Extreme weather episodes and health degradation at Porto the heat wave of 2003?

Ana Monteiro*
Helena Madureira*
Carlos Sousa**
José Sousa**

* Department of Geography – Porto- Portugal
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Introduction

Heat kills by challenging the human body beyond its abilities.

No one can know:

i) how many more deaths are advanced by heat wave weather;

ii) how many diseased or aging hearts surrender that under better conditions would have continued functioning;

iii) how cities contribute to increase heat stress or to mitigate it (urban heat islands vs air conditioning)
How do our body communicate with the environment?

Focus: Thermal Environment
We know that human bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, The heart begins to pump more blood, blood vessels dilate to accommodate the increased flow, and the bundles of tiny capillaries threading through the upper layers of skin are put into operation. The body’s blood is circulated closer to the skin’s surface, and excess heat drains off into the cooler atmosphere.
Background information

Heat transference by conduction

Heat transference by convection

Heat transference by radiation

GONZÁLEZ, 1986
At the same time.....

water diffuses through the skin as perspiration.

The **skin** handles about 90% of the body's heat dissipating function.

**Sweating**, by itself, does nothing to cool the body, unless the water is removed by evaporation, and high relative humidity retards evaporation.

The heat energy required to evaporate the sweat is extracted from the body, thereby **cooling it**.

**So,**

Under conditions of **high temperature** and **high relative humidity**, the body is doing everything it can to maintain 37°C inside.
The body will do everything it can to maintain 37°C inside
The heart pumps a torrent of blood through dilated circulatory vessels

The sweat glands pour liquid
(including essential dissolved chemicals, like sodium and chloride onto the surface of the skin)

Heat disorders

have to do with

a reduction or collapse of the body’s ability to shed heat by:
- circulatory changes
- sweating

a chemical (salt) imbalance caused by too much sweating.
When **heat gain** exceeds the level the body can **remove**

or

when **the body cannot compensate** for fluids and salt lost through perspiration

the temperature of the body’s inner core begins to **rise**

and

heat-related illness may develop.
Heat disorders share common features:

- the individual has been overexposed
- the individual has been over exercised for his age and physical condition in the existing thermal environment.

Sunburn, with its ultraviolet radiation burns, can significantly retard the skin’s ability to shed excess heat.
Reasons for doing this

Do we feel the same under equal thermal environments?
Thermal Comfort

i) **Diet** - habits that affect the metabolism and justify the differences of diet between different geographic areas;

ii) **Age** - the more aged prefer warmer environments;

iii) **Sex** - the women present an inferior metabolism than men (produce little heat, so they prefer warmer environments);

iv) **Body form** - the relation between volume and surface influences in the thermal preference;

v) **Body fat** – fatness act as a thermal insulator;

vi) **Health state** - a sick person can have its comfort limits narrowed;

vii) **Clothes** - thermal exchanges filter;

viii) **Acclimatization** - the time of permanence of a human being in one determined climatic context tends to produce metabolic alterations and increase thermal adaptation.
Reasons for doing this

Why

Porto?

Urban Environment?

Cities pose special hazards
21 July 2006

“Heat wave kills in Portugal” – emergency rooms occurrences increase 25%

25 July 2008

“...in 2003 we had more than 2000 deaths due to heat waves, in 2004 about 100, in 2005 about 400 and in 2006 about 1400……”, Costa Alves

“...Heat waves are, in Portugal, the natural hazard that kills more people after the earthquake of 1755....”, Costa Alves
Reasons for doing this
Alteration of the frequency and/or intensity of extreme weather and climate events have a number of implications for health if appropriate response strategies are not formulated, including:

- possible increases in heat-related mortality especially amongst sectors of the population that are unable to protect themselves against heat stress, such as the elderly and the urban poor.

In urban areas

**Reasons for doing this**

**Threats**
- high number of persons
- high population density
- high social and economic diversity
- high inequality in housing conditions
- severe local and regional impacts on climatological context (*urban heat island*)

**Chances**
- more air conditioning equipment
- more private and public places with thermal indoor comfort conditions
- more leisure activities
In urban areas

The stagnant atmospheric conditions of the heat wave trap pollutants

and

add the stresses of severe pollution

to

the dangerous stresses of hot weather

creating a bigger health problem
Reasons for doing this

Why Porto?

Why looking to heat waves through the last century?
**Porto**

2nd most important Portuguese city

250 000 inhab.
(in a metropolitan area of 1 million)

600 vehicles/1000 inhab.

400 000 vehicles/day
Porto is a *medium-size* city (at a global scale) – 250 000 inhab.

West coast city

On the way of the polar front routing

The 1\textsuperscript{st} continental obstacle found by the west flux after crossing Atlantic Ocean

*Urban Heat Island + Global Warming*
Built density (%) at Porto
Solar Exposure at Porto
Anomalias térmicas

Urban Heat Island
4ºC-6ºC
Urban heat island with several forms and magnitudes

Dia: 22 de Janeiro de 1998
Inicio: 00h21m00s
Temperatura med. itinerantes: 6.3 a 14.0°C
Temperatura HSJ: 11.0 a 12.1°C
Vento: - velocidade: 1.2 m/s
- rumo (HSJ): NW
(aeroporto): E
Humidade Relativa HSJ: 44.4%
Sit. Sinóptica à superfície: Margem Anticiclónica

Mapa elaborado eplo método de Kriging
Effects of urbanization on climate
PORTO’s population
Porto’s minimum and maximum temperature (1901-2005)
Number of days with minimum temperature above 20ºC
- tropical nights (1901-2005)
Number of days with maximum temperature above 25ºC
- tropical days (1901-2005)
Porto bioclimatic needs (Givoni)

1- comfort zone
2- ventilation
3- cooling by evaporation
4- thermal inertia
5- artificial cooling
6- wetness
7- thermal inertia
8 – passive solar heating
7- artificial heating

At Porto the problem is with cold spells and not with heat waves!
Porto bioclimatic needs (Givoni)
Porto bioclimatic needs (Watson & Labs)
PET index to Porto
thermal index PET (physiological equivalent temperature)
When we approach this heat wave issue

we must have in mind

the acclimatization of Porto’s inhabitants
Heat wave?

Criteria?

Option → WHO

maximum temperature 5°C above the average (>30 years) for a sequence of more than 5 days

HWDI – Heat Wave Duration Index, WCDMP-No.47, WMO-TD No. 1071
Reasons for doing this

Heat waves at Porto (1900-2006)

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<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nº ocorrencias</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

using the WMO criteria

2000 ?...
2003?...
2004?...
2005?...
2006?...
# Heat Waves

## Why not 2003?

Because it was a sequence of:
- 5 days
- not
- 4 days
- not

<table>
<thead>
<tr>
<th>Julho/Agosto</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>23,2</td>
<td>25,5</td>
</tr>
</tbody>
</table>
HEALTH (comfort)? vs criteria
How assess the real effect of climate on health at Porto?

still great gaps....
### Table 1

Total and daily average number of deaths registered in participant civil Registrars' offices during the period of the heat wave for all 3 comparison periods, Portugal, 2003

<table>
<thead>
<tr>
<th></th>
<th>Heat wave period 30 July - 18 August</th>
<th>Period 15-28 July</th>
<th>Period 1-14 July</th>
<th>Period 1-28 July</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of deaths</td>
<td>1966</td>
<td>1427</td>
<td>1454</td>
<td>2881</td>
</tr>
<tr>
<td>Daily average no.</td>
<td>140.4</td>
<td>101.9</td>
<td>103.9</td>
<td>102.9</td>
</tr>
</tbody>
</table>

The excess deaths estimates varied slightly for the three comparison periods.

### Table 2

Number of expected deaths, excess of deaths and proportion of the expected deaths, in the period of the heat wave, in the counties of participant civil Registration Offices, according to the used reference periods, Portugal, 2003

<table>
<thead>
<tr>
<th></th>
<th>Deaths expected in the heat wave period (30 July-12 August)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period 15-28 July</td>
</tr>
<tr>
<td>No. of expected deaths (E)</td>
<td>1427</td>
</tr>
<tr>
<td>Excess of deaths (Observed-Expected) (O-E)</td>
<td>539</td>
</tr>
</tbody>
</table>

http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=553,
Delta between the number of deaths observed during 2003 and the average number of deaths noted during the five years of the reference period and the excess mortality ratio compared with the same 1998-2002 reference period (expressed as a percentage) for various periods in 2003 (before the summer, during the summer and after the summer) and for various countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Before summer</th>
<th>Summer</th>
<th>After summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nb</td>
<td>Ratio</td>
<td>Nb</td>
</tr>
<tr>
<td>Belgium</td>
<td>-4</td>
<td>-0.01</td>
<td>139</td>
</tr>
<tr>
<td>Switzerland</td>
<td>92</td>
<td>0.34</td>
<td>253</td>
</tr>
<tr>
<td>Germany</td>
<td>9290</td>
<td>2.55</td>
<td>642</td>
</tr>
<tr>
<td>Spain</td>
<td>-1464</td>
<td>-0.90</td>
<td>4268</td>
</tr>
<tr>
<td>France</td>
<td>-3977</td>
<td>-1.70</td>
<td>1482</td>
</tr>
<tr>
<td>Greece</td>
<td>-902</td>
<td>0.65</td>
<td>163</td>
</tr>
<tr>
<td>Italy</td>
<td>5875</td>
<td>2.24</td>
<td>5274</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>69</td>
<td>3.47</td>
<td>33</td>
</tr>
<tr>
<td>Netherlands</td>
<td>304</td>
<td>0.50</td>
<td>78</td>
</tr>
<tr>
<td>Portugal</td>
<td>-2068</td>
<td>-4.26</td>
<td>220</td>
</tr>
<tr>
<td>Slovenia</td>
<td>351</td>
<td>4.30</td>
<td>13</td>
</tr>
<tr>
<td>England &amp; Wales</td>
<td>-5695</td>
<td>-2.41</td>
<td>-1060</td>
</tr>
<tr>
<td>Total</td>
<td>3355</td>
<td>0.23</td>
<td>11516</td>
</tr>
</tbody>
</table>

Countries used as controls:

<table>
<thead>
<tr>
<th>Country</th>
<th>Nb</th>
<th>Ratio</th>
<th>Nb</th>
<th>Ratio</th>
<th>Nb</th>
<th>Ratio</th>
<th>Nb</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>708</td>
<td>2.12</td>
<td>-42</td>
<td>-0.71</td>
<td>172</td>
<td>2.86</td>
<td>159</td>
<td>2.63</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2408</td>
<td>5.17</td>
<td>207</td>
<td>2.43</td>
<td>190</td>
<td>2.18</td>
<td>58</td>
<td>0.67</td>
</tr>
<tr>
<td>Denmark</td>
<td>-113</td>
<td>-0.44</td>
<td>-43</td>
<td>-0.95</td>
<td>-92</td>
<td>-1.95</td>
<td>-49</td>
<td>-1.04</td>
</tr>
<tr>
<td>Total</td>
<td>4520</td>
<td>1.86</td>
<td>-365</td>
<td>-0.77</td>
<td>-273</td>
<td>-0.56</td>
<td>-750</td>
<td>-1.56</td>
</tr>
</tbody>
</table>

Source: European Union Project Etude de l'impact de la canicule d'août 2003 sur la population européenne
It is still very difficult to establish the relationship

Health – Heat waves

Databases quality

Criteria
Background conditions

Heat waves have increased?
Vulnerability has increased?
Discussion

We know that...

Elderly persons,
small children,
chronic invalids,
and persons with weight and alcohol problems

are particularly susceptible to heat reactions especially during extreme warm episodes (heat waves?) in areas where a moderate climate usually prevails.
But

how mitigate the most severe damages at Porto?
Discussion

Better heat wave period definitions appropriate to each place taking into account several social, economic and biological profiles
Discussion

Health Risk

Demographic sensitivity
- Physical constraints
- Mobility constraints
- Cognitive impairments
- Economic constraints
- Social isolation

Behavioral choice
- Wearing inappropriate clothing
- Failing to get adequately hydrated
- Consuming alcohol
- Engaging outdoor activities
- Eating inappropriate meals

Regional and local factors
- Geographical location
- Urbanization
- Urban design
- Resident location
- Social isolation

EHE Notification and Response Programs, USA, 2007.
There are already several experiences done with success…

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**On the Definition of a Heat Wave**

Peter J. Robinson  
*Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina*

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### Average number of heat waves per decade as a function of length of event, and number of stations with events of specified length at any time during the 1951–90 period

<table>
<thead>
<tr>
<th>Length (days)</th>
<th>1*</th>
<th>1.5*</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
<th>5.5</th>
<th>6</th>
<th>&gt;6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg No. events</td>
<td>4.68</td>
<td>3.36</td>
<td>1.18</td>
<td>1.03</td>
<td>0.52</td>
<td>0.49</td>
<td>0.37</td>
<td>0.34</td>
<td>0.33</td>
<td>0.28</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>No. stations</td>
<td>137</td>
<td>123</td>
<td>111</td>
<td>99</td>
<td>70</td>
<td>56</td>
<td>41</td>
<td>36</td>
<td>19</td>
<td>15</td>
<td>12</td>
<td>17</td>
</tr>
</tbody>
</table>

1% threshold:

| Avg No. events | 7.02 | 5.41 | 2.01 | 2.01 | 0.94 | 0.86 | 0.39 | 0.35 | 0.32 | 0.51 |
| No. stations   | 137 | 123 | 111 | 100 | 73 | 77 | 61 | 57 | 33 | 36 | 22 | 41 |

* These lengths do not qualify as heat waves but are included for comparison purposes.
Learn/ Multidisciplinary Research

Test

Apply
Thank you.