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TrendsTalk

Stephanie Thomas: Modeling Disease Transmission in a Changing World

Stephanie Thomas is a researcher at the University of Bayreuth, Germany. She is also the coordinator of the graduate program in Global Change Ecology within the Elite Network of Bavaria. Stephanie studies the spatial and temporal variability of distribution patterns of invasive mosquito vectors and the diseases they transmit. In this interview with *Trends in Parasitology*, Stephanie shared her dream that improvements in health care will lead to a conflict-free world.

What does your research focus on?

My current research focuses on invasive disease vectors, mainly mosquitoes of tropical and subtropical origin. Thereby, the consideration of spatial and temporal variability of distribution patterns of vector species, and the diseases they transmit, is of great interest for me. I specialize in biogeography and have always been interested in understanding why species live where they do. Biogeographical theories and methods can be very useful to study variations in the distribution of vector species over time and space, and to understand the evolution in patterns of transmission of mosquito-borne diseases. Pathogens that spend time outside the human body, and any vectors involved in their transmission, have particular environmental requirements. Links between pathogens, vectors, and environmental conditions are rarely simple, however. Every single link in the chain of infection is subject to a range of biological, environmental, and socioeconomic factors that combine in complex ways to influence the occurrence and epidemic potential of a mosquito-borne disease. I am especially interested in understanding major drivers of disease transmission – such as changes in land use, loss of biodiversity, global trade and travel, and climate change – using modelling techniques and experimental approaches to estimate risks.

What is the current status of these diseases?

Mosquito-borne arboviruses – such as dengue virus, chikungunya virus, or Zika virus – are on the rise, globally. Dengue is widespread in the tropics and subtropics and is a major threat for human health there. It is one of the most rapidly spreading mosquito-borne diseases worldwide: the global incidence has increased 30-fold over the past 50 years. Now, about half of the world's population is at risk, with the 2016 El Niño event characterized by large dengue outbreaks. Approximately 20 000–25 000 deaths per year are estimated to occur, mainly in children. Therefore, the World Health Organization has set up the Global Strategy for dengue prevention and control 2012–2020, which aims to reduce mortality and morbidity from dengue by 2020 by at least 50% and 25%, respectively (baseline 2010). There has been a low level of concern about the occurrence of dengue in more temperate regions, but initial autochthonous cases, and smaller outbreaks, started to occur in the Mediterranean area and on Madeira island (Croatia, France, Portugal) in the past decade. As viruses adapt rapidly, and as climate change will likely make for more feasible environmental conditions for the highly invasive vector of dengue, *Aedes albopictus*, this may well be just a sign of things to come in temperate regions.

Chikungunya virus is also transmitted by *Aedes* species and was historically endemic in tropical climates such as in Africa, Southeast Asia, and the Indian subcontinent, but a substantial geographic expansion has been observed in recent decades. In India, an outbreak with nearly 1.4 million reported cases occurred in 2005–2006, followed by a large outbreak on La Réunion, which led to over 250 000 reported cases. In temperate continental Europe, autochthonous transmission by *Aedes albopictus* was recorded for the first time in Italy in 2007, and again in 2017 with 238 confirmed and 190 probable cases. Apart from Italy, only France reported outbreaks of autochthonous cases in Europe in the past. In 2013, Chikungunya arrived on the Caribbean island of

St Martin, from which it subsequently spread, leading to at least 1.2 million suspected and 0.3 million confirmed cases up to now.

Are there any pressing steps that, in your opinion, should be taken to control mosquito-borne diseases?

As long as there are no vaccinations readily available, or only licensed for use in defined risk groups, vector-control measures, early case detection, education of the public, and appropriate management of severe cases are probably the most effective measures for the prevention and control of mosquito-borne arboviral diseases. In regions where cases have been sparse so far, the public health systems need to be made aware of the emerging threat in order to be ready to intervene if needed. Effects of extreme events, precipitation regimes, and seasonality on diseases are still poorly studied, and a thorough validation of models is still a challenge and is complicated by a lack of field and laboratory data. Initiating research and data management activities in these fields would give an impulse in the right direction.

Taken as a whole, I still have the vision that investment in health care systems will soon be recognized as the most rewarding peacemaking measure in the world.

How can modelling best be leveraged to help control vector-borne diseases?

There are several levels where different kinds of model can be useful. Small-scale species distribution models that take into account hydrology, land use, microclimate, etc., can aid vector control agencies in targeting their measures more efficiently, while larger-scale climate-based models can identify new areas at risk that should be investigated more closely. Long-term models based on climate change scenarios can raise awareness in hitherto unaffected countries, giving a picture for the upcoming decades. Short-term models based on daily or weekly weather forecasts can alert public health authorities and practitioners of impending outbreaks in affected regions. Overall, I believe that models can be used to effectively manage financial resources for mosquito control and disease surveillance, spatially and temporally, and create awareness of emerging risks in a world of global change.

What is the key message our readers should retain from your review?

We have reviewed the current state-of-the-art in both mechanistic and correlative disease modelling, the data driving these models, and climate models applied to assess future risk. We see that the use of multiple different mechanistic or correlative disease models, as well as ensembles of different climate models for future projections per study, is increasing. This allows for better communication of uncertainties related to disease models, different climate models, and emission and population pathways to end users. Any model, be it mechanistic or correlative, short- or long-term, global or local scale, is just as good as the data it is built upon. Many mosquito-borne diseases, even those of global importance like chikungunya, are still severely under-studied in terms of their environmental drivers. There is still a need for more elaborate field surveys and laboratory experiments to support risk models in the best possible way. Cross-disciplinary and cross-sectoral transfer of data and methods is key for tackling the upcoming challenges in this fast-lived and well-connected world.

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