From data to action: a machine learning model to support tick-borne encephalitis surveillance and prevention in Europe

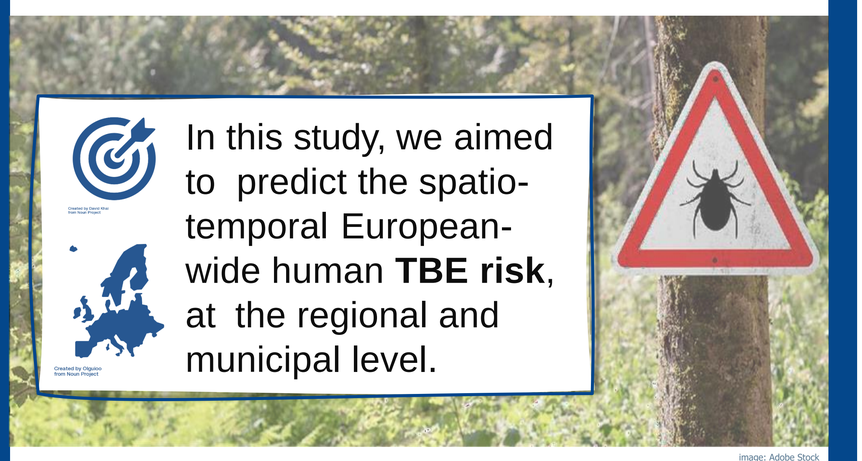
F. Dagostin[1], D. Erazo[2], G. Marini[1], D. Da Re[1,3], V.Tagliapietra[1], M. Avdicova[4], T. Avšič – Županc[5], T. Dub[6], N. Fiorito[7], N. Knap[5], C. M. Gossner[8], J. Kerlik[4], H. Mäkelä[6], M. Markowicz[9], R. Olyazadeh[10], L. Richter[9], W. Wint[10], M. G. Zuccali[11], M. Žygutienė[12], S. Dellicour[2], A. Rizzoli[1]

1. Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige (TN), Italy
2. Spatial Epidemiology Lab, Université Libre de Bruxelles, Bruxelles, Belgium
3. Center for Agriculture Food Environment, University of Trento, Trento, Italy
4. Regional Authority of Public Health in Banská Bystrica, Banská Bystrica, Slovakia
5. Institute of Microbiology and Immunology, Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia
6. Department of Health Security, Finnish Institute for Health and Welfare, Helsinki, Finland
7. Unità Locale Socio Sanitaria Dolomiti, Belluno, Italy
8. European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden
9. Austrian Agency for Health and Food Safety, Vienna, Austria
10. Environmental Research Group Oxford Ltd, c/o Dept Biology, Oxford, United Kingdom
11. Azienda Provinciale Servizi Sanitari, Dipartimento di prevenzione, Trento, Italy
12. National Public Health Center under the Ministry of Health, Vilnius, Lithuania

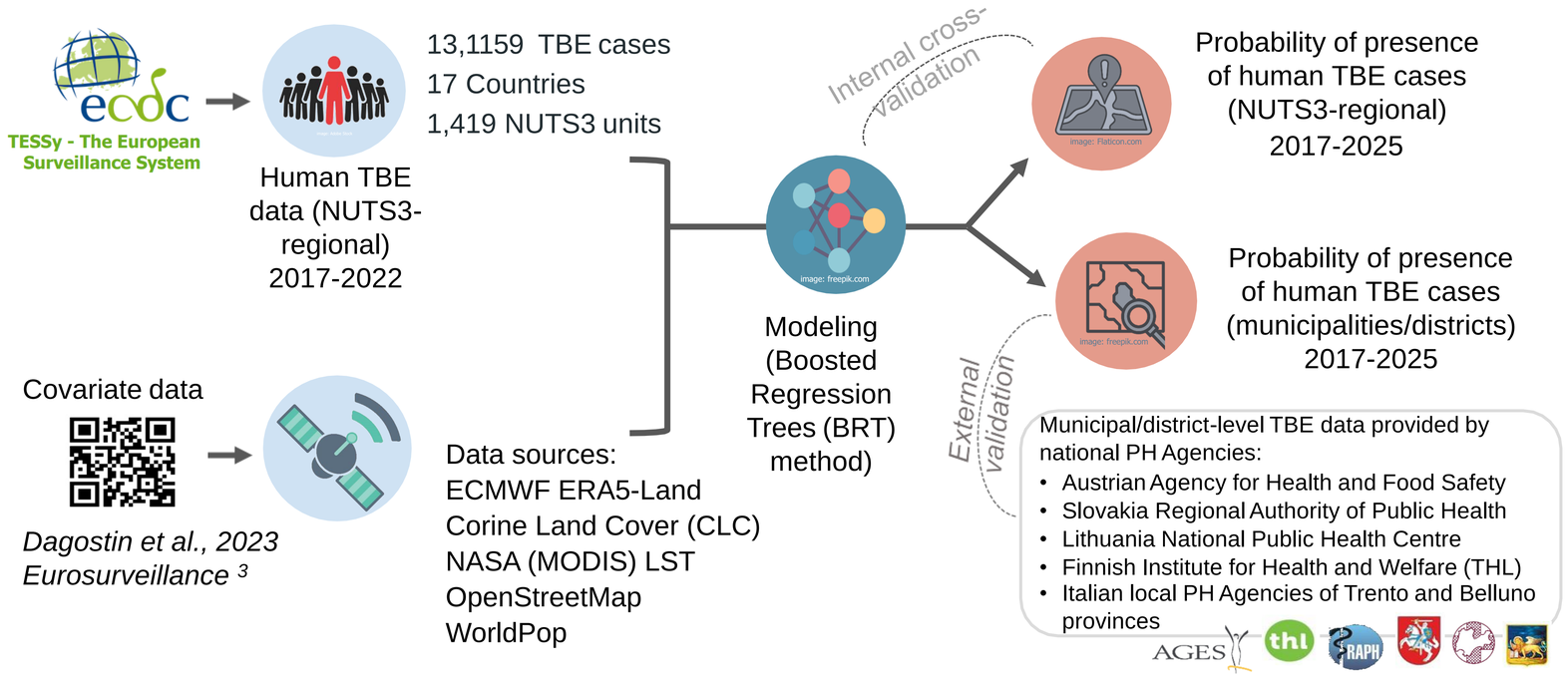
Image by brgfx on Freepik

INTRODUCTION AND AIM

Tick-borne encephalitis (TBE) is a growing public health concern in Europe, with an increasing number of reported human cases and new hotspots appearing in previously non endemic areas[1,2]



METHODS



RESULTS

BRT Response Curves

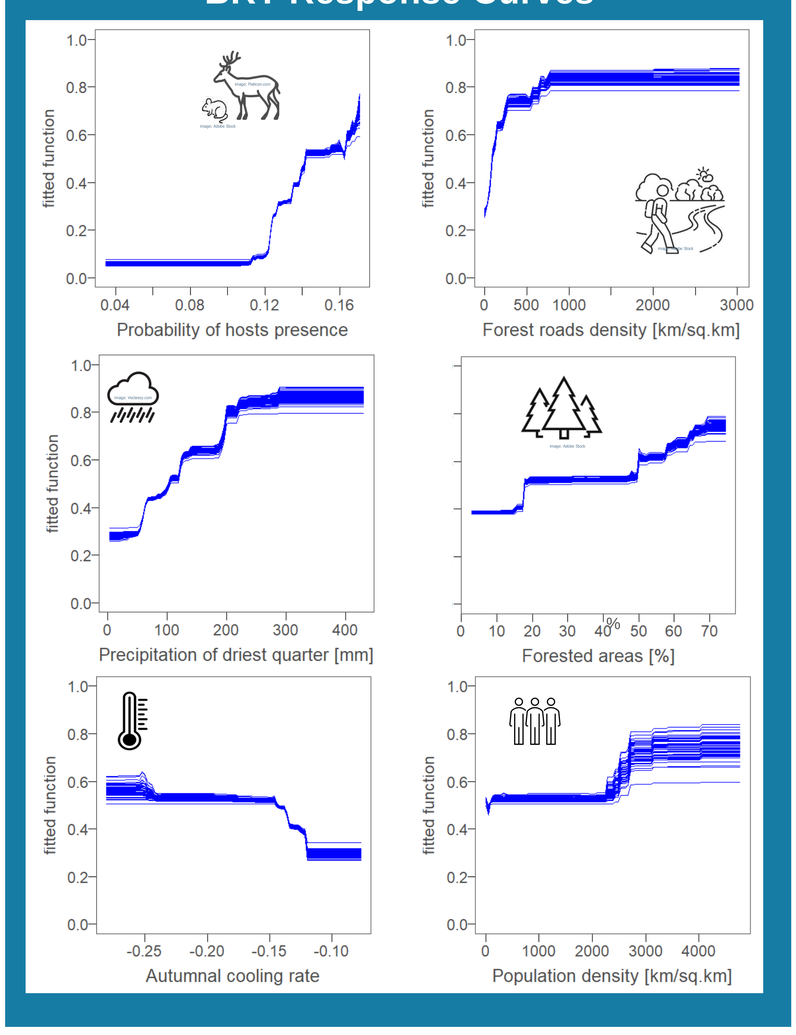


Fig. 1 – Boosted Regression Trees (BRT) fitted functions with respect to each variable.

Risk map (EU NUTS3 regions)

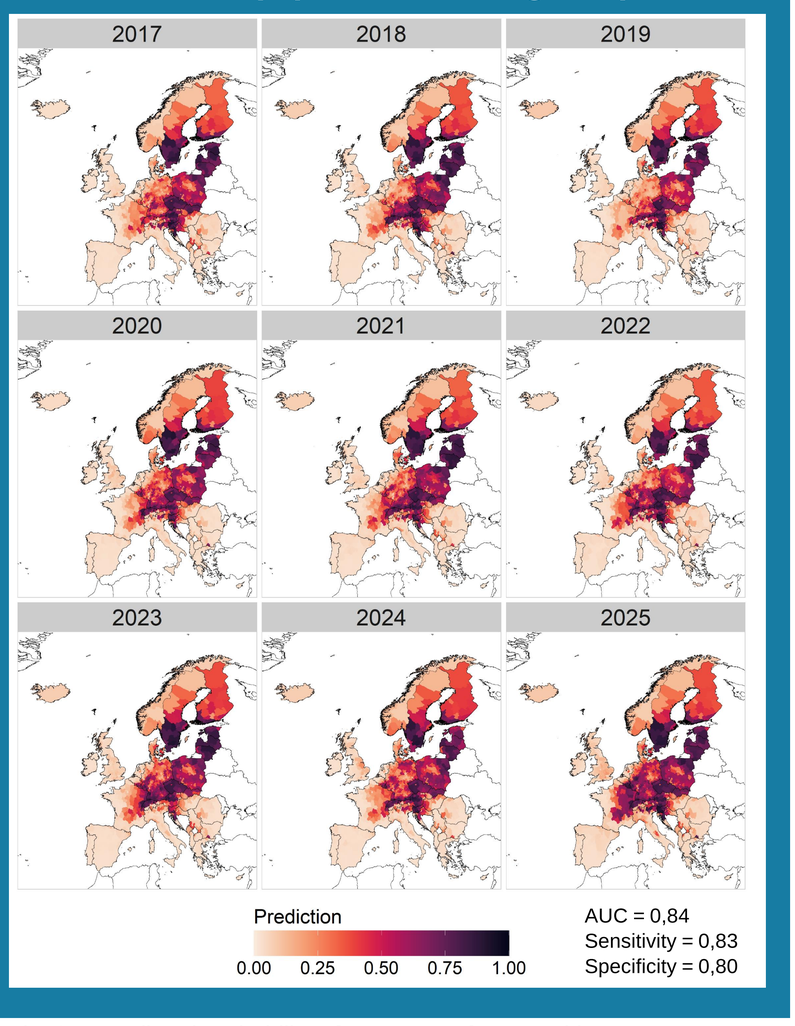


Fig. 2 – Predicted probability of presence of reported human TBE cases at the NUTS3 (regional) level (2017-2025).

Risk map (EU municipalities)

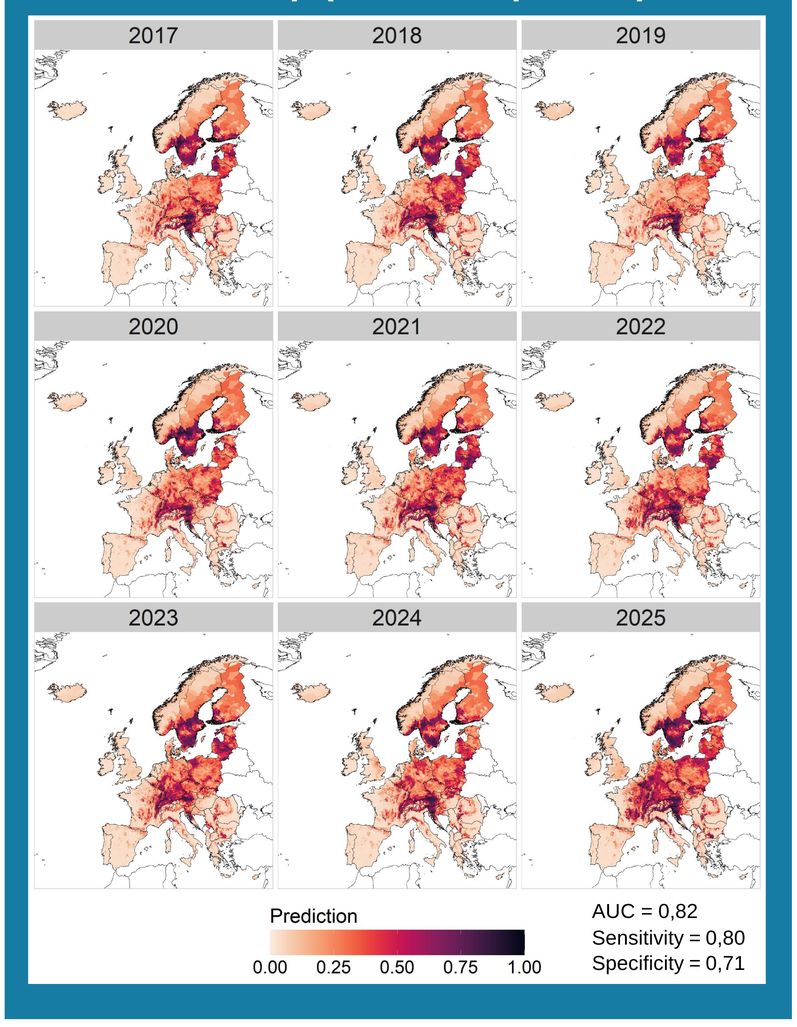


Fig. 3 – Predicted probability of presence of reported human TBE cases at the municipal level (2017-2025).

CONCLUSIONS

- **High-risk areas** are characterized by the combined presence of **vertebrate hosts (cervids and rodents)**, **forest roads**, **high annual precipitation amounts** and **steep decline in late summer temperatures**.

Presence of key rodent species (*A. flavicollis*, *M. glareolus*) **and deer species** (*C. elaphus, D. dama, C. capreolus*)
- Rodents transmit the virus to feeding ticks, supporting viral circulation
- Deer amplify ticks abundance and move them over long distances.

Density of forest roads
- People engaged in activities in forests are at increased risk of tick bites

High precipitation in the driest months
- Favours tick questing during the driest months of the year and lowers tick mortality

% of forested areas
- Habitat for ungulates, rodents and ticks, promoting their encounter.

Autumnal cooling rate
- favours co-feeding of larvae and nymphs the following spring, one of the most critical factors in TBEv transmission

- This study will support competent authorities and public health agencies in deploying One-Health integrated actions by providing a **high-resolution** estimate of **TBE potential risk areas** one year in advance.
- The annual risk maps can be explored on the **MOOD Epidemic Intelligence Platform**

https://mood-h2020.eu

REFERENCES

1. European Centre for Disease Prevention and Control. Tick-borne encephalitis. *In: ECDC. Annual epidemiological report for 2020.* Stockholm: ECDC. 2022.
2. Stoefs A, Heyndrickx L, De Winter J, Coeckelbergh E, Willekens B, Alonso-Jiménez A, et al. Autochthonous Cases of Tick-Borne Encephalitis,Belgium,2020. *Emerg Infect Dis*. 2021 Aug;27(8):2179–82.
3. Dagostin F, Tagliapietra V, Marini G, Cataldo C, Bellenghi M, Pizzarelli S, et al. Ecological and environmental factors affecting the risk of tick-borne encephalitis in Europe, 2017 to 2021. Euro Surveill. 2023;28(42):pii=2300121.

ACKNOWLEDGEMENTS

We are grateful to ECDC, Dr. Mateusz Markowicz and Dr. Lukas Richter from the Austrian Agency for Health and Food Safety, Dr. Jana Kerlik and Maria Avdicova from Regional Authority of Public Health in Banská Bystrica, Slovakia, Dr. Milda Žygutiene from Lithuania National Public Health Centre under The Ministry of Health, Dr. Henna Mäkelä and Dr. Timothée Dub from Finnish Institute for Health and Welfare (THL), Dr. Maria Grazia Zuccali and Dr. Silvia Molinaro from APSS Trento, Dr. Nahuel Fiorito from ULSS N.1-Dolomiti for data sharing.

DISCLAIMER

FUNDING

This work has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement MOOD N°874850.

CONTACTS

francesca.dagostin@fmach.it
/francescadagostin