HELMHOLTZ AI | ARTIFICIAL INTELLIGENCE COOPERATION UNIT

Noise2NAKO: AI Methods linking Environment and Health - a largescale cohort application

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Motivation

- Environment has major impacts on human
  - Adverse effects of noise on human health, e.g. hypertension [1,2]
  - Several studies also found a systematic bias w.r.t. social status [3]

- Advanced statistical and data science approaches are needed to understand the complex interplay between the environment and population health

[1] WHO, *Burden of disease from environmental noise. Quantification of healthy life years lost in Europe*. 2011.
[2] Hahad, O., et al., *The Cardiovascular Effects of Noise.* Deutsches Arzteblatt international, 2019. **116**(14): p. 245–250.
[3] Dreger, S., et al., *Social Inequalities in Environmental Noise Exposure: A Review of Evidence in the WHO European Region.* Int J Environ Res Public Health, 2019.

Problem Specification

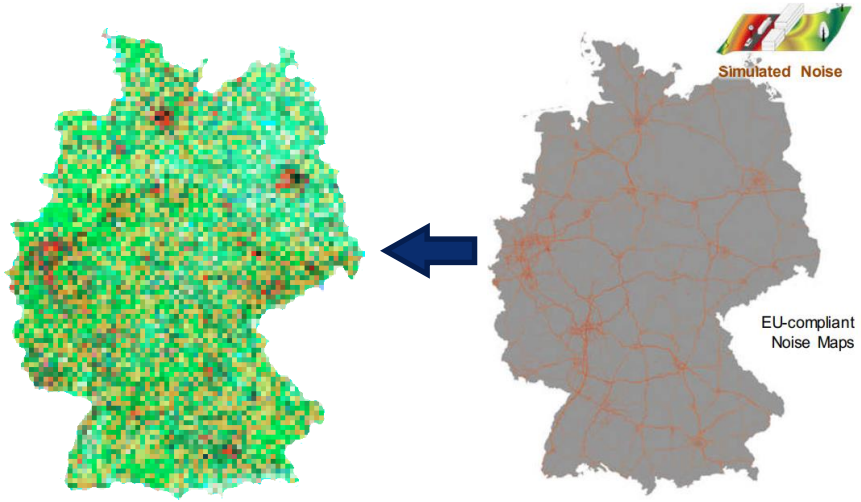
GOAL

- Investigating the long-term impact of **environmental factors** on **human health**
- Use case
  - Environmental Factors → Noise
  - Human Health → Hypertension

APPROACH

We employ **AI/ML methods** to:

- advance currently available **noise maps (WP1)**



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APPROACH

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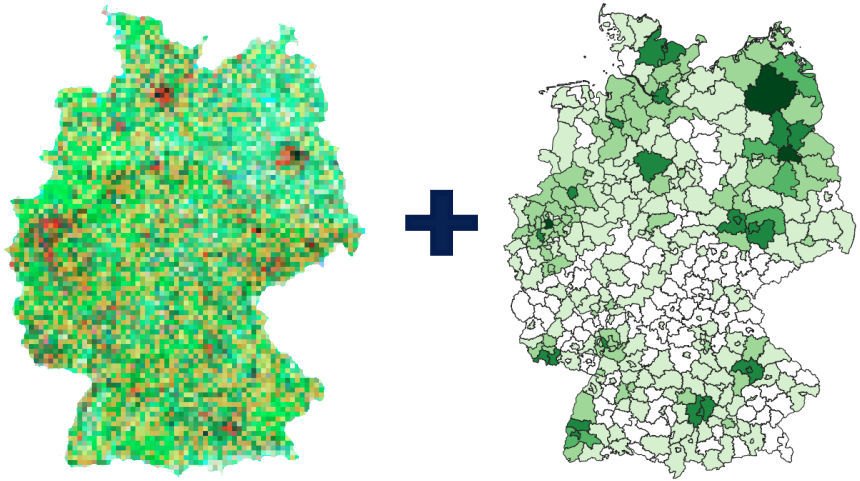
- advance currently available **noise maps (WP1)**
- improve the **quantification of noise effects on health (WP2)**



WP1

Building Structure Catalog (DLR)

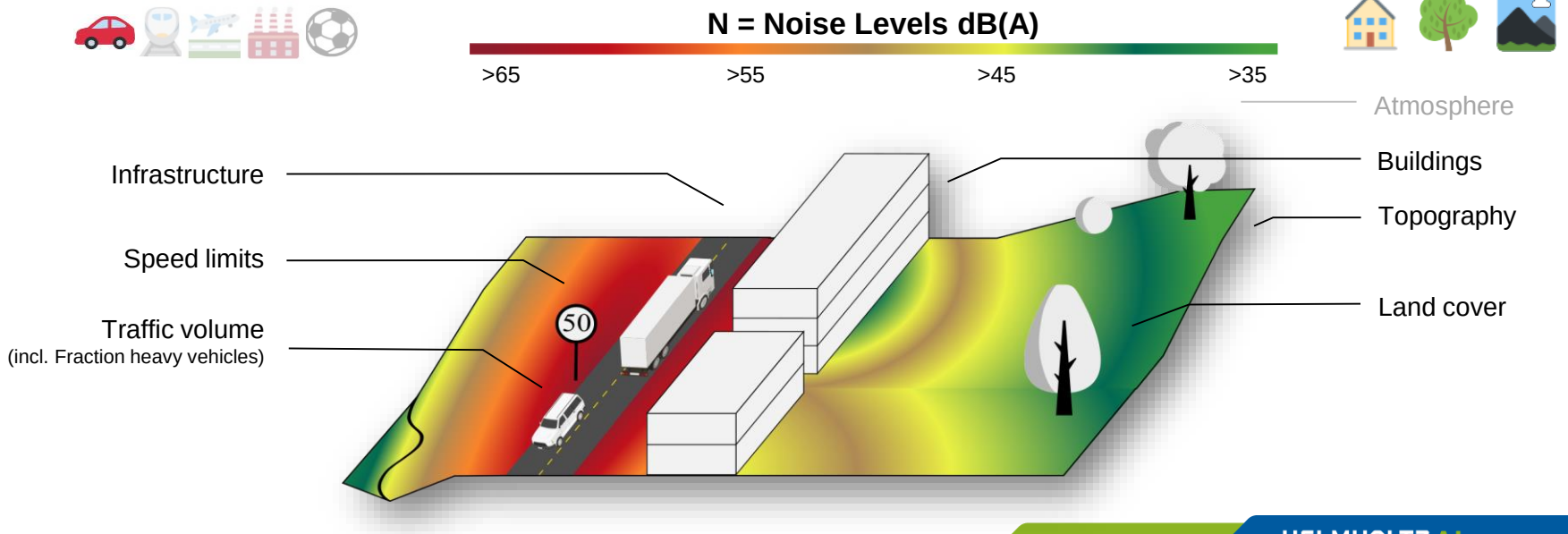
$$N = f(E, I)$$

E = Emission

I = Env. Interaction

N = Noise Levels dB(A)

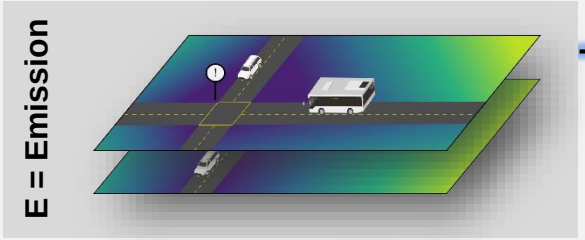
>65 >55 >45 >35

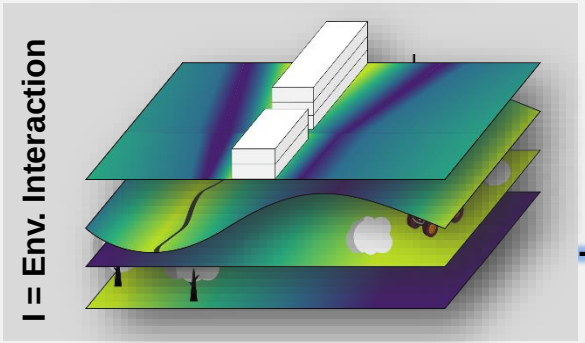


WP1

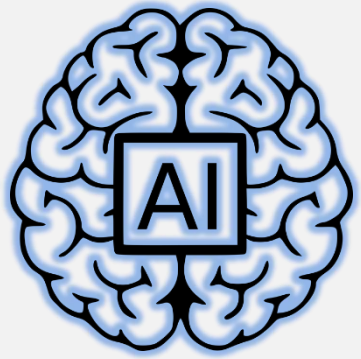
German-wide Noise Modeling (DLR)

Structure Catalog

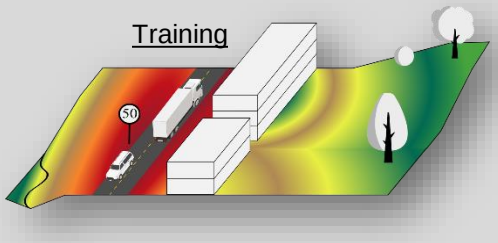


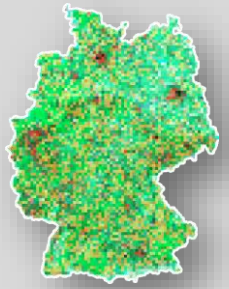


AI/ML methods for noise modeling



N = f(E, I)





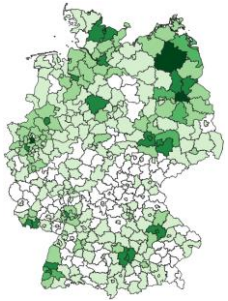
Prediction
- 10 Meter Resolution
- Large Scale Consistency

N = Noise

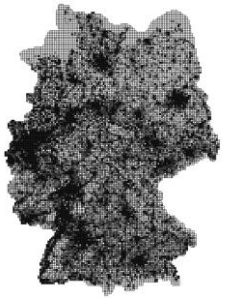
WP2

Improving the Quantification of Noise Effects on Health (HMGU)

Health

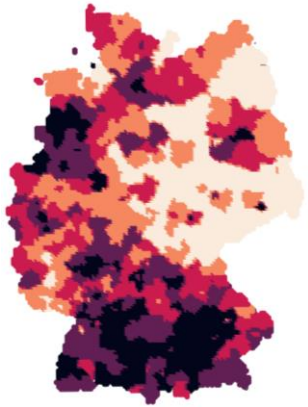


Noise



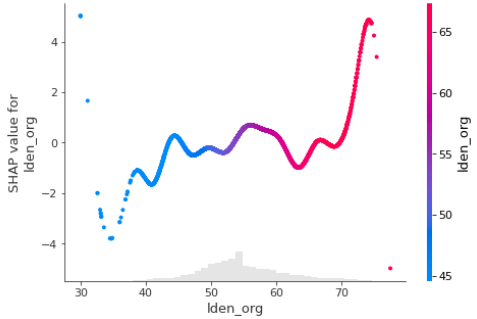
Neighborhood

Task 1



Predicting Vulnerable Clusters for Hypertension

Task 2

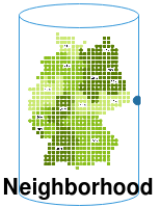


Effects of Noise (lden_org) on Hypertension

WP2 – Task 1

Predicting Vulnerable Clusters for Hypertension

Hypertension



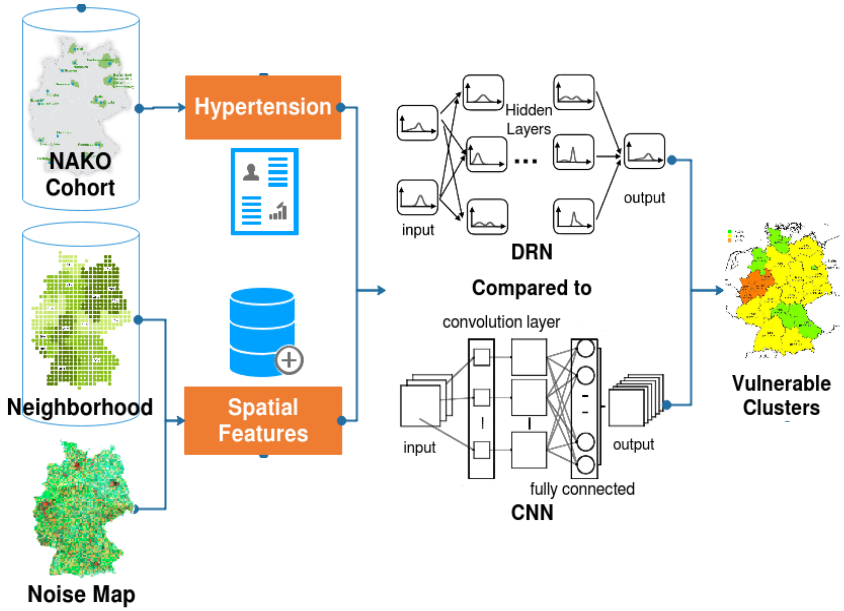
SES: Rate of unemployed / employed, Income score, Population, household density

Environment: Greenness, Imperviousness, Building density

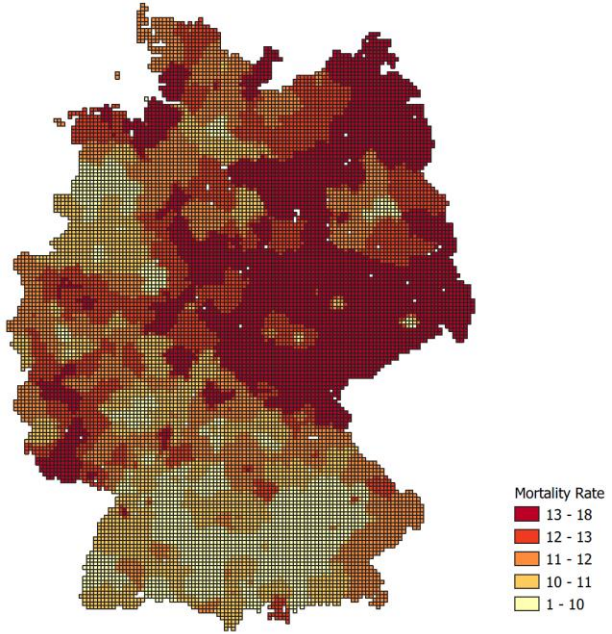
Noise maps, output WP1

WP2 – Task 1

Predicting Vulnerable Clusters for Hypertension



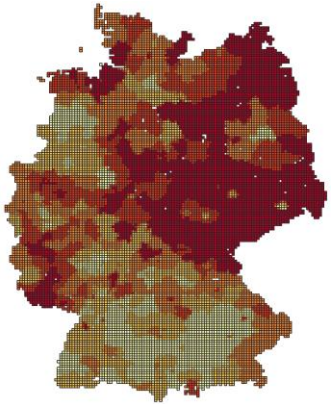
German-wide Mortality Rate Aggregated for 5km Grid Cells

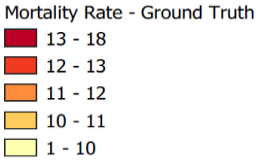


WP2 – Task 1

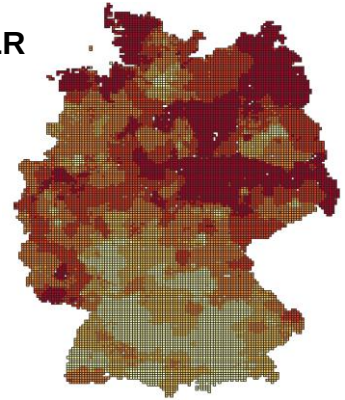
First Results for Predicting the Mortality Rate

Ground Truth

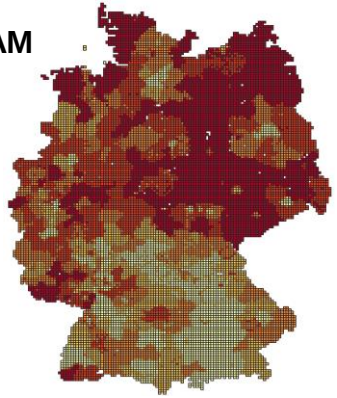




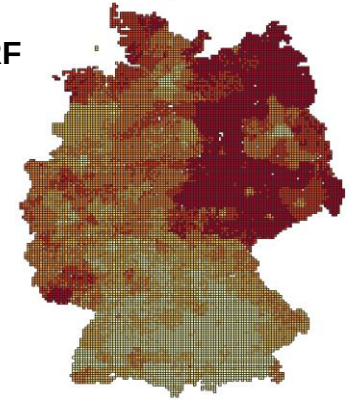
LR



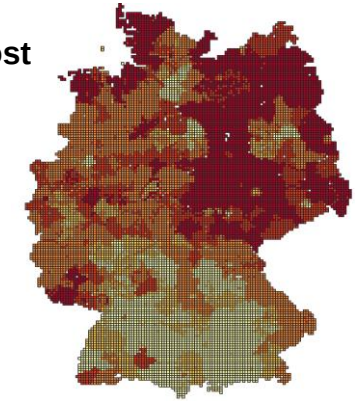
GAM



RF



XGBoost



Method	MSE	MAE	R_2
LR	1.49	0.92	0.55
GAM	1.67	0.99	0.50
RF	1.41	0.90	0.58
XGBoost	**1.28**	**0.86**	**0.61**

WP2 – Task 2

Investigating the Effect of Noise on Hypertension

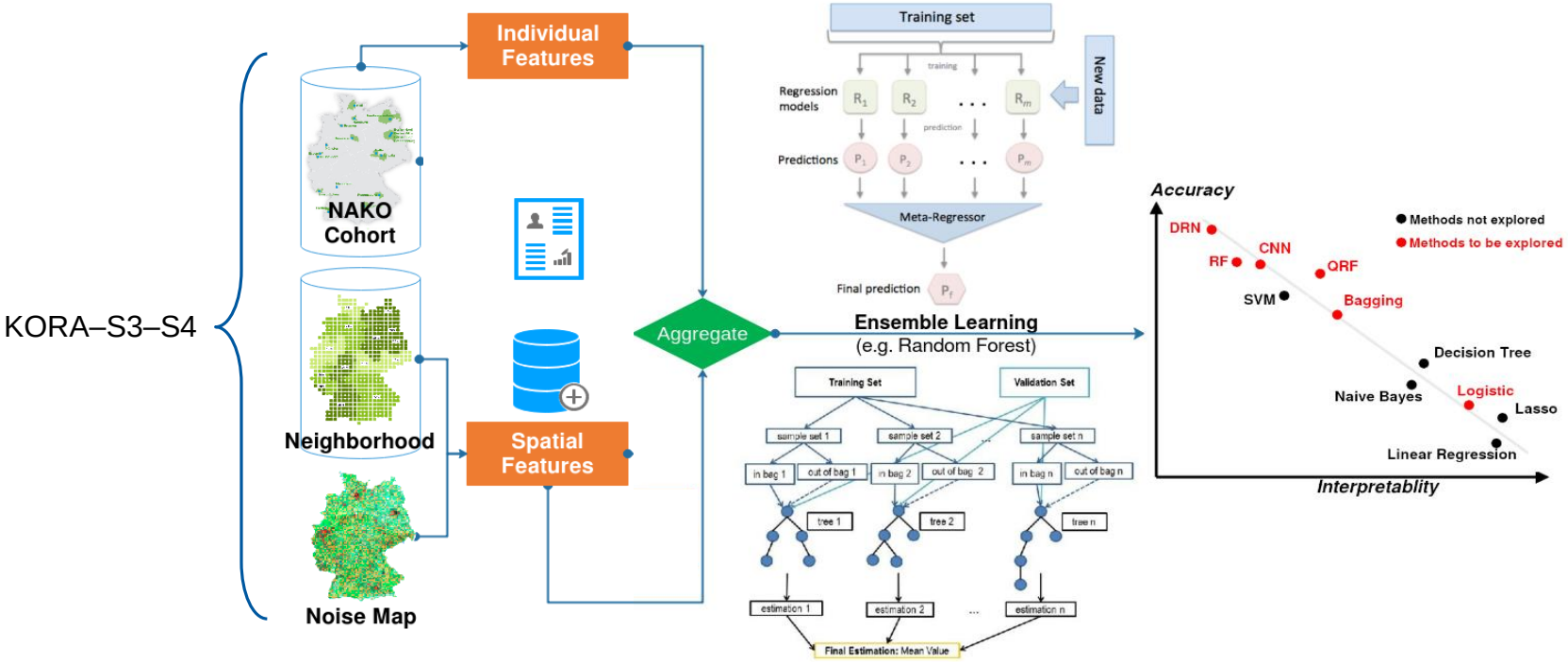
socio-economic, demographic, and health data from more than 200.000 participants of the German national cohort (NAKO)

SES and environmental variables

Noise maps (output WP1)

WP2 – Task 2

Investigating the Effect of Noise on Hypertension



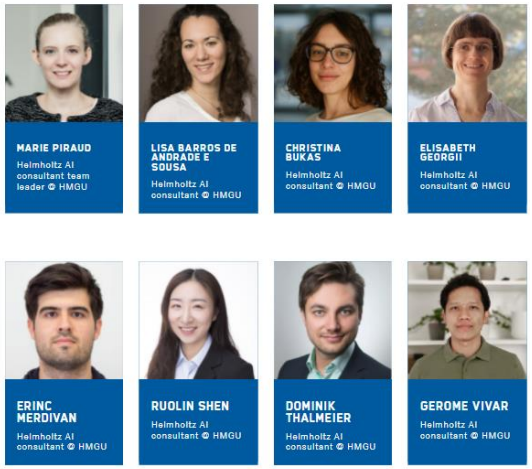
WP2 – Task 2

Investigating the Effect of Noise on Hypertension

- Inherently Interpretable Algorithms
  - Linear Regression (LR)
  - Generalized Additive Models (GAM)
  - Semi-Structured Deep Distributional Regression (SDDR)

- Explainable Artificial Intelligence (XAI)
  - Local Interpretable Model-agnostic Explanations (LIME)
  - SHapley Additive Explanations (SHAP)
  - Forest-guided Clustering

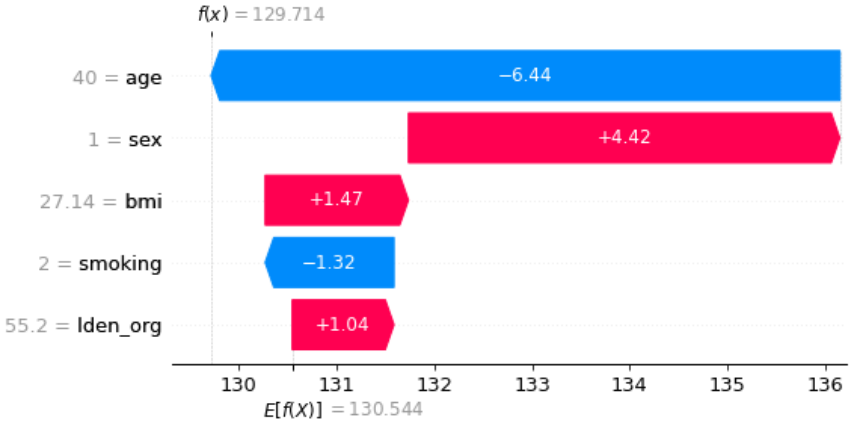
Helmholtz AI consultant Groups
Health Team



XAI

SHAP (SHapley Additive Explanations)

- Additive feature attribution methods



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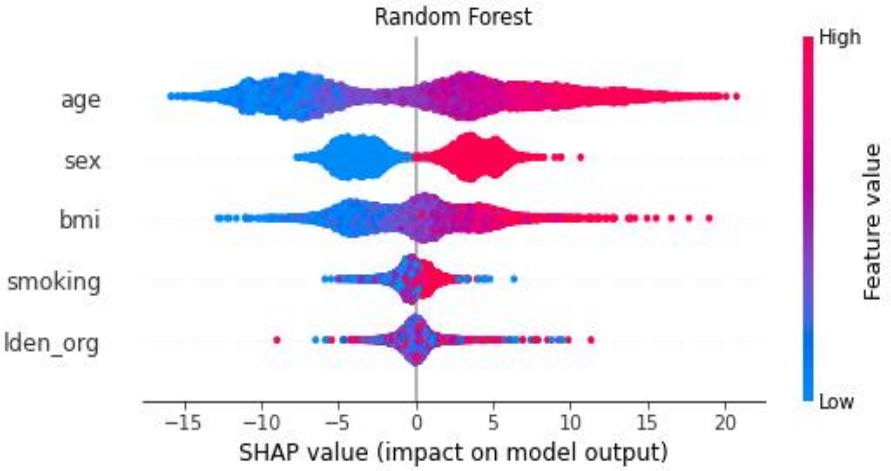
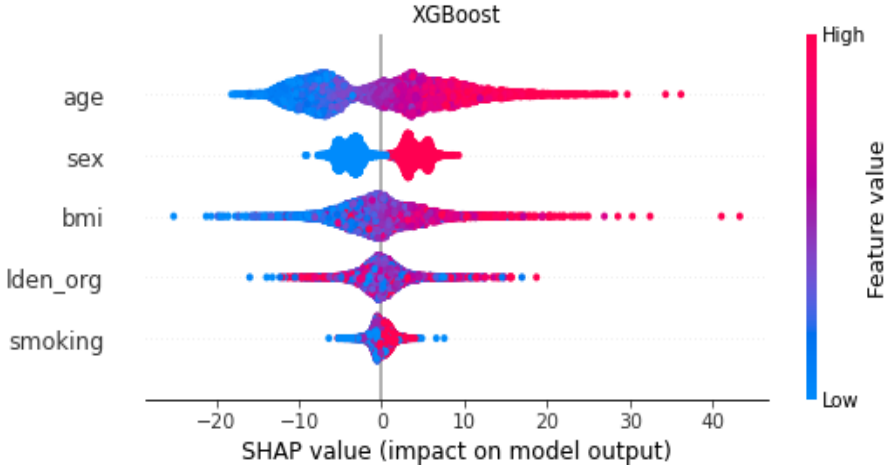
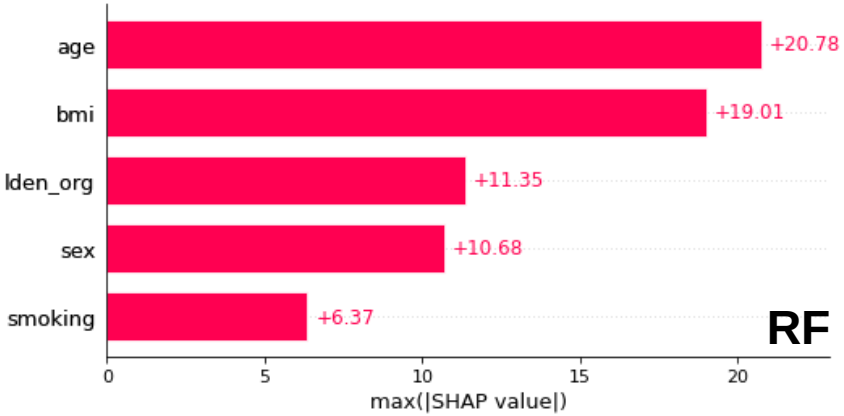


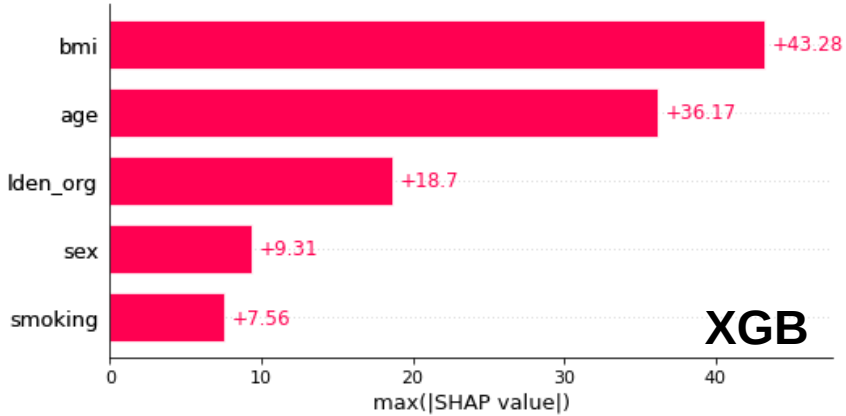


XAI

SHAP (SHapley Additive Explanations)

- SHAP values as a unified measure of feature importance





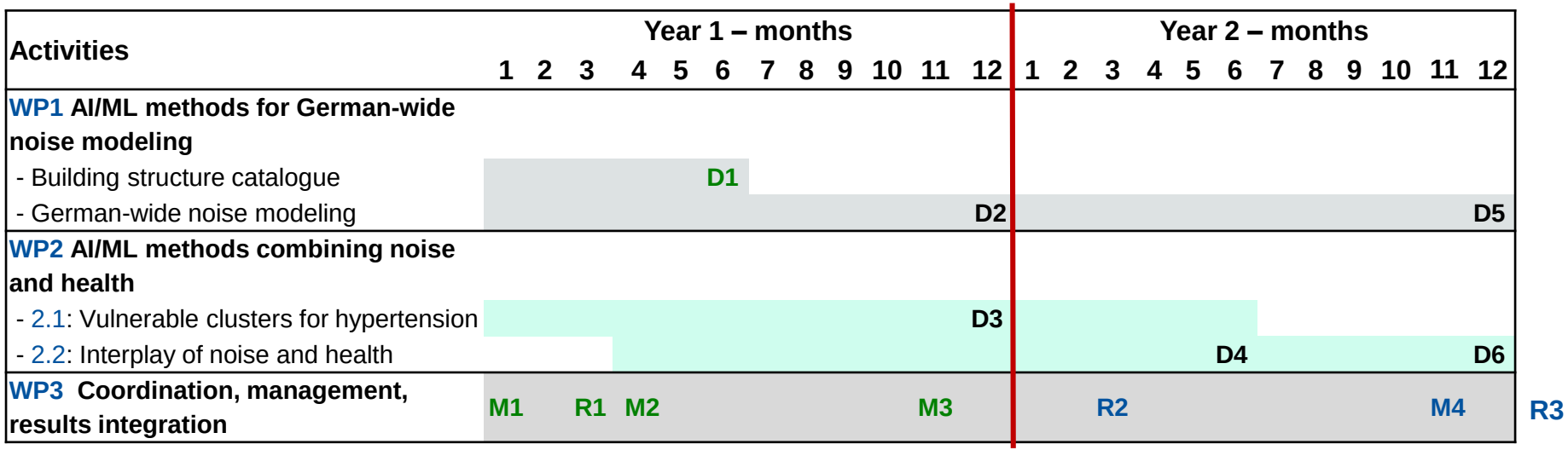
Publications

- 14./15.4.2021 Helmholtz AI Virtual Conference:
  https://www.helmholtz.ai/no_cache/themenmenue/latest/events/helmholtz-ai-virtual-conference-2021/index.html
  https://www.helmholtz.ai/fileadmin/HAICU/PDF/HelmholtzAIcon21_AbstractBook_DinA4_FV2.pdf

- 14.-17.6.2021 ICBEN Congress on Noise as a Public Health Problem:
  https://www.icben2021.se/

👈 Click here

Timeline



M1: Kick-off meeting (24.11.2020)
M2: Methodological workshop (22.2.2021)
M3: Month 11 status meeting (27.09.2021)
M4: Month 23 status meeting (tbd)

D1: Building structure catalogue
D2: Test AI set up for noise modelling
D3: Test AI set up for vulnerable cluster prediction
D4: Test AI set up for interplay of noise, neighborhood health
D5: Publication on noise models
D6: Publication on AI/ML models linking noise, neighborhood and health

R1: 2020 report (03.02.2021)
R2: 2021 report (Feb 2021)
R3: Final report (?)

Thank you for your attention!