Estimating Population-Level Exposomic Risk of Hospital Admissions

From environmental exposures to actionable insights for public health

Integrating multiple dimensions of health

Acute non-communicable diseases are influenced by interactions among environmental exposures, weather, demographic characteristics, and socioeconomic conditions. ENACT studies these combined influences -the **exposome**- to estimate how the risk of hospital admission changes across space and time.

External exposome

Environment

- Air pollution
- Light pollution
- Urban noise
- Temperature

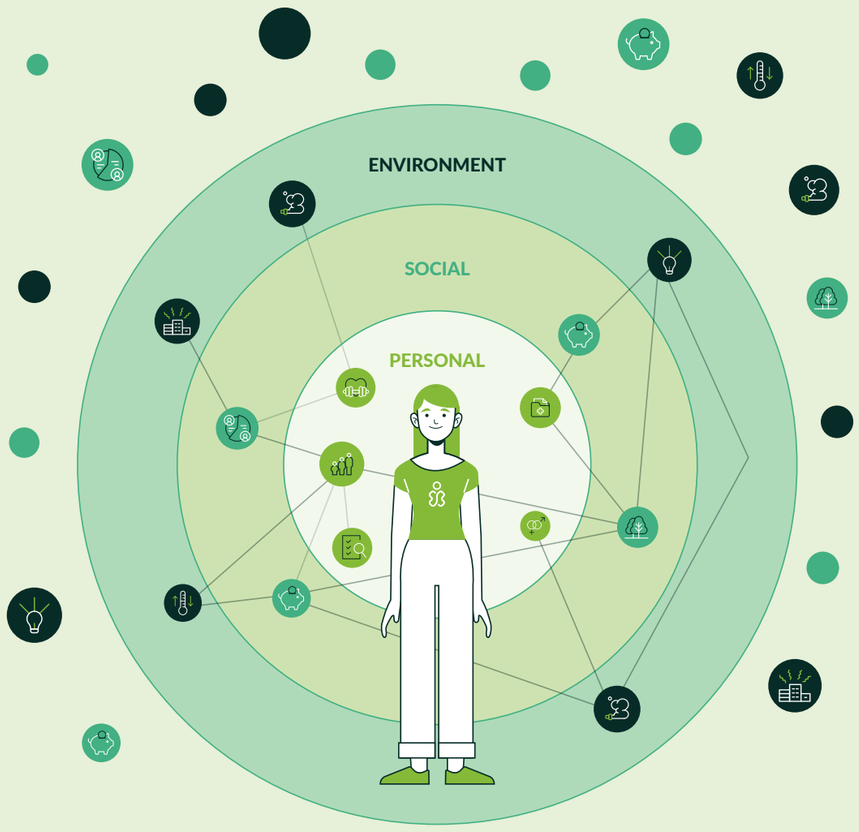
Social

- Residential environment
- Population characteristics
- Socio-economic indicators

Internal exposome

Patient Profiles (Personal)

- Age
- Gender
- Risk Profile: *Track lifestyle triggers like smoking duration*
- Treatment Pathway: *Document in-hospital interventions (revascularization type)*
- Baseline Status: *Record chronic conditions (hypertension, diabetes) at admission*



Individual records are aggregated into regional representations, preserving privacy while capturing environmental and population patterns.

From data to risk estimates

Multi-source data → Pseudonymisation (TTP) → Secure integration → Data preparation → Forecasting models → Exposomic risk estimation

ENACT compares multiple modelling approaches

- Classical time-series methods
- Neural network models
- Probabilistic forecasting models
- Transformer models
- Graph-augmented spatio-temporal transformer model
- Graph-based spatio-temporal models

All methods are evaluated using the same benchmarking protocol, allowing fair comparison across forecasting strategies.

Key scientific findings

Population-level risk matters:

ENACT forecasts regional hospitalization rates, enabling fair comparisons between areas with vastly different population sizes and demographic backgrounds.

Patient-derived information enhances forecasting:

Adding aggregated patient-derived regional information improved prediction by complementing environmental and regional exposure data, although its impact depended on the forecasting approach.

Spatio-temporal modelling improves predictions:

For monthly/weekly and daily forecasting, models combining spatial and temporal relationships achieved the strongest predictive performance, highlighting the importance of modelling how neighbouring regions and changing environmental conditions interact.

Transparent Risk Modelling:

- Regional risk maps visualise predicted hospitalization risk across space.
- Variable-importance and attention analyses help understand which inputs the model relied on. Temperature-related variables and black carbon emerged as important predictors.

Variable importance and attention scores indicate which inputs were useful for prediction, but they do not establish that these variables causally drive hospitalization risk.

What makes ENACT different?

Exposome-centred: Considers multiple environmental influences simultaneously.

Population-focused: Produces regional risk estimates rather than individual predictions.

Open and scalable: Disease-agnostic software that can be adapted to other acute non-communicable diseases.

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