td>
<td></td>
</tr>
</tbody>
</table>
A young lady who experienced near fatal asthma in concomitance with a thunderstorm in June 2004 was admitted again in the emergency room department of Cardarelli hospital in Naples on 24 May 2011 and on 28 May 2012 for other two attacks of near fatal asthma (the last, in 2012, in pregnancy).
NUTRIZIONE ARTIFICIALE

ENTERALE
- Glucosio 33%
- Glucosio 20%
- Glucosio 10%
- Glucosio 5%
- Ivclip 20%

PARENTERALE
- Solamin 7.5%
- A. essenziali
- A. selettivi
- A. ramificati
- Sol n° 6
- Sol n° 7

Terapia:

Permanenza 26 ore
Inizio 16.00 ore
Fine 18.00 ore
Durata 2 ore

Sollievo al riposo 2 g v/d v in.

Gia' in paziente

Stato: VALIDATO
31/05/2012 12:15:55
Tipo campione: Arterioso
Campione No.: 436
Paziente: Nome
Sesso: S
Strumento: Modello: GEM 3000
S/N: 14845

Misurati (37.0°C)
- pH 7.22
- pCO2 103 mmHg
- pO2 132 mmHg
- Na+ 136 mmol/L
- K+ 3.5 mmol/L
- Ca++ 1.02 mmol/L
- Glu 138 mg/dL
- Lat 0.8 mmol/L
- Hct 37 %

Parametri derivati
- Ca++(7.4) 1.04 mmol/L
- HCO3- 25.3 mmol/L
- HCO3std 26.5 mmol/L
- TC02 26.3 mmol/L
- Beecf 1.8 mmol/L
- BB(B) 2.1 mmol/L
- SO2c 96 %
- ?THbc ------

A-AO2 32 mmHg
pA02 107 mmHg
paO2/pAO2 0.70
RI 0.4
Take home message:
Subjects affected by pollen allergy should be alert to the danger of being outdoors without correct treatment of rhinitis and asthma during a thunderstorm in the pollen season.
Changes in CO2 concentration and climate changes.

- Heat waves
- Extreme events
- Precipitation
- Temperature

Changes in aeroallergens:
- Timing
- Location
- Quantity

Atmospheric pollutants (O₃, PM, NO₂, SO₂, CO)

Human health impacts:
- Allergic rhinitis
- Asthma exacerbation
- Atopic dermatitis

Policies measures:
- Mitigation
- Adaptation
What can we do?
Decreasing use of fossil fuels and controlling vehicle emissions.
Reducing the private traffic in towns.
Increased use of public transport, cycling, and walking.
Planting in cities non-allergenic trees
Minimize outdoor activity on days with high pollution
Suggest patients live in remote areas from heavy traffic
Reduction in meat consumption

Two for the price of one: climate change mitigation measures also reduce air pollution
Each year 13 millions of forests ‘hectares are destroyed or deteriorated.
In the last 50 years 50% of pluvial forests of our Planet have been destroyed.

Food cultivation on wasted areas of tropical pluvial forests determined about 35% of deforestation in South America, 70% in African and 50 % in Asian countries
Climate change and allergy, the contribution of forests of Brazil to a clean atmosphere.

Gennaro D'Amato; Carolina Vitale; Nelson Rosario; Herberto Jose Chong Neto; Debora Carla Chong-Silva; Francisco Mendonça; José Perini; Loraine Landgraf; Dirceu Solé; Mario Sanchez; Ignacio Ansotegui; Maria D'Amato

World Allergy Organization Journal, in press
Climate change and allergy, the contribution of forests of Brazil to a clean atmosphere. Gennaro D'Amato; Carolina Vitale; Nelson Rosario; Herberto Jose Chong Neto; Debora Carla Chong-Silva; Francisco Mendonça; José Perini; Loraine Landgraf; Dirceu Solé; Mario Sanchez; Ignacio Ansotegui; Maria D'Amato

World Allergy Organization Journal, in press
Norway Is The First Country To Ban Deforestation
“This is an important victory in the fight to protect the rainforest.”
Strategies to reduce climate changes and air pollution are political in nature, but citizen and in particular health professionals and societies must raise their voices in the decision process to give strong support for clean policies on both national and international levels.
Thanks
gdamatomial@gmail.com

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