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Climate Change, Dengue and *Aedes* mosquitoes

Past Trends and Future Scenarios

Jing Helmersson

Akademisk avhandling

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Fakultetsopponent: Richard Paul, Functional Genetics of Infectious Diseases Unit, Institut Pasteur, Paris

Department of Public Health and Clinical Medicine,
Epidemiology and Global Health

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Author
Jing Helmersson

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Abstract

Background Climate change, global travel and trade have facilitated the spread of *Aedes* mosquitoes and have consequently enabled the diseases they transmit (dengue fever, Chikungunya, Zika and yellow fever) to emerge and re-emerge in uninfected areas. Large dengue outbreaks occurred in Athens in 1927 and in Portuguese island, Madeira in 2012, but there are almost no recent reports of *Aedes aegypti*, the principal vector, in Europe. A dengue outbreak needs four conditions: sufficient susceptible humans, abundant *Aedes* vector, dengue virus introduction, and conducive climate. Can *Aedes aegypti* establish themselves again in Europe in the near future if they are introduced? How do the current and future climate affect dengue transmission globally, and regionally as in Europe? This thesis tries to answer these questions.

Methods Two process-based mathematical models were developed in this thesis. Model 1 describes a vector's ability to transmit dengue – vectorial capacity – based on temperature and diurnal temperature range (DTR). Model 2 describes vector population dynamics based on the lifecycle of *Aedes aegypti*. From this model, vector abundance was estimated using both climate as a single driver, and climate together with human population and GDP as multiple drivers; vector population growth rate was derived as a threshold condition to estimate the vector's invasion to a new place.

Results Using vectorial capacity, we estimate dengue epidemic potential globally for *Aedes aegypti* and in Europe for *Aedes aegypti* and Aedes *albopictus*. We show that mean temperature and DTR are both important in modelling dengue transmission, especially in a temperate climate zone like Europe. Currently, South Europe is over the threshold for dengue epidemics if sufficient dengue vectors are present. *Aedes aegypti* is on the borderline of invasion into the southern tip of Europe. However, by end of this century, the invasion of *Aedes aegypti* may reach as far north as the middle of Europe under the business-as-usual climate scenario. Or it may be restricted to the south Europe from the middle of the century if the low carbon emission – Paris Agreement – is implemented to limit global warming to below 2°C.

Conclusion Climate change will increase the area and time window for *Aedes aegypti's* invasion and consequently the dengue epidemic potential globally, and in Europe in particular. Successfully achieving the Paris Agreement would considerably change the future risk scenario of a highly competent vector – *Aedes aegypti's* – invasion into Europe. Therefore, the risk of transmission of dengue and other infectious diseases to the mainland of Europe depends largely on human efforts to mitigate climate change.

Key words: dengue, mathematical modelling, vectorial capacity, DTR, *Ae. aegypti, Ae. albopictus*, climate change, Europe, vector invasion, abundance.

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