Is heat stress really a human health problem in hot countries? Heat acclimatization and vulnerabilities of people living in the Sahel. The case of Senegal

Richard LALOU1, Papa Daouda Amad DIENE2 and Oumy THIANDOUM3
1MERIT,IRD,Paris – 2 Performance Group, Dakar – 3ENSÆ-Dakar

ABSTRACT

This study analyzed the heat-related impact on mortality and morbidity for a rural population in Senegal. To evaluate the effect of the duration of heat exposure, we measured heat by the apparent temperature, and we distinguished two periods: (1) visit (medical visit, death), ranging from one, five, and ten to thirty days. We investigated the effect of heat stress on birthweight and vulnerability by groups (children and elderly people) and by temperature type (daily minimum, maximum and average). Finally, we used three types of models: GLM, GAM and ARIMAX.

We found that, between 1984 and 2014, heat resulted in an excess of mortality and medical diagnosis morbidity, especially among children and elderly people.

- Under five heat is affected by high heat at a lower temperature threshold and after a shorter exposure than for the elderly.
- The health of the elderly (aged 55 and over) is mostly impaired by extreme heat and are therefore more vulnerable to heat waves. Extreme heat impacts the mortality risk of elderly people immediately (the same day) and after a long exposure. Finally, people over 55 are much more sensitive to humid heat than dry heat. High heat affects bodies weakened by diseases, particularly cardiovascular and respiratory diseases, and modifies the ecology of infectious diseases.
- The risk of visiting a health facility for cardiovascular problems increases with extreme heat and duration of exposure to this extreme heat.
- Medical visits at a health facility for malaria is all the more frequent than the number of very hot nights preceding the visit is high.

OBJECTIVES

This study addressed three issues:

- Are Sahelian populations less vulnerable to extreme heat?
- Does the effect of extreme heat on health vary with intensity and duration of exposure?
- Are the impacts of global warming and extreme events (HW) expressed differently in tropical areas?

 MATERIAL AND METHODS

The implementation of standard analysis models faced incomplete data, and Oumy

- The GSOD or Global Surface Summary of the Day data provided by the US National Oceanic and Atmospheric Administration (NOAA) – Kaolack weather dataset (1984 – 2014)
- Morbidity data from medical consultations in four health facilities in the Niakhar area (1994 – 2015)

The maximum, minimum and average ambient temperature

Studies have shown that the temperature optimum corresponding to the minimum mortality rate (threshold) varies across different latitudes. We found that the apparent temperature threshold in rural Senegal is higher than in Europe (23°C<T<35°C according to the European cities, Baccini et al., 2008), indicating that studied communities are sensitive to heat but at higher apparent temperatures.

Our results provide evidence of an effect of intensity and duration of exposure of heat on mortality and morbidity. Between 1984 and 2014:

- The mortality risk increased beyond the threshold occurring at 37°C maximum daily apparent temperature. During the dry and warm season, the threshold occurred at the daily optimal temperature of 44°C and the rate of increase in mortality is 1.08% per additional degree.
- Over a month, a 10% increase in the average apparent temperature causes a 9.3% increase in the number of deaths in the same month.
- The probability of visiting a health facility increased beyond the 36°C threshold and medical consultations increased by 7.4% per degree above 36°C.

After 2008, medical visits increased faster (12.4%) per added degree above 37°C than before 2008 (5.8%).

IMPORTANT RESULTS

This research shows that in a rural area in Senegal:

- People, like everywhere else, can be affected by direct heat-related illnesses (heat strokes) and mostly through various biological mechanisms.
- Sustained periods of hot weather probably explain, as much as extreme events (HW), the excess mortality associated with high temperature.
- The communities studied are affected by both extreme heat and its accumulation effect (long exposure producing decompensation among adults).
- Very high heat (with or without humidity) affects bodies weakened by cardiovascular and respiratory diseases and modifies the ecology of infectious disease vectors.

Without a thermal improvement of the habit conditions, heat related health impacts should be higher as global warming, urbanization and elderly people increase.

ADDITIONAL INFORMATION

The risk of visiting a health facility for cardiovascular problems and malaria increases with extreme heat and duration of exposure to this extreme heat.

- Consultations for cardiovascular problems increase: i) by 3.7% per additional degree for each day above a 42°C threshold; ii) by 4.5% per additional degree for 5 continuous days above a 41°C average threshold; and iii) by 23% per additional degree for 10 continuous days above a 42°C average threshold.
- When temperature reaches a 37°C average for the five nights before the medical visit, the probability of visiting a health facility for malaria increases 22% per additional degree above the 32°C threshold for 5-night period.
- Survival of under-sixes is also threatened by long-term exposure to nighttime heat, above an average monthly threshold of 24°C.
- These findings suggest an increased risk of malaria transmission during very hot nights. Anopholes vectors breed faster and are more aggressive as nighttime heat rises. In addition, the use of the mosquito net decreases during extremely hot nights.

<table>
<thead>
<tr>
<th>temperature type</th>
<th>Age groups</th>
<th>Entire Year (12 months)</th>
<th>DEMIREN (daily counting)</th>
<th>GAM (monthly counting)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall population</td>
<td>36.8</td>
<td>12.9</td>
<td>10</td>
<td>36.5</td>
</tr>
<tr>
<td>Children under the age of five</td>
<td>35.0</td>
<td>1.20</td>
<td>10</td>
<td>39.0</td>
</tr>
<tr>
<td>Adults (15-54 years)</td>
<td>44.0</td>
<td>8.67</td>
<td>7</td>
<td>8.00</td>
</tr>
<tr>
<td>Elderly persons (over 55 years)</td>
<td>8.00</td>
<td>6.27</td>
<td>7</td>
<td>9.00</td>
</tr>
<tr>
<td>Average apparent temperature</td>
<td>30.6</td>
<td>12.4</td>
<td>10</td>
<td>32.0</td>
</tr>
<tr>
<td>Overall population</td>
<td>30.6</td>
<td>1.20</td>
<td>10</td>
<td>39.0</td>
</tr>
<tr>
<td>Children under the age of five</td>
<td>30.6</td>
<td>12.4</td>
<td>10</td>
<td>32.0</td>
</tr>
<tr>
<td>Adults (15-54 years)</td>
<td>20.8</td>
<td>1.13</td>
<td>8</td>
<td>24.0</td>
</tr>
<tr>
<td>Elderly persons (over 55 years)</td>
<td>30.6</td>
<td>1.20</td>
<td>10</td>
<td>32.0</td>
</tr>
</tbody>
</table>

Children

- Children are very sensitive to short exposure to high °C. They react very quickly to high heat, probably due to the increased risk of dehydration that may be associated with heatwaves. Beyond the 35°C threshold, the risk of heat death increases by 1% per additional °C.
- Children are sensitive to long exposure to high heat (more than 34°C). This result suggests a risk associated with the transmission of malaria. Anopholes breed quicker and are more aggressive as nighttime heat rises. In addition, the use of an impregnated mosquito net decreases with high heat.

Elderly people

- Elderly people are the most vulnerable to heat. The mortality risk increases by 23% per additional °C. Above the threshold of 40°C of apparent °C.
- Elderly people are sensitive to a long exposure of a high °C. They are probably vulnerable to heat dehydration which weakens the body (decompensation effect).
- People aged between 25°C and 31°C are at a higher mortality risk by 1.3%, probably due to a lack of physiological recovery from sustained period of high-nighttime heat.

CONTACT INFORMATION

Daouda DIENE email: daoudaamad@gmail.com
Richard LALOU email: richard.lalou@ird.fr