Climate and weather effects on health...

Prof. Dr. Luis B. Lecha Estela
Councilor for Latin America and the Caribbean
International Society of Biometeorology (ISB).

The content is fundamental for the future main functions of healthy hospitals...
CONTENT

1. The problem
2. The current facts
3. The close perspectives
4. The proposal of actions
Climate and weather are in the mass media

The behavior of climate and weather is a topic of high interest at present time due to the heavy implications that their potential effects have on human´s life in the whole planet.

But the Polar Bear is not the only threatened species...
The transferable and chronic diseases have different relationship with climate or weather influences

Focal Points

**Transferable:**
- The beginning of an illness outbreak or epidemic is weather related, i.e. natural disasters.
- The geographical extend for a given diseases is close related with climate and favorable habitats.
- Global warming helps the spread of vector-borne diseases.
- The prevention and control depend more on social and environmental conditions.

**Chronic:**
- Weather conditions may produce massive health crisis at different space-time scales.
- The seasonal outbreak of human illnesses are always climate related.
- The impact of weather on mortality is higher than from other external factors.
- The biotropic responses may be controlled with adequate medical - biometeorological preventive procedures.
The Problem to Face

How the medical community can deal with the potential impacts of climate variability and weather extremes on human health?

The hypothesis:

*Based on previous results from Brazilian-Cuban researches oriented to forecast weather conditions and air pollution episodes potentially dangerous for human health and considering the current computer technology available at CPTEC/INPE, it is feasible to design, apply and validate an Early Health Alert System for the healthy hospitals of the state of Sao Paulo, Brazil, oriented to prevent the occurrence of massive and significant meteor-tropic effects in the most vulnerable population's groups of the region.*
The increase of CO\textsubscript{2} and the global warming

Recent reports from the scientific community (IPCC and other sources) have shown that the world climate is changing very fast, even faster than expected, with more intense and frequent episodes of severe weather and extreme climate anomalies.
What the Greenhouse effect is?

The Green House effect is normal in the atmosphere due to the interaction of reflected solar radiation with aerosols and water vapor, but the increase of CO$_2$ and other gases produce the catchment of outgoing infrared radiation and the start of the warming process of the troposphere.
The effects are already present

Some effects of climate and weather variability are already affecting human health in a specific or non-specific ways. It is necessary to be concerned on this.

Another phenomena like strong “El Niño” events help global warming, increasing the occurrence of severe weather, major hurricanes and changing the regional rainfall patterns all around the world.

The European heat wave in 2003 had strong effect on mortality with more than 50,000 deaths.
Global Effects

- Changes in the ocean streams
- Sea level rise
- Global increase of air temperature
- Annual records of global temperatures
- More intense hurricanes
- More frequent droughts
- More natural disasters

Annual records of global temperatures
Regional Effects

**EFFECTS:**
- Diseases
- Epizooties
- Hunger
- Poverty
- Migrations
- Pollution
- Employment
- Development
- Water supply
- Food production
- Life quality

**REGIONAL WARMING**

- Heavy defrost in the Arctic and Greenland

**CURRENT IMPACTS ON...**

- Biodiversity loss
- Lost of swamps
- More extreme weather events
- More droughts

**Hadley model projection for 2030**
Country-level Effects

**IMPACTS**

- Heavy coastal erosion
- Important rise of temperature
- Significant sea level rise
- Higher space-time variability of rainfall processes
- More frequent droughts
- More frequent and intense hurricanes
- Changes in the duration of the climate seasons
- Changes in phonological phases of cultivations

The national reports to the U.N. Convention Framework for Climate Change is the fundament for the evaluation of CC impacts at the country level.

Rise of annual temperature

Longer and hottest summers, less winters duration
The climate and weather effects act on different scales

The climate impacts are present in space-scales at global and regional levels. While in time-scales are present in the annual and multiyear variations.

**CLIMATE:**
- Changes in the global balance of energy and heat.
- Changes in the patterns of the General Circulation of the Atmosphere due to the increase of energy transfer.
- Changes in the season’s duration.
- Longer and steady summer seasons.
- Shorter and more stormy winter seasons.
- More climate extremes.

**WEATHER:**
- More energy available for bad weather processes.
- Increase role of subtropical anticyclones in drought intensity and frequency.
- More hurricanes all around the world and more intense.
- More winter cyclones during winter time and more intense.
- More weather extremes and their related disasters.
- More space-time weather contrasts and local records.

The weather impacts are present in space-scales at local and mesoscale levels. While in time-scales are present at inter-daily and daily variations.
Multiyear changes of climate

Records of global monthly temp. have been recently broken…

+ 1.35°C

Successive annual records of global air temperatures since 2013

But representative morbidity and mortality data is also needed for long periods.

Trend of air temperatures in regions of Cuba

Long-term sequency of “El Niño” events
Seasonal changes of climate and health crisis occurrence

The role of adaptation to...

Changes in the seasonal behavior

Rates by 100,000 inhabitants of respiratory infections, HTA crisis and bronchial asthma crisis in Sagua la Grande during the years 2006-2010

A common picture: Seasonal picks of health crisis

Asthma crisis in Sao Paulo, Brazil (2004-2015)

Asthma crisis in Deusto, Spain (2006-2010)
The day by day weather and disease occurrence

Weather changes happen through the day by day variability of synoptic situations. Some of them affect the most vulnerable people.

Weather conditions in given days may produce massive increases of health crisis in vulnerable people, including deaths in excess.
The daily rhythm of weather and the human physiology

- Noon:
  - Leucocitos
  - Hormona del crecimiento
  - Linfocitos, TSH
  - Prolactina

- 6 AM:
  - Péptido natriurético atrial
  - Act. Renina plasmática
  - Eosinófilos
  - Melatonina
  - ACTH
  - FSH, LH
  - Cortisol
  - Aumento de catecolaminas
  - Presión Arterial/Aumento FC
  - Distensibilidad arterial/

- 6 PM:
  - Péptido gen-relacionado con la calcitonina
  - Secreción de ácido gástrico
  - Colesterol
  - Triglicéridos
  - Flujo sanguíneo periférico
  - (antebrazo)
  - Diuresis

- Midnight:
  - Insulina
  - Hemoglobina
  - Permeabilidad vía aérea
  - Frecuencia respiratoria
  - Frecuencia cardíaca

- Leucocitos
  - Hemoglobina
  - Permeabilidad vía aérea
  - Frecuencia respiratoria
The daily circadian rhythm

In a recent study with more than 1,400 HTA patients, the “riser” type was the most vulnerable to weather influences (84%), followed by the “non-dipper” type (68%). It explains the dangerous night occurrence of hypertensive crisis when vulnerable people sleep.
The role of adaptation

In the past decade of the years 90s Dr. W.H. Weihe, former ISB President, defined biometeorology as “the science of adaptation”. Such interpretation of biometeorology was uncommon at that time because of the available studies were more focused on the meteorological, physical or statistical sides of the problem, nor in medical, sanitary or epidemiological approaches.

The medical counterpart must have methods to know: how vulnerable a person is to external influences?... Especially from climate or weather impacts.
The biotrophic response

The weather conditions and synoptic situations are external factors that can affect human physiology.

The influence of these factors act in two ways on humans: first, the demands on the tolerance threshold of organs and the regulation process, while the second way moves through the necessity to adjust the individual capacity of adaptation.

Here are the fundaments to design preventive actions, mitigation or adaptation procedures to face the climate and weather effects on human health.

When adaptation process fail diverse and massive health crisis may occur in a vulnerable population. This is a very complex area of biometeorology because of adaptation depends on multiple individual factors (age, sex, race, the general state of health, the level of physical training and many other factors).
What meteor-tropic effects are?

**Meteor-tropic effects** are given weather conditions able to influence on human physiology, to break the individual threshold of the regulation process and to produce abnormal reactions in some internal organs or body functions. They can act like trigger to start health crisis in vulnerable people, affecting the thermal balance of the body, the cardiovascular or neurological functions or they may develop specific disorders in patients with a given chronic disease.

**Meteor-tropic reactions** will depend on the individual capacity of adaptation and the complex interaction with other risk factors eventually present. Also they are function of the intensity of the weather contrast and the duration of the stress due to weather stimuli.
When meteor-tropic effects occur?

Not all daily maxima for a given disease is due to meteor-tropic effects. Most of them depend of local influences. To define the occurrence of meteor-tropic effects, the following conditions must be observed:

- The weather impact must be synchronic, when the disease maxima occur in several health centers of the same city or in neighbor places within the same county or province.
- The disease maxima should be significant, higher than 150% of the monthly mean value or higher than 75 percentile for the given disease.
The biometeorological forecasts are especial types of weather forecasts dedicated to prevent the negative impacts of the meteorological conditions on humans, animals and plants.
The Background

1992
Biomet. forecasts vs heat stroke in broilers production

1996
First Model
“SAAS ver 1.0”

2007
Second Model
“PronBiomet”

2015
Heat waves model

The new model for the global monitoring of meteor-tropic effects
The Global Monitoring

<table>
<thead>
<tr>
<th>Biomet. Conditions</th>
<th>Low Latitude</th>
<th>Middle Latitude</th>
<th>High Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme hyperoxia</td>
<td>&gt; 10.0</td>
<td>&gt; 20.0</td>
<td>&gt; 30.0</td>
</tr>
<tr>
<td>Very strong hyperoxia</td>
<td>8.1 to 10.0</td>
<td>16.1 to 20.0</td>
<td>24.1 to 30.0</td>
</tr>
<tr>
<td>Strong hyperoxia</td>
<td>6.1 to 8.0</td>
<td>12.1 to 16.0</td>
<td>18.1 to 24.0</td>
</tr>
<tr>
<td>Moderate hyperoxia</td>
<td>4.1 to 6.0</td>
<td>8.1 to 12.0</td>
<td>12.1 to 18.0</td>
</tr>
<tr>
<td>Weak hyperoxia</td>
<td>2.1 to 4.0</td>
<td>4.1 to 8.0</td>
<td>6.1 to 12.0</td>
</tr>
<tr>
<td>THE NEUTRAL ZONE</td>
<td>-2.0 to 2.0</td>
<td>-4.0 to 4.0</td>
<td>-6.0 to 6.0</td>
</tr>
<tr>
<td>Weak hypoxia</td>
<td>-2.1 to -4.0</td>
<td>-4.1 to -8.0</td>
<td>-6.1 to -12.0</td>
</tr>
<tr>
<td>Moderate hypoxia</td>
<td>-4.1 to -6.0</td>
<td>-8.1 to -12.0</td>
<td>-12.1 to -18.0</td>
</tr>
<tr>
<td>Strong hypoxia</td>
<td>-6.1 to -8.0</td>
<td>-12.1 to -16.0</td>
<td>-18.1 to -24.0</td>
</tr>
<tr>
<td>Very strong hypoxia</td>
<td>-8.1 to -10.0</td>
<td>-16.1 to -20.0</td>
<td>-24.1 to -30.0</td>
</tr>
<tr>
<td>Extreme hypoxia</td>
<td>&lt; -10.0</td>
<td>&lt; -20.0</td>
<td>&lt; -30.0</td>
</tr>
</tbody>
</table>
Health crisis were observed in less than 10% of asthmatic people. Only 3% needed medical assistance and 0.1% required hospital admission.
The validation results

With samples from two Cuban municipalities (2007-2009) and Basurto city in Spain (2005-2007)

<table>
<thead>
<tr>
<th>Condition to evaluate</th>
<th>CAB</th>
<th>CVD</th>
<th>HTA</th>
<th>MIG</th>
<th>STR</th>
<th>Suma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right forecasts</strong></td>
<td>51</td>
<td>31</td>
<td>46</td>
<td>45</td>
<td>35</td>
<td>208</td>
</tr>
<tr>
<td>Due to hyperoxia</td>
<td>33</td>
<td>19</td>
<td>11</td>
<td>7</td>
<td>8</td>
<td>78</td>
</tr>
<tr>
<td>Due to hypoxia</td>
<td>18</td>
<td>12</td>
<td>35</td>
<td>38</td>
<td>27</td>
<td>130</td>
</tr>
<tr>
<td><strong>Mistakes type 1</strong></td>
<td>3</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>38</td>
</tr>
<tr>
<td>Due to local effects</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Due to hyperoxia</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Due to hypoxia</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL FORECAST</strong></td>
<td>54</td>
<td>41</td>
<td>53</td>
<td>55</td>
<td>43</td>
<td>246</td>
</tr>
<tr>
<td>Due to hyperoxia</td>
<td>35</td>
<td>26</td>
<td>14</td>
<td>10</td>
<td>11</td>
<td>96</td>
</tr>
<tr>
<td>Due to hypoxia</td>
<td>19</td>
<td>15</td>
<td>39</td>
<td>45</td>
<td>32</td>
<td>150</td>
</tr>
<tr>
<td><strong>SKILL (%)</strong></td>
<td>94.4</td>
<td>75.6</td>
<td>86.8</td>
<td>81.8</td>
<td>81.4</td>
<td>84.6</td>
</tr>
</tbody>
</table>
The BRAMS 4.5 Brazilian model makes regional air quality forecasts.

The Cuban PronBiomet model forecasts the intensity and extend of weather changes.

The year 2015 an integrated and global versión of both models was developed. Now it may be available in Brazil.

The models go from regional to global scale and to APPs development.
The Global APPs “OxyAlert”

Inter-daily weather contrast up to 72 hours in advance

The small screen of OxyAlert global forecast

The output uses the colors of the traffic light

User’s explanation and questionnaire for direct feedback under alerts.
Proposal of Actions to side A (meteorology)

• The meteorological counterpart (side A) should finish the model output and the web design for the public access to the forecasts up to 84 hours in advance.
• Also capacity building must be created at CPTEC/INPE to assure the correct elaboration of written forecasts for selected health institutions or under demand.
• Biometeorological forecasts need access to current and forecast weather data. The forecaster should know the influence of given synoptic situations on the occurrence of hyperoxia or hypoxia conditions, as well as the meteor-tropic effects related with the day by day dynamic of weather types in the place or region under monitoring.
• Forecasters must interact continuously with the medical counterpart, especially during the validation process.
Proposal of Actions from the medical side

• The medical counterpart must learn how to read and apply the forecast information, identifying on the march which local biotropic responses are best related with the weather contrasts due to hyperoxia or hypoxia conditions.

• Healthy hospitals should prepare a local meteorogram in order to follow the inter-daily behavior of weather elements and disease occurrence, identifying the days with meteor-tropic effects.

• Medical experts must design operational procedures, according with the illnesses in order to avoid or mitigate the weather impacts on vulnerable people.

• The weather and human health relationship is an open field for applied researches. The design and execution of new projects in this area is highly recommended.
The link with climate change

THE FUTURE = PREVENTION + MITIGATION + ADAPTATION

The prevention and mitigation of meteor-tropic effects based on biometeorological forecasts will diminish the occurrence of health crisis and mortality due to some chronic diseases with high prevalence in many countries. It will be an important contribution, facing climate change impacts.
Climate and weather effects on human health are well known and today they can be forecasted in order to mitigate the most negative impacts on vulnerable people. The global climate is changing, increasing the weather variability and extremes. It implies more risks for human health, but still there is not a clear conscience on the magnitude and urgency of the problem. Healthy hospitals and medical services should be more receptive to apply biometeorological forecast services. It implies a lot of interdisciplinary work and to develop capacity building in all sides of the joint framework. Biometeorological forecast services can diminish morbidity and mortality due to climate or weather related diseases. This is the world health challenge for the XXI Century.
If you have any question, please… I’m ready to answer… Thanks for your attention!