Climate change

Vector-borne diseases

Food-borne diseases

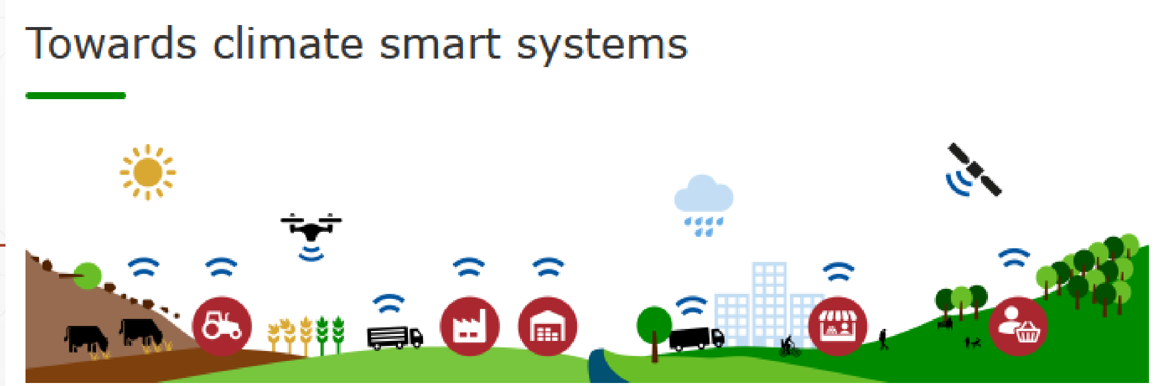
Data

Anticipation of outbreaks

A novel machine learning approach to **assess the risk of future mosquito-borne disease outbreaks**

Causal links of outbreaks

Multimethod analysis of the **effect of climate change on food-borne disease outbreaks**



Will AI help us solve the climate problem?

Thanks to:


Hien thi dieu Truong
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PostDoc


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AEW/QVE


Ricardo da Silva Torres
AI


Quirine ten Bosch
QVE

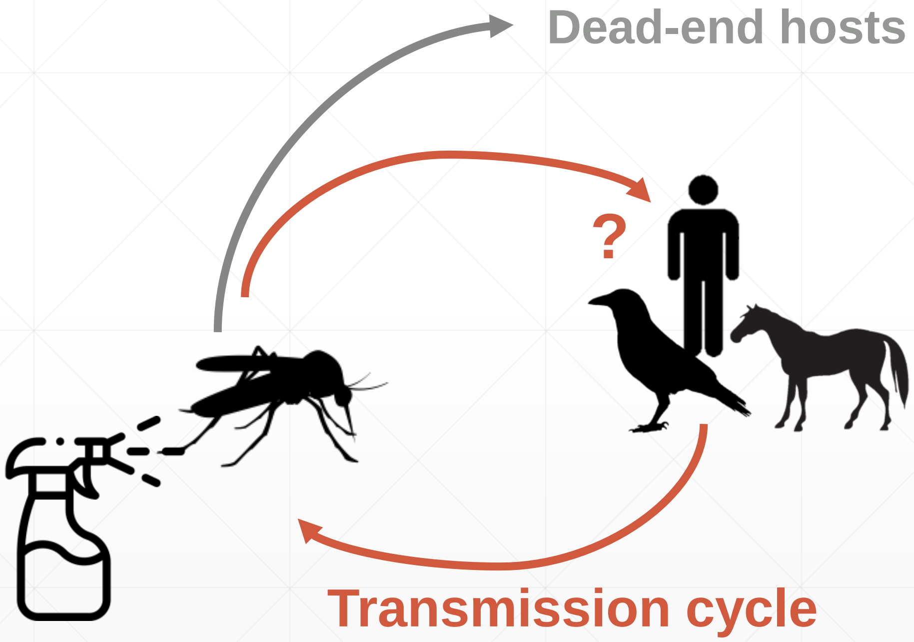

Egbert van Nes
AEW


Marten Scheffer
AEW

With climate change:

Increasing threat of mosquito-borne diseases

Control efforts: mosquito population control



Machine learning approaches in epidemiology

Many potential applications for machine learning approaches in epidemiology.

Risk mapping

(Mapping the transmission risk of Zika virus using machine learning models, Jiang et al, 2018)

Forecasting

(Machine learning and dengue forecasting: Comparing random forests and artificial neural networks for predicting dengue burden at national and sub-national scales in Colombia, Zhao et al, 2020)

Machine learning approaches in epidemiology

Many potential applications for machine learning approaches in epidemiology.

Risk mapping

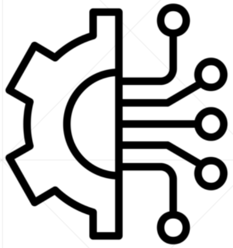
Only tells us about suitability, not if an outbreak will start

Forecasting

Requires large amounts of data for training the algorithm

Objective: predict the risk of future outbreaks from real-time monitoring data

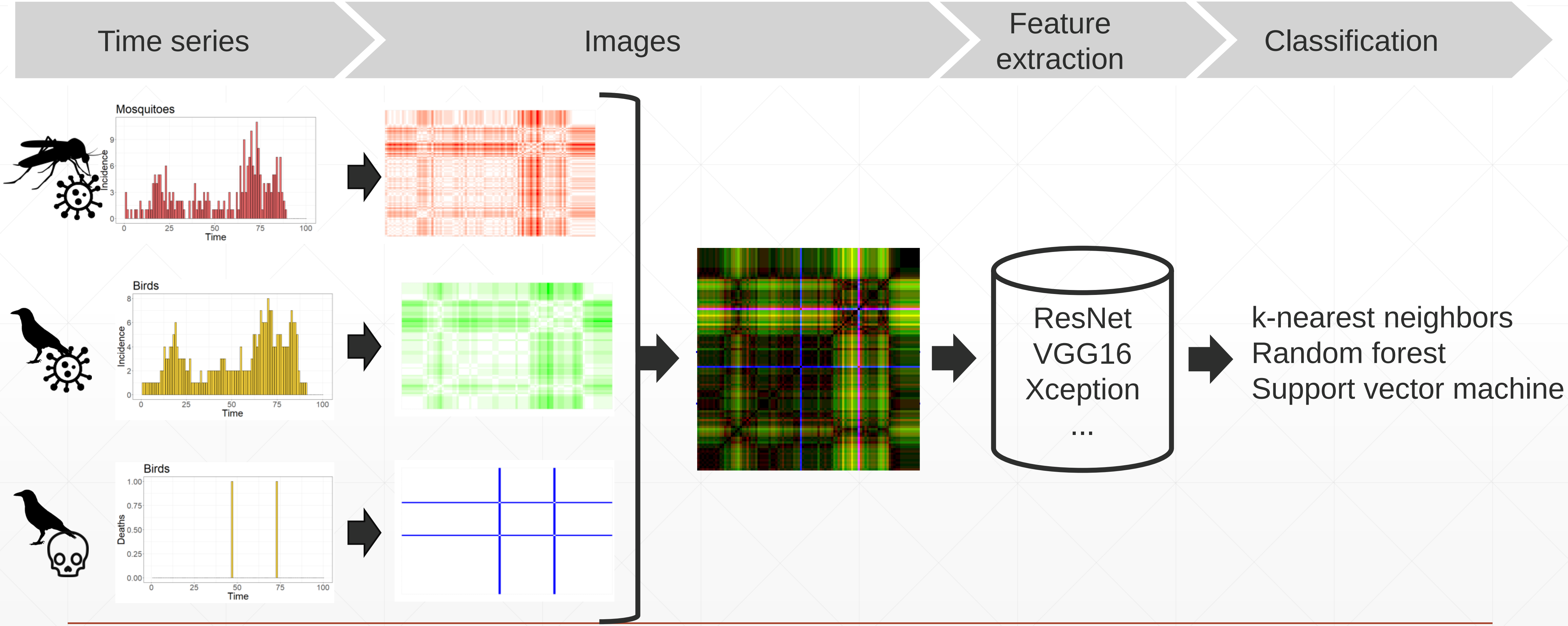
- Data: incidence time series
- Classify into risk categories based on R_0
- Generic: suitable for several mosquito-borne diseases
- Reduce data requirements compared to existing approaches:
  1. Use pre-trained, computer vision models
  2. Train using synthetic data



Machine learning pipeline

Creation of the synthetic training dataset

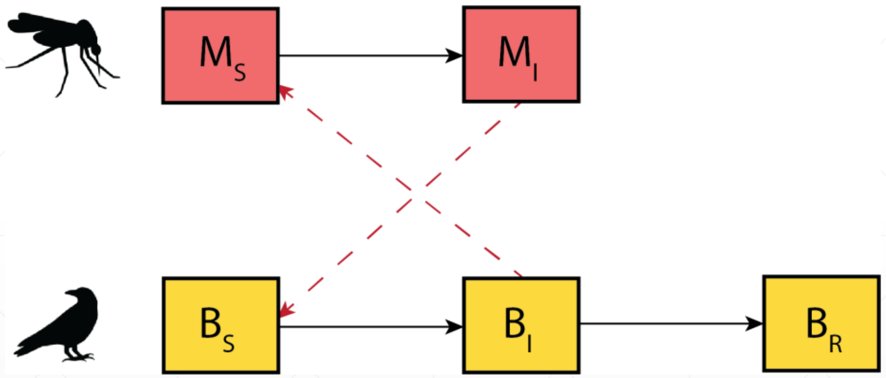
Machine learning pipeline



Creation of the synthetic dataset

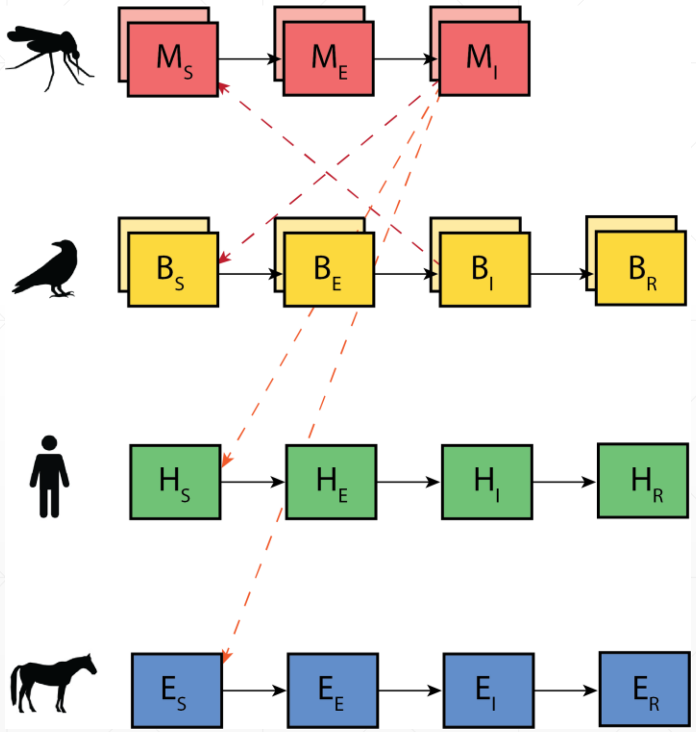
To ensure enough diversity in the dataset: random model generator

Minimal model assumptions



And everything in-between

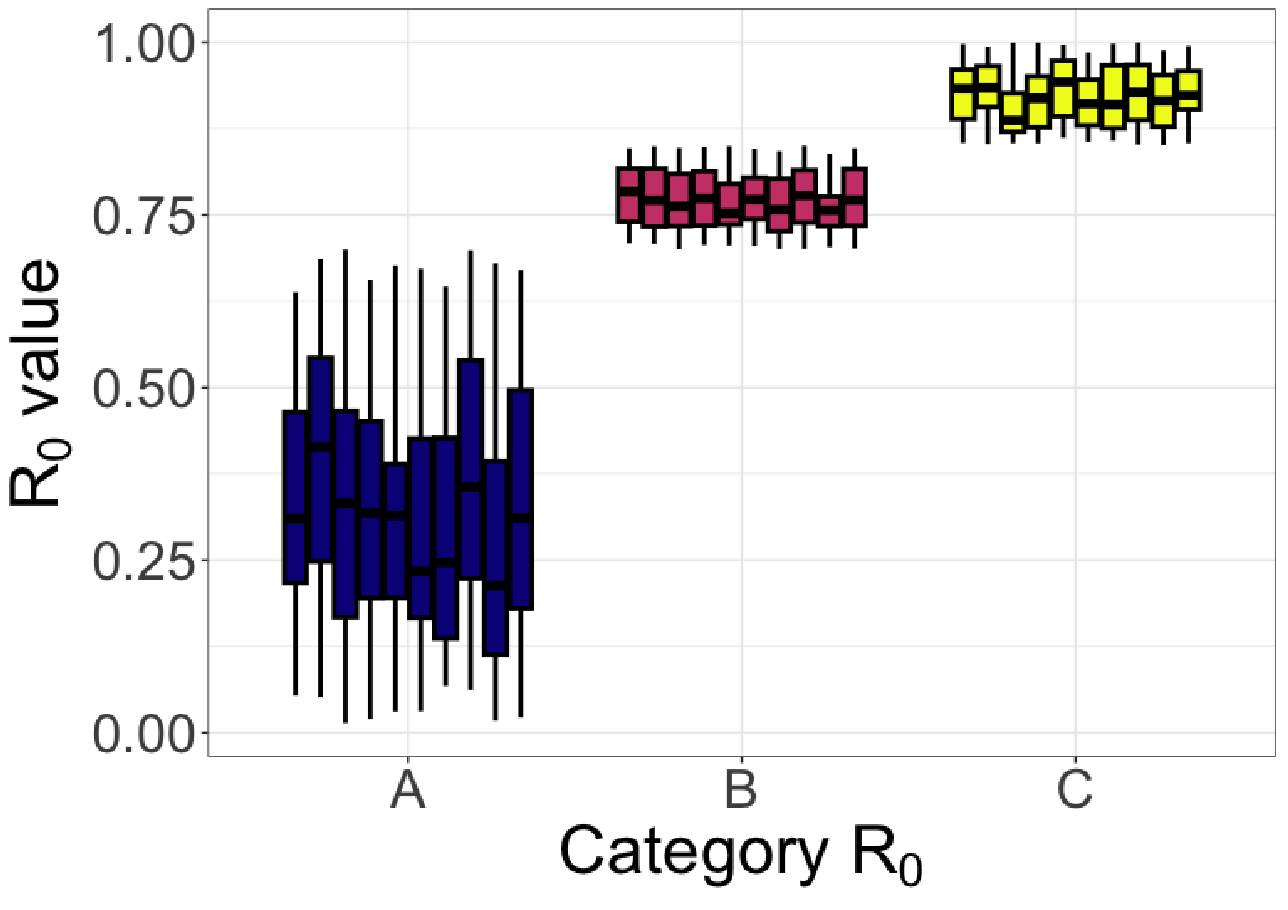
All model assumptions



Creation of the synthetic dataset

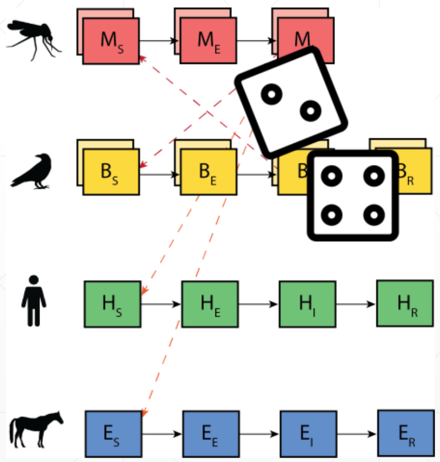
R_0 is calculated using the Next Generation Matrix

We defined several categories for the classification



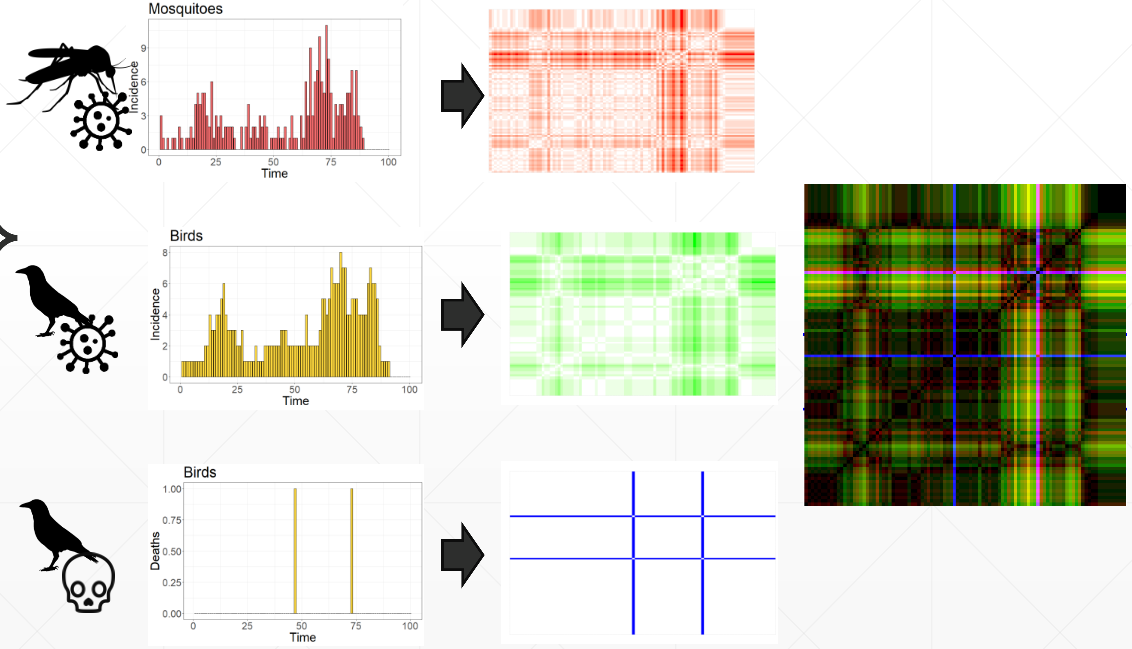
Summary of the approach

Random model generator



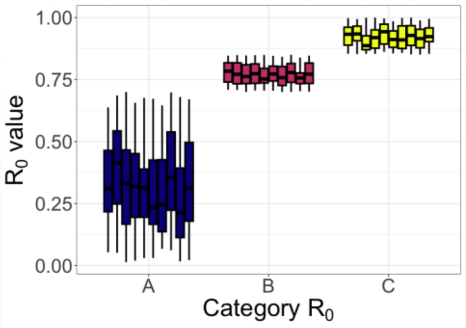
Used to train

Machine learning pipeline



Feature extraction + classification

Assess risk of future outbreak



Preliminary results – 3 classes

Performance metric: **accuracy**, i.e. proportion of correctly classified instances

Feature extractor \ Classification algorithm	XGBoost	Support vector machine (SVM)	Random forest (RF)
ResNet	0.513	0.487	0.526

Preliminary results – 2 classes: A & C

Performance metric: **accuracy**, i.e. proportion of correctly classified instances

Feature extractor \ Classification algorithm	Random forest (RF)
ResNet	0.85

Conclusions

- Machine learning approaches have the potential to improve control efforts for mosquito-borne diseases by assessing the risk of future outbreaks based on real-time monitoring, but finetuning needed
- Transforming time series into images allows to leverage pre-trained computer vision algorithms
- Using a random model generator makes the framework flexible to many mosquito-borne diseases, and to test other approaches
- Future work: validate the pipeline with real-data

Multimethod analysis of the effect of climate change on food-borne disease outbreaks

Zuzanna Fendor[1], Mary Godec[1], Cheng Liu[1], Wenjuan Mu[1], Eva Christoff[1], Hajo Rijgersberg[2], Sander van Leeuwen[2], Ingrid Friesema[3], Coen van der Weijden[4], Floor van Meer[1]

[1]*Wageningen Food Safety Research*

[2]*Wageningen Food & Biobased Research*

[3]*National Institute for Public Health and the Environment*

[4]*Netherlands Food and Consumer Product Safety Authority*

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Where do you keep your tomatoes?

Climate change in the Netherlands is tangible

"1 in 3 households is not able cool down their houses during hot days"

1 op de 3 huishoudens krijgt woning niet koel op warme dagen

19-7-2024 06:30

© Hollandse Hoogte / Patricia Rehe

In 2023 zei 34 procent van de huishoudens in Nederland dat ze hun woning niet voldoende kunnen koelen op warme dagen. Vooral huishoudens in huurwoningen, flats en oudere woningen hebben hier moeite mee. 's Avonds en/of 's nachts de ramen openzetten is de meest genoemde manier om de woning te koelen. Dit meldt het CBS op basis van het onderzoek Belevingen 2023.

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Climate change in the Netherlands

Temperature rises, more heat waves

Wetter winters, drier summers

More heat stress in cities

Based on the KNMI (Royal Netherlands Meteorological Institute) ‘23 climate scenarios

Food safety in the light of climate change

efsa EUROPEAN FOOD SAFETY AUTHORITY

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What about the tomato on our kitchen counter?

REVIEWS

Climate Change and Emerging Food Safety Issues: A Review

Ramona A. Duchenne-Moutien[1], Hudaa Neetoo[1]

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- e may heighten the occurrence and virulence of hogens.
- ination of food by chemical hazards will also likely
- Climate change may likely result in a rise in foodborne infection and intoxication.
- Frequent extreme weather events brought by climate change also affect food safety.
- Ensuring food safety under a changing climate requires key adaptation strategies.

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Dairy farm
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Animal health

ABSTRACT

The aim of this study is to analyse the effect of climate change on emerging food safety hazards ir production chain. For this purpose, a holistic approach was used to select critical factors from insid side the production chain that are affected by climatic factors. An expert judgement study was cor identify and to rank the most important critical factors with relation to emerging food safety haz Dutch dairy production chain. Results included major critical factors affecting the occurrence of f hazards when the climate will change in variable and extreme weather conditions, e.g. an increasin ature and excessive rainfall. The experts mentioned feed-related issues (raw materials, pasture, si age, and manufacturing of compound feed) and animal health as the most important critical fa affect the occurrence of food safety hazards due to climate change. Feed manufacturing and animal health need to be closely monitored in order to anticipate on climate change effects. The results of the present study can be used as basic elements of an Emerging Risk Detection Support System (ERDSS), a system for stakeholders from industry and government to identify and control emerging hazards in the dairy production chain.

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Multimethod analysis

Microbial growth meta-analysis

What is the effect of temperature on pathogen growth in different foods outside the fridge?

Statistical approach

What is the effect of temperature and degree of urbanity on the number of cases of foodborne illness?

What is the effect of temperature on pathogen growth in different foods outside the fridge?

- *Listeria monocytogenes* (Lm)
- Microbial counts of Lm on the food items for different temperatures taken from literature
- Estimated maximum growth rates
- Only focus on temperature increase as factor

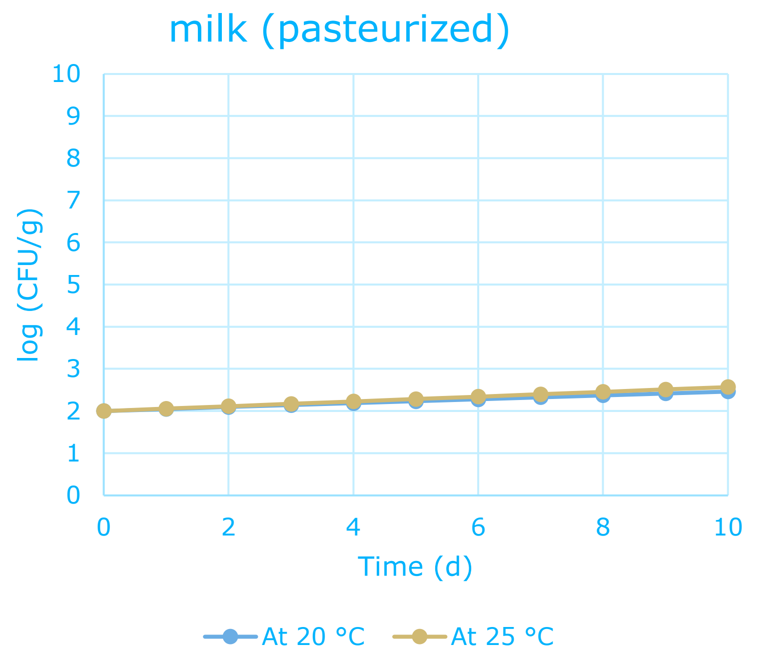
Listeria count influenced by temperature

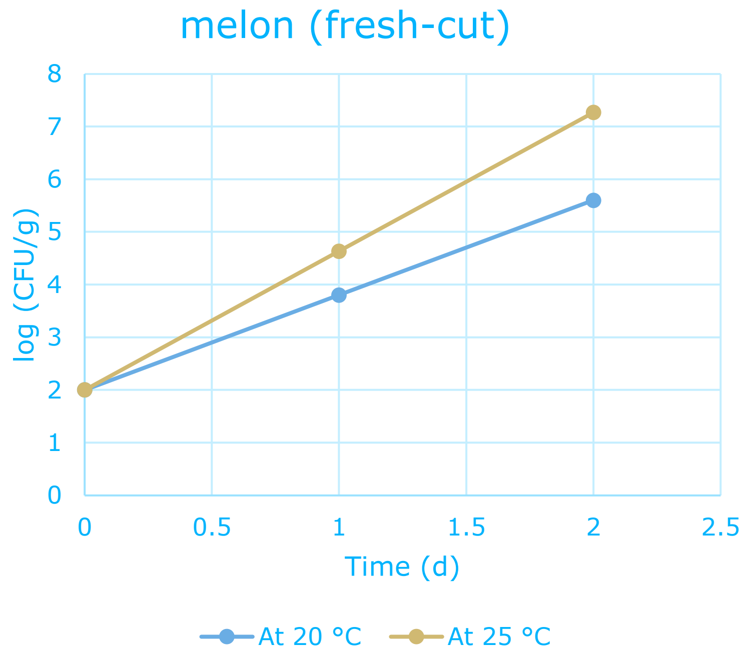
the number of CFU/g increase at 5 °C higher indoor temperature :

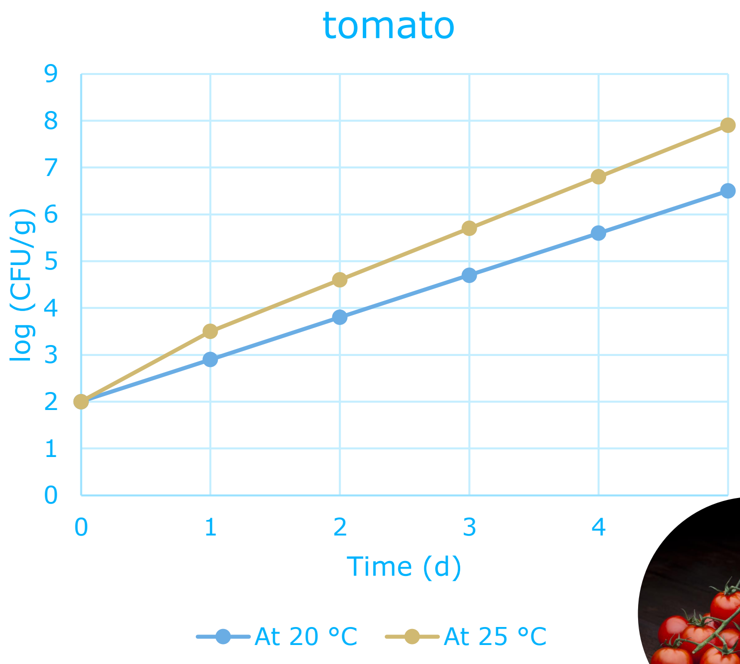
- Papaya (fresh-cut): 58%
- Melon (fresh-cut): 36%
- Persimmon: 23%
- Canary melon: 23%
- Tomato: 22%
- Mandarin: 15%
- Spinach: 6%

What will be the effect of climate change on pathogen growth in different foods?

Listeria monocytogenes growth in different products







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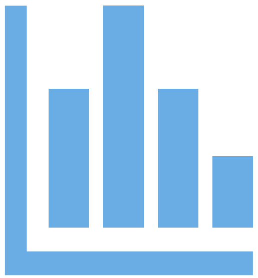
What is the effect of temperature and urbanity on the number of cases of foodborne illness?

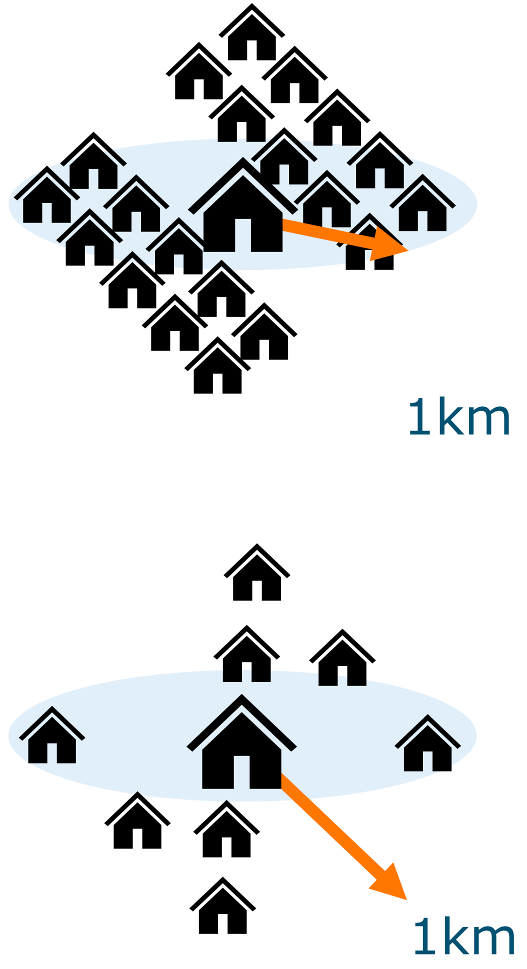


Hypothesis: The effect of temperature on number of cases will be greater in urban environments than in rural environments

What is urbanity?

Average number of addresses per km2

- 2500 or more: Extremely urban
- 1500 – 2500: Strongly urban
- 1000 – 1500: Moderately urban
- 500 – 1000: Little urban
- 500 or less: Not urban



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Data: weather, urbanity, and outbreak data

- Open data sources: meteorological and demographic
- Foodborne illness outbreak data
- Data from between 2006-2022, with information about 8168 registered foodborne illness outbreaks

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Rijksinstituut voor Volksgezondheid en Milieu
Ministerie van Volksgezondheid, Welzijn en Sport

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Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

Nederlandse Voedsel- en Warenautoriteit
Ministerie van Landbouw, Natuur en Voedselkwaliteit

Data preparation

outbreak size	date	location	coordinates	municipality	urbanity	Temperature (°C)
10	12-11-2006	Zwolle	(52.51, 6.10)	Zwolle	2	8.12
…		…	…	…	…	…
2	30-12-2022	Bennekom	(51.97, 5.67)	Ede	2	-1.23

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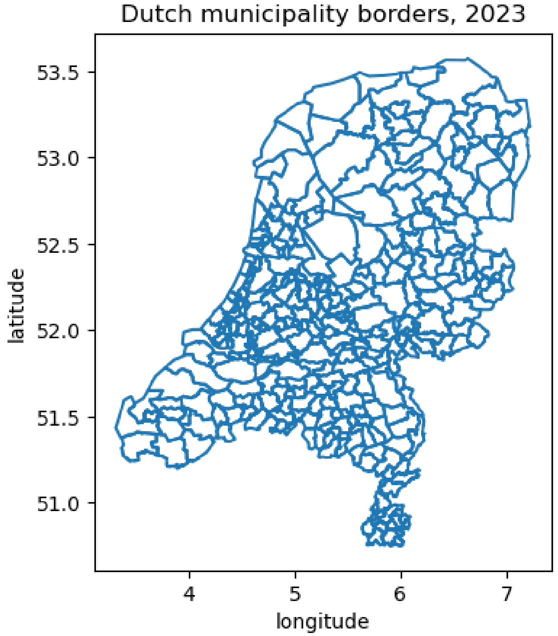
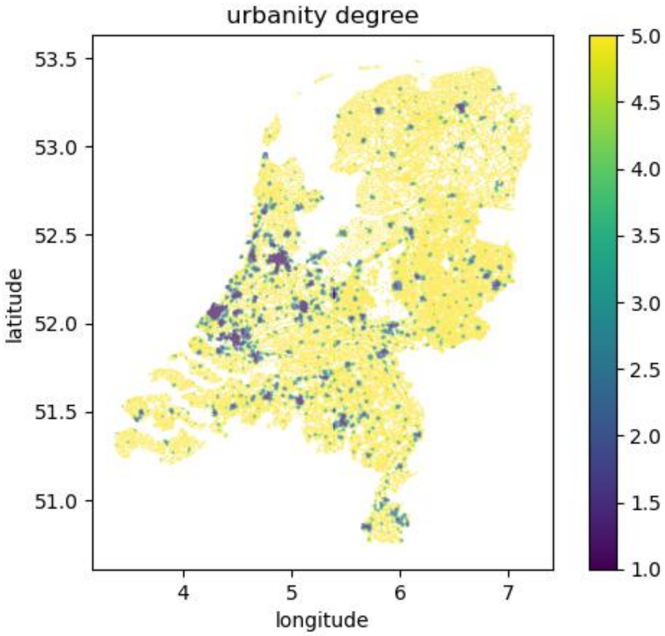
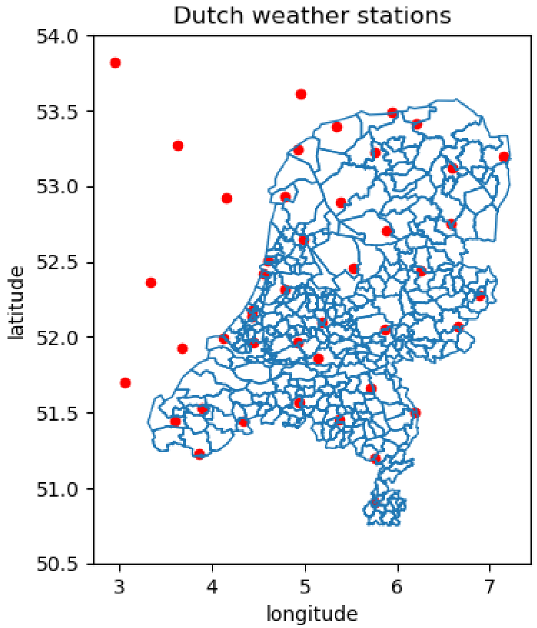
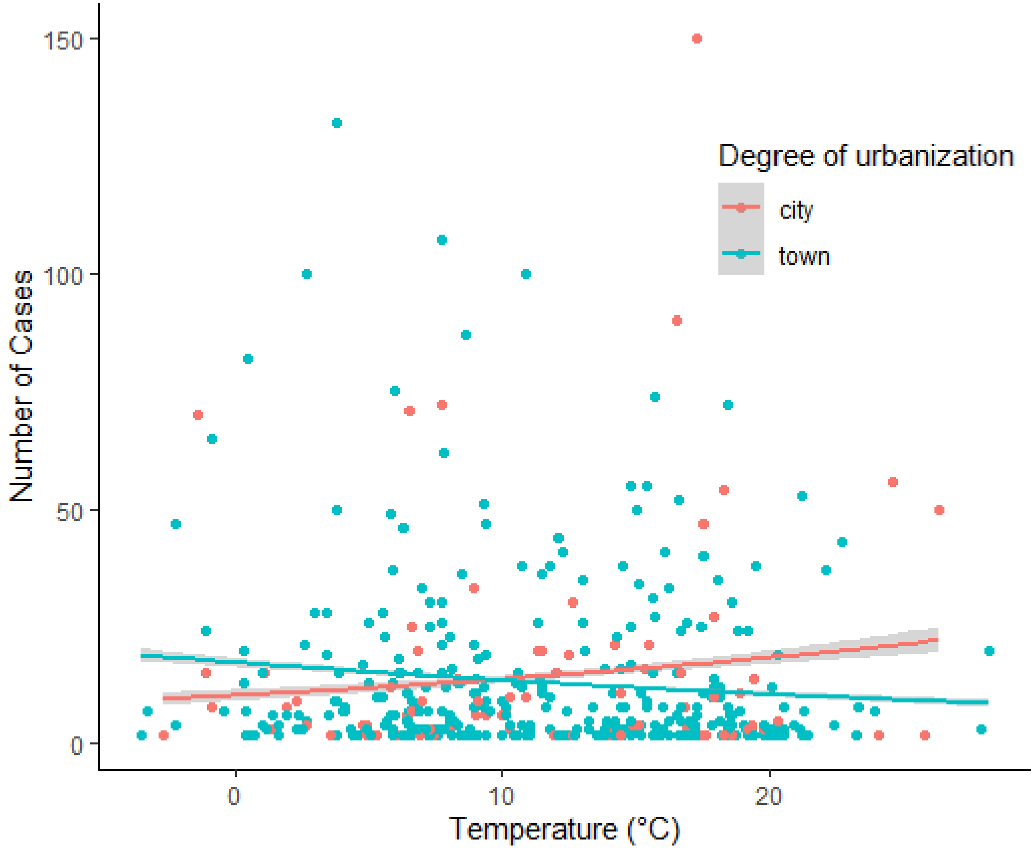






Results

- Poisson regression
- There was a main effect on number of cases with:
  - Temperature (IRR = 1.034, $p < 0.001$)
  - Urbanity (IRR = 0.900, $p < 0.001$)
- There was an interaction effect of temperature and urbanity on the number of cases (IRR = 0.995, $p < 0.001$)



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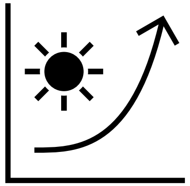
What is the effect of the temperature and the degree of urbanity on the number of cases of foodborne illness?



More registered outbreaks,
Larger registered outbreaks

Smaller registered outbreaks,
when compared to urban areas

Implications in the light of climate change:

More warm days may lead to more cases of foodborne illness, especially in urban municipalities

What about our countertop tomato?

Temperature-driven pattern found, but details unknown

- Lack of fine-grained data
  - Indoor temperatures
  - Pathogen measurements from samples at the home
  - Types of housing…

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Take home message

A difference of 5 °C leads to higher Listeria counts in some food products

Temperature has an effect on the Dutch foodborne disease outbreaks

Differences were found between urban and rural areas of the Netherlands

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Thank you!

Wageningen Food Safety Research:

Zuzanna Fendor, Mary Godec, dr. Cheng Liu, dr. Wenjuan Mu, Eva Christoff,

dr. Floor van Meer

Wageningen Food & Biobased Research:

dr. Hajo Rijgersberg,

Sander van Leeuwen

National Institute for Public Health and the Environment:

dr. Ingrid Friesema

Netherlands Food and Consumer Product Safety Authority:

ing. Coen C van der Weijden

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Netherlands Food and Consumer Product Safety Authority
Ministry of Agriculture, Nature and Food Quality

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Discussion with audience

- Added value of this project for mosquito-borne diseases:
  - Opened up an entire new research path
  - Early warning signals using AI on images-from-timeseries: promising for other type of (climate-driven) tipping points as well