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Machine learning and AI for predicting climate-sensitive diseases

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EU-US Frontiers of Engineering Symposium

Outline

- 1. What is disease ecology?
- 2. Mapping diseases: then and now
- 3. Climate and health
- 4. Modelling methods: statistical and machine learning
- 5. Challenges in disease prediction



Outline

What is disease ecology?
Mapping diseases: then and now
Climate and health
Modelling methods: statistical and machine learning
Challenges in disease prediction



Epidemiology is the branch of medical science that investigates the factors that determine the

presence or absence of **diseases** and health conditions



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Dengue virus transmission





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Ecology is the study of the **interactions** between living organisms, including humans, and their physical **environment**



Dengue virus transmission



Epidemiology is the branch of medical science that investigates the factors that determine the presence or absence of diseases and health conditions

Ecology is the study of the **interactions** between living organisms, including humans, and their physical **environment**

Disease Ecology is the study of host-

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pathogen interactions within the context of their environment and evolution



Lyme Disease: Tick and Host Lifecycle

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2/5 Mapping diseases























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Coronavirus > By country Data explorer Deaths Cases Tests Hospitalizations Vaccinations Mortality risk Excess mortality Policy responses

About





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About



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Impact of Climate Change on Human Health

Injuries, fatalities, mental health impacts Asthma, cardiovascular disease



abcNEWS	VIDEO	LIVE	SHOWS	ELECTION 2024	538	 Q

4 more cases of locally acquired dengue reported in Florida as virus continues to spread: Officials

Cases have been detected in Broward and Miami-Dade counties.

By Mary Kekatos August 16, 2023, 9:18 PM

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An Aedes Aegypti mosquito is photographed on human skin in a lab of the International Training and Medical Research Training Center (CIDEIM) on Jan. 25, 2016, in Cali, Colombia. Luis Robavo/APP via Getty Images. FILE

https://abcnews.go.com/Health/4-cases-locally-acquired-denguereported-florida-virus/story?id=102306525

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Mosquito-borne diseases becoming increasing risk in Europe

③ 22 June · ₱ Comments

Climate change



Using insect repellent and covering up can help protect against mosquito bites

By Smitha Mundasad Health reporter

https://www.bbc.com/news/health-65985838



Agence France-Presse Fri 1 Sep 2023 01.34 BST

'A first in Paris': city fumigates for tiger mosquitoes as tropical pests spread, bringing disease

Parisian health authorities treat French capital for the first time as Zika and dengue-carrying tiger mosquitoes advance through northeastern Europe



✿ A Tiger Mosquito (Aedes Albopictus) bites through clothes in Paris, France on 20 August2023. This invasive mosquito brings tropical diseases such dengue, zika or chikungunya. Photograph: Geyres Christophe/ABACA/Shutterstock

https://www.theguardian.com/world/2023/sep /01/paris-fumigates-city-tiger-mosquitoescarry-zika-dengue-disease-france







Relevant information for Public Health

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Vector-borne diseases forecasting









- Assumes that data comes from a statistical distribution
- 2. Primarily aimed at inference: finding connections between variables
- 3. Can do prediction, but generalisation is challenging
- 4. More sensitive to missing data, outliers, and collinearity
- 5. Explicit assessment of model uncertainty

- 1. Learns patterns directly from data, less assumptions
- 2. Primarily aimed at prediction: all about the outcomes
- 3. Can do inference, but usually black-box methods
- 4. Less sensitive to missing data, outliers, and collinearity
- 5. Challenging to assess model uncertainty



Dengue and climate in Ecuador: Bayesian hierarchical model





 $y_t \sim NegBin(\mu_t, \kappa)$

```
log(\mu_t) = log(p_{T'(t)}) + log(r_t)
```



Cooler and drier than usual \rightarrow less dengue

Warmer and wetter than usual \rightarrow more dengue



Φ-lab

Predicting dengue in Brazil with AI







Read more about the project by scanning:



Ensemble ML approach for predicting and forecasting climate-sensitive diseases

Sebastianelli et al., 2023 (in prep.)

4/5 Modelling methods: Machine learning

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1. Harvesting data into ready-to-use formats



model



1. Harvesting data into ready-to-use formats





1. Harvesting data into ready-to-use formats





http://www.brazildatacube.org/



2. Explicit uncertainty estimates for decision-makers

Prototype developed by Barbados Meteorological Services







5/5 Challenges

3. Opening the black boxes



5/5 Challenges

3. Opening the black boxes



5/5 Challenges

Take-home messages



Climate-sensitive diseases can be predicted by machine learning and statistical methods



Open data from climate models, weather forecasts, satellite imagery and other sources can be used as predictors (features)



Model uncertainty and interpretation are key challenges to be addressed to improve uptake of ML in disease prediction



Meet the Global Health Resilience Group



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Software engineer for climate and health

YOU??

We are hiring!







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Funded by the European Union wellcome



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Thank you

Questions?