Mapping Malaria Risk in Dakar, Senegal

Marion Borderon, Sébastien Oliveau
When entomology meets social sciences...
Framework of the research

- ANR ACTU PALU -

- interdisciplinary project

- Data & method Social and behavioural surveys & thick blood smears (TBS) assessment (epidemiological data) in 50 areas in Dakar in 2008

- Specific geographical goal to highlight and describe the urban contexts that have contributed to the resurgence and development of malaria in Dakar

- Project on Malaria transmission in Dakar -

- interdisciplinary project

- Data & method Extensive entomological survey that was conducted in 45 areas in Dakar from 2007 to 2010

- Goal Mapping the risk of *Anopheles gambiae s.l.* densities using remotely-sensed environmental and meteorological data in Dakar

Perspective about malaria in Dakar:

2 substantial projects in the same place at the same time
Same object, same place, same time

THE STUDIED SITE
THE FOUR CITIES OF THE DAKAR METROPOLITAN AREA

Malaria in an urban area: Dakar (2008)
The epidemiological chain of malaria

- One mosquito bites an infected man
- One infected mosquito bites a man
- Reservoir host
- Vector

The pathogenic complex
The simplified socio-pathogenic system of urban malaria

**ECOLOGICAL CONDITIONS**
- Strong population density
- Population mobility
- Socio-economic disparities of populations
- Public policies to fight against malaria
- Various access to care and medicines
- Disease perceptions

**SOCIAL CIRCUMSTANCES**
- Limited anophelian development
- Uneven exposure of hosts regarding vectors
- Vulnerability of some populations to the parasite transmission

**GENETIC VULNERABILITY**
- Quality of human immunity

**LIMITED ANOPHELIAN DEVELOPMENT**
- Low malaria exposure in general but a very heterogenous transmission
- No or just little immunity with delayed acquisition

The simplified socio-pathogenic system of urban malaria
An example of socio-ecological overlapping
<table>
<thead>
<tr>
<th>Type</th>
<th>Spatial coverage</th>
<th>Time frame</th>
<th>Source</th>
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<tr>
<td>Landcover data with 2.5 m raster size</td>
<td>Region of Dakar</td>
<td>2007 - 2008</td>
<td>satellite data from SPOT 5</td>
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<td></td>
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<td>- 2010</td>
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<td>Multitemporal analysis of landcover</td>
<td>Maps on all the region of Dakar</td>
<td>1988 – 2008</td>
<td>Centre de Suivi Ecologique (CSE)</td>
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<td>Socioeconomic variables (Census Districts)</td>
<td>2000 CDs</td>
<td>2002</td>
<td>Census ANSD</td>
</tr>
<tr>
<td>Prevalence Rate</td>
<td>112 CDs</td>
<td>2008</td>
<td>ANR ACTUPALU</td>
</tr>
</tbody>
</table>

**Materials**
Human Biting Rate (HBR)

Machault V et al. (2012) published in Plos one

Final models (1/2)
THE SOCIAL VULNERABILITY - SV-
in the Dakar Metropolitan area, Senegal

Borderon (2013) published in UNU-EHS

Final models (2/2)
Kruskal-Wallis rank sum test: Observed statistics: 15.0
p-value: 0.0046
Test parameters: 4
The horizontal relationship at the district scale

Moran’s $I = 0.80$

Moran’s $I = 0.87$
Luc Anselin’s BiLISA

\[
I_i = \frac{\sum_j w_{ij} (z_i - \bar{z})(u_j - \bar{u})}{\sum_i (z_i - \bar{z})^2}
\]

- \( W_{ij} \): contiguity matrix
- \( Z_j \): value of the Z variable for the i individual
- \( U_j \): value of the U variable for the j individual

Measuring the spatial link between HBR and social vulnerability
BiLISA Cluster map

42% of the entomological vulnerability (HBR) is explained by the social around (Human vulnerability)

49999 permutations (max.)
Significance filter: 0.01
First order contiguity

Spatial Risk Approach by BiLISA
Malaria parasite prevalence in Dakar (Senegal)

As a percentage on the investigated census districts

Diallo et al. (2012)
Published in Plos one

Epidemiological data – data used for validation
Prevalence rate and spatial co-location

BiLISA Cluster map

Dakar

Pikine & Guediawaye

Prevalence rate by types

Not Significant (994)
High-High (199)
Low-Low (200)
Low-High (80)
High-Low (3)

49999 permutations (max.)
Significance filter: 0.01

Average

Low-Low
Low-High
High-High
Conclusion

Almost half of the location of Anopheles is explained by the social vulnerability of human individuals.

Suggested explanations:

✓ Vulnerable people have less choice of location, they live on /near the floodplain or wetlands- favorite landscapes for mosquitoes.

✓ Vulnerable people are less able to protect themselves from mosquitoes, which can more easily take blood meals and breed.

✓ Non-vulnerable people are more able to control their environment.
Conclusion

Major contributions of the study:

• Recognition and statistical demonstration of the link between the physical and social attributes of the urban landscapes.

• Risk mapping of malaria transmission with typologies of urban areas at risk (at the district scale) - (in logic with the Hyogo Protocol).
Thank you for your attention

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