IMPROVED ASSESSMENT OF PERSONAL EXPOSURE TO AIR POLLUTANTS USING AGENT BASED MODELLING (ABM) COUPLED WITH MULTI-SENSORS NETWORKS

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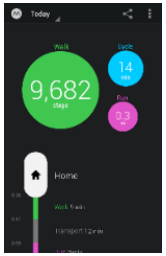
http://www.enve-lab.eu

Introduction

- Use sensors for tracking personal location and activities in order to assess **exposure at a personal level**.
- Hurdles involved in collecting real data for large populations.
- Development of an individual exposure model **based on Agent Based Modelling (ABM).**



Methodology

2019 wearable sensors campaign

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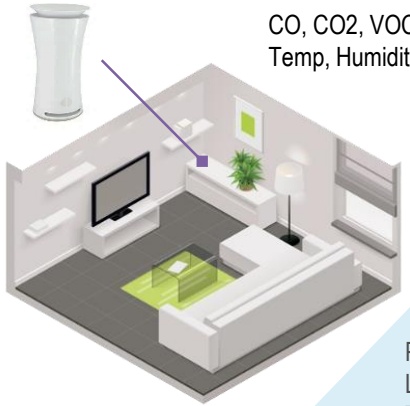
Multi-sensor Campaign



Online Platform

Smart Data Collection

LoRa

9 EU cities
100 participants/city
Duration: 7 days
Summer & Winter period

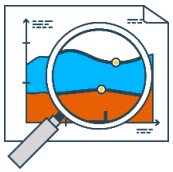
Data Analysis & Interpretation

Time | Activities

Location

Statistical Models

Pollutants' Concentration



Exposure modelling

Personal Exposure

Methodology

PM and PAHs sampling

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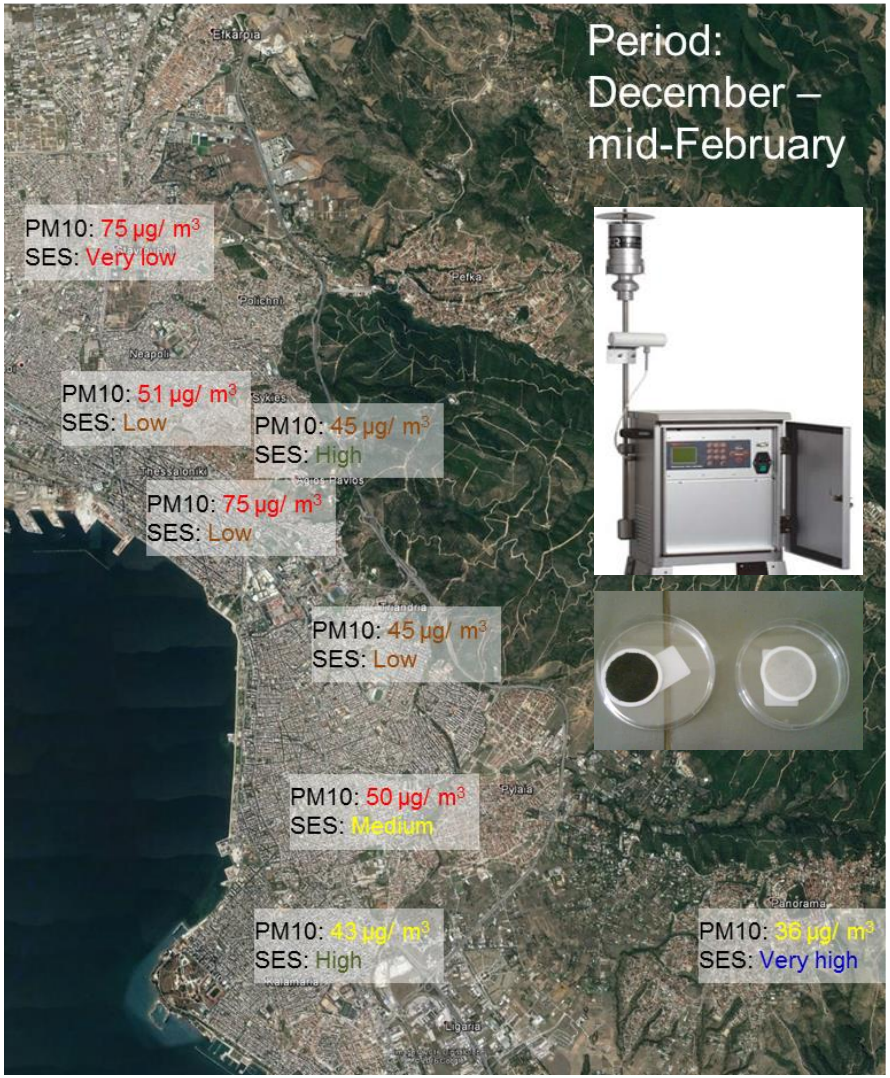

Methodology

PAHs analysis

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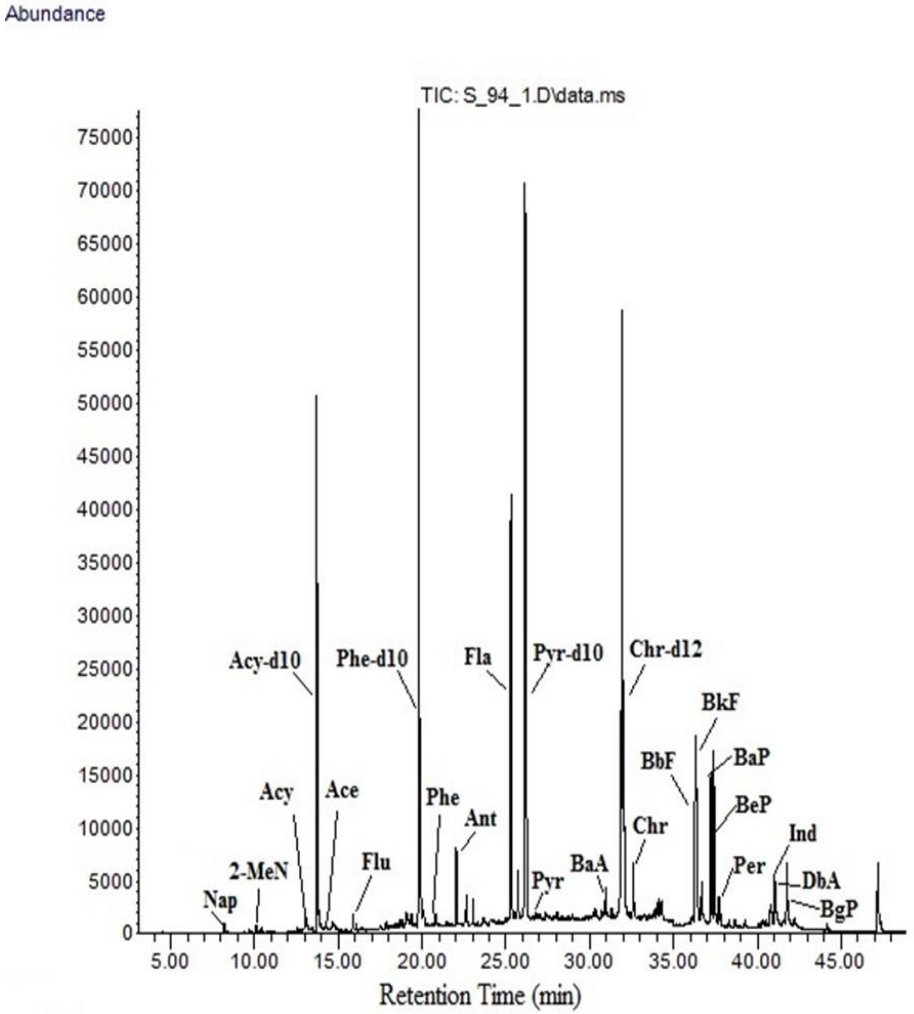
- **Extraction of filters with organic solvents**
- **GC-MS analysis**
- **Determination of concentrations using internal standards**



Methodology

AQ sensors data validation

Place	Settings	Duration (h)	LR			NLR			MLR			MLR_RV			ANN		
			PM1	PM2.5	PM10	PM1	PM2.5	PM10	PM1	PM2.5	PM10	PM1	PM2.5	PM10	PM1	PM2.5	PM10
Lab	**Laboratory Conditions**	24	0.79	0.75	0.71	0.84	0.82	0.81	0.83	0.81	0.80	0.86	0.85	0.84	0.87	0.85	0.85
	Closed Windows / AC Off	17	0.84	0.81	0.70	0.89	0.86	0.86	0.85	0.83	0.80	0.95	0.94	0.95	0.96	0.96	0.96
	Closed Windows / AC On	24	0.85	0.83	0.79	0.92	0.92	0.90	0.89	0.89	0.88	0.96	0.96	0.95	0.97	0.97	0.97
	Open Windows / AC Off	24	0.86	0.84	0.67	0.90	0.90	0.86	0.88	0.83	0.67	0.96	0.95	0.91	0.97	0.96	0.94
	Closed Windows - Battery Low	6	0.52	0.53	0.45	0.58	0.60	0.56	0.63	0.75	0.77	0.78	0.87	0.90	0.84	0.91	0.91
	Mixed - Fri/Sat/Sun	72	0.85	0.86	0.77	0.91	0.89	0.83	0.88	0.86	0.78	0.95	0.93	0.87	0.97	0.96	0.90
Office	Closed Windows / AC On	24	0.85	0.84	0.47	0.91	0.88	0.64	0.92	0.88	0.62	0.97	0.96	0.80	0.97	0.97	0.84
	Open Windows / AC On	10	0.70	0.56	0.19	0.74	0.62	0.20	0.67	0.60	0.37	0.84	0.77	0.68	0.89	0.79	0.65
	Open Windows / AC Off	11	0.81	0.78	0.72	0.85	0.83	0.81	0.84	0.83	0.80	0.86	0.84	0.82	0.86	0.86	0.85
Living Room	Open Windows / Fan Off	18	0.86	0.84	0.71	0.90	0.89	0.80	0.90	0.89	0.78	0.97	0.95	0.87	0.97	0.96	0.89
	Open Windows / Fan On	12	0.88	0.86	0.70	0.92	0.90	0.80	0.92	0.91	0.88	0.97	0.96	0.96	0.96	0.96	0.97
	Closed Windows / Fan On	12	0.87	0.83	0.77	0.91	0.88	0.85	0.91	0.89	0.82	0.96	0.96	0.92	0.96	0.97	0.94
	Closed Windows / Fan Off	12	0.81	0.68	0.37	0.85	0.77	0.49	0.85	0.73	0.46	0.93	0.82	0.56	0.94	0.86	0.68

**work in progress – testing period: 15 days (Aug – Sept 2018), results from 5 sensors*

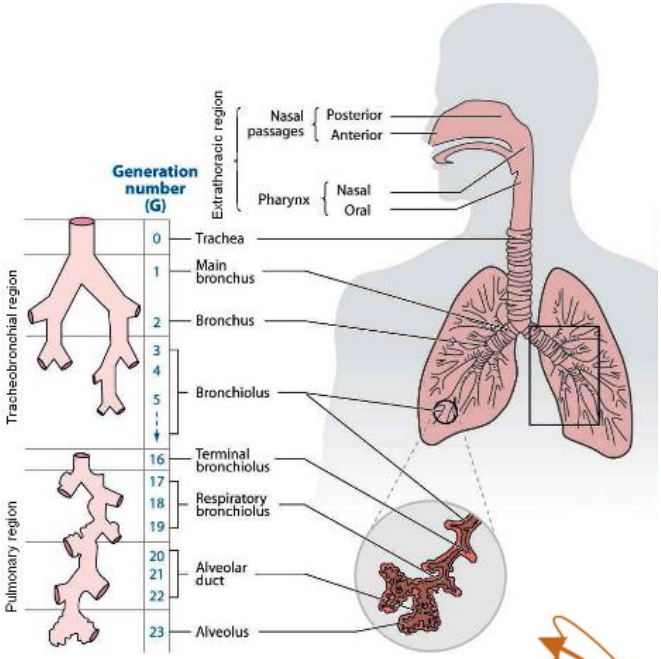


- Test device under diverse environmental conditions prior deployment
- Include additional environmental parameters that influence concentration
- Properly interpret the physicochemical phenomena and use the right statistical tools

Methodology

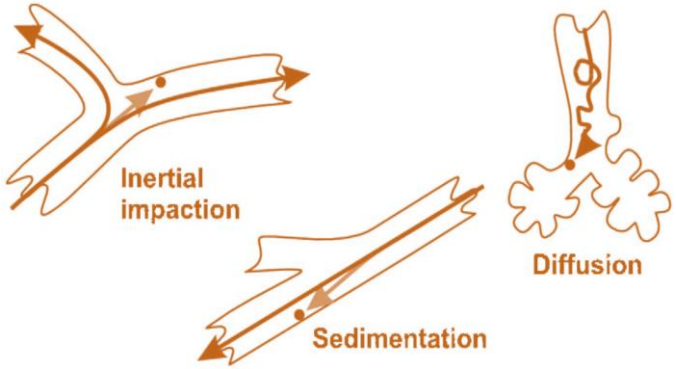
PM and PAHs deposition

- **Multiple Path Particle Deposition Model:** Tidal Volume, Functional Residual Capacity, URT volume and Breathing Frequency as inputs



Major:
- Diffusion
- Sedimentation
- Inertial Impaction

Minor:
- Interception
- Electrostatic



Aerosol property
- Size distribution
- Concentration
- Particle hygroscopicity
- Gas-particle interaction
- Chemical reaction
- Particle surface

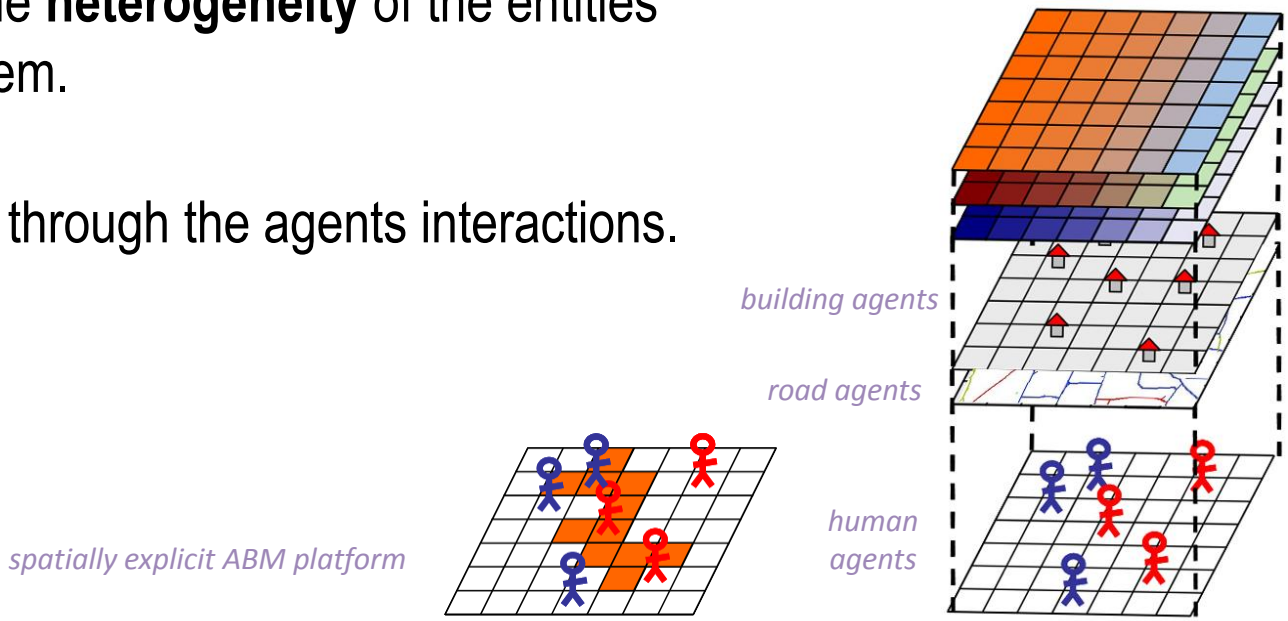
Air Flow property
- Lung capacity
- Breathing frequency

Respiratory tract
- Lung structure and morphology

Methodology

Agent Based Modelling (ABM)

- A system is modelled as a collection of agents and the relationships between them.
- The agents, programmed as autonomous decision-makers, react and act in their environment.
- Take into account the **heterogeneity** of the entities composing the system.
- Behaviours emerge through the agents interactions.



Methodology

Buildings & Road Network

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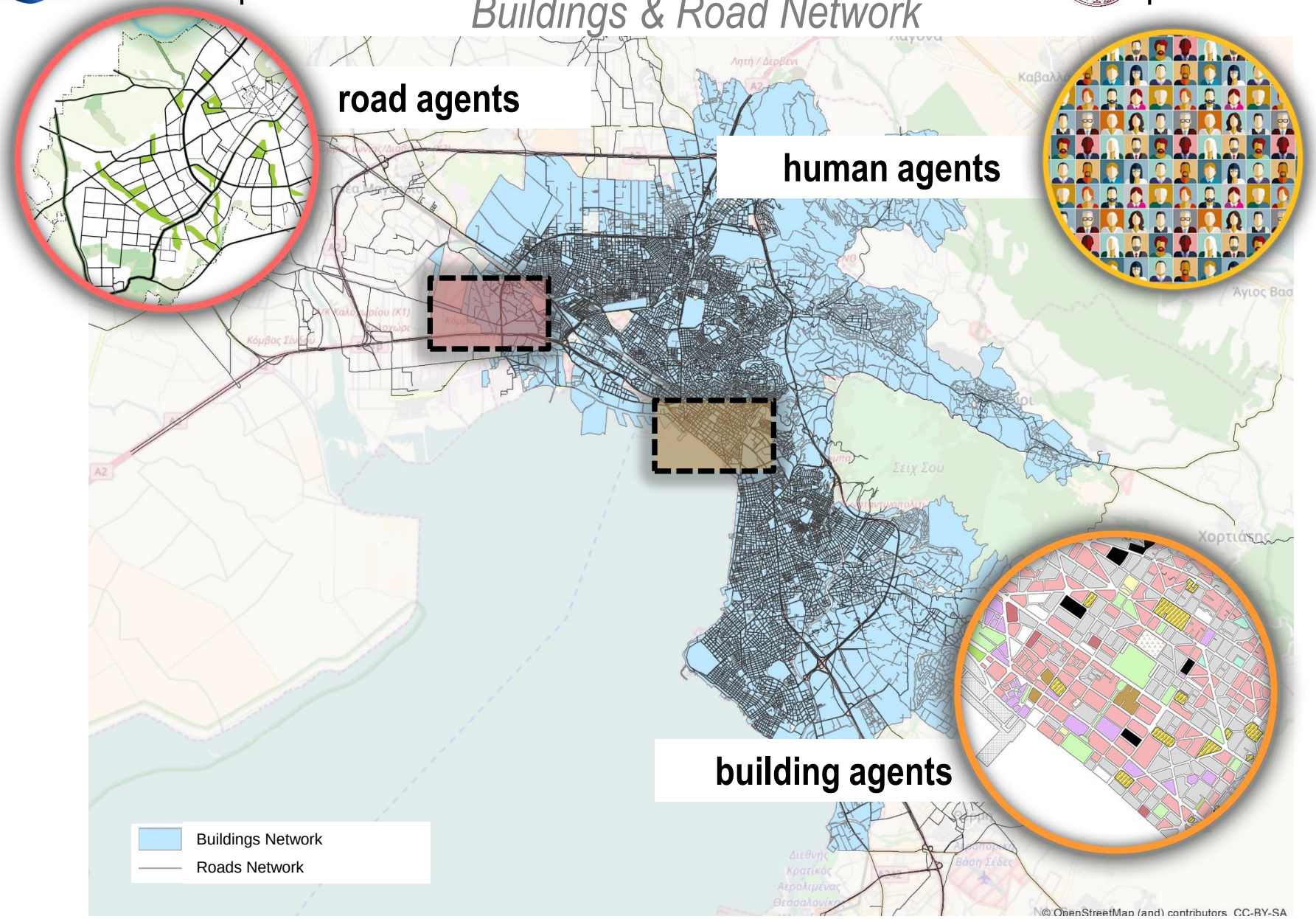

Methodology

Human agents spatiotemporal behaviour

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— sources —

- Time-Use Surveys
- Literature associations
- Campaigns findings

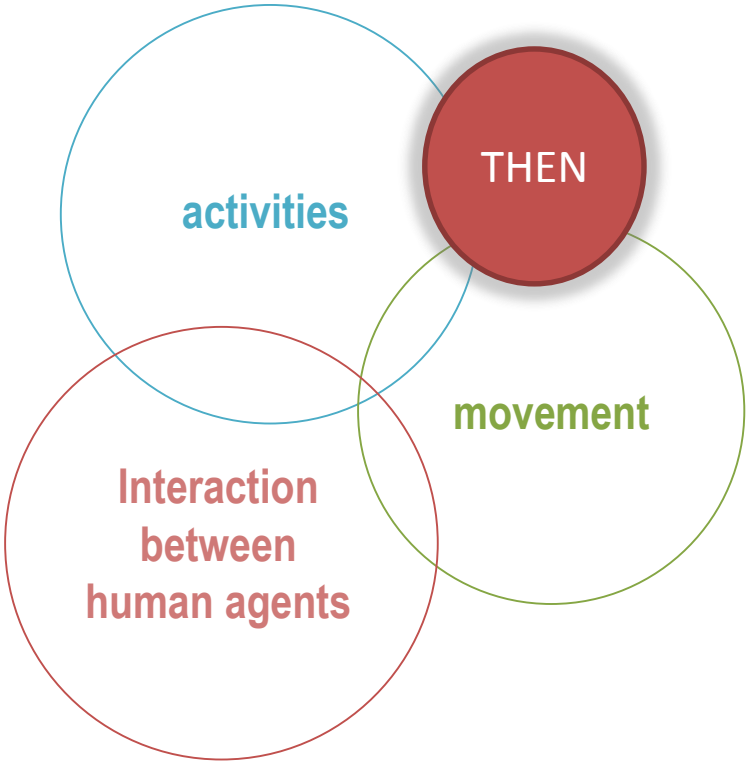
——— attributes ———

IF

- Age
- Gender
- Socio-Economic Status
  - Level of education
  - Occupational status
  - Marital status
  - Income

——— behavioural rules ———

THEN



$$P_{activity} = f(age, gender, income, education, P_o)$$

Methodology

Personal exposure modelling

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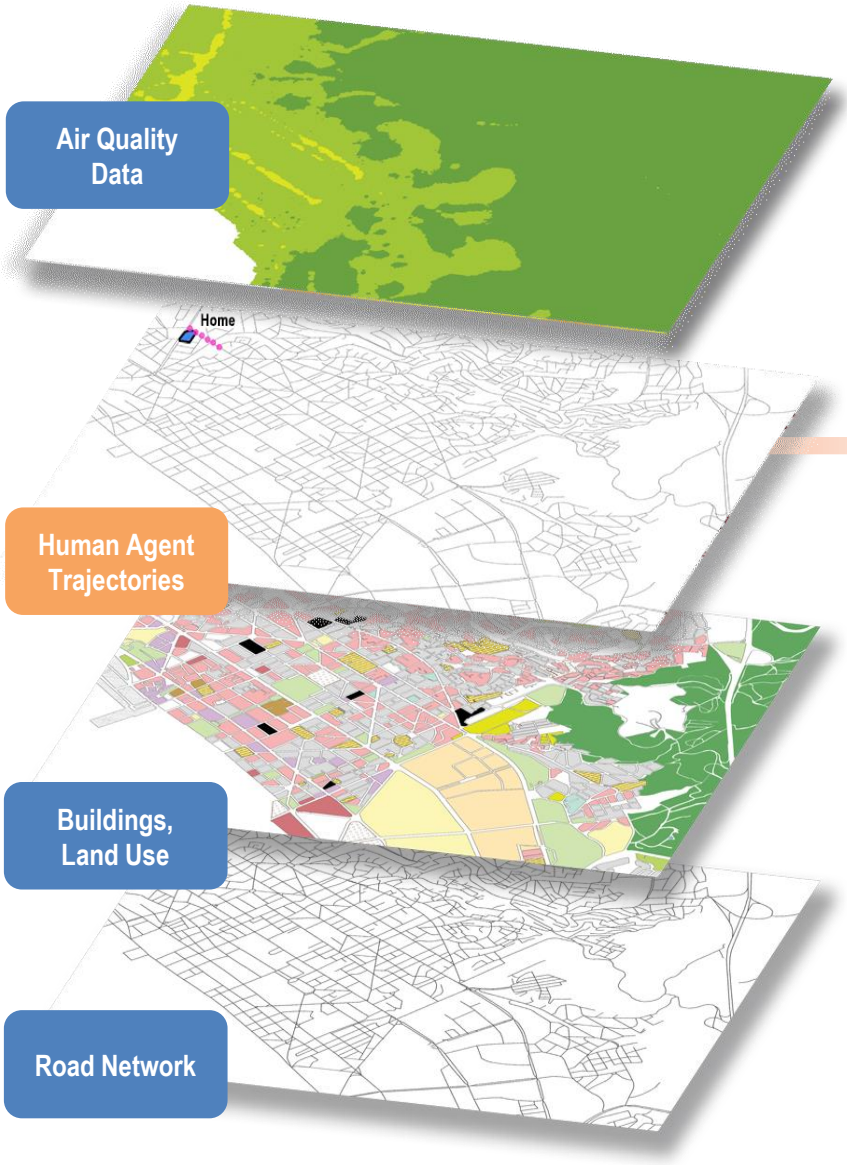
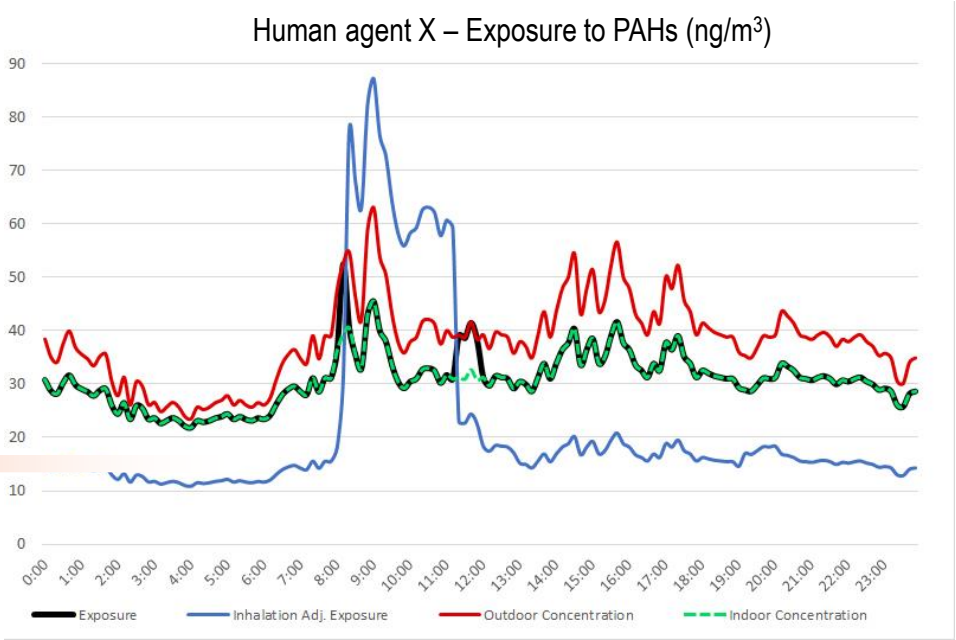
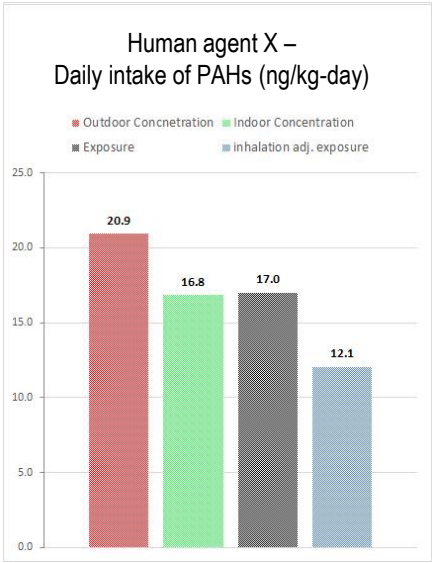


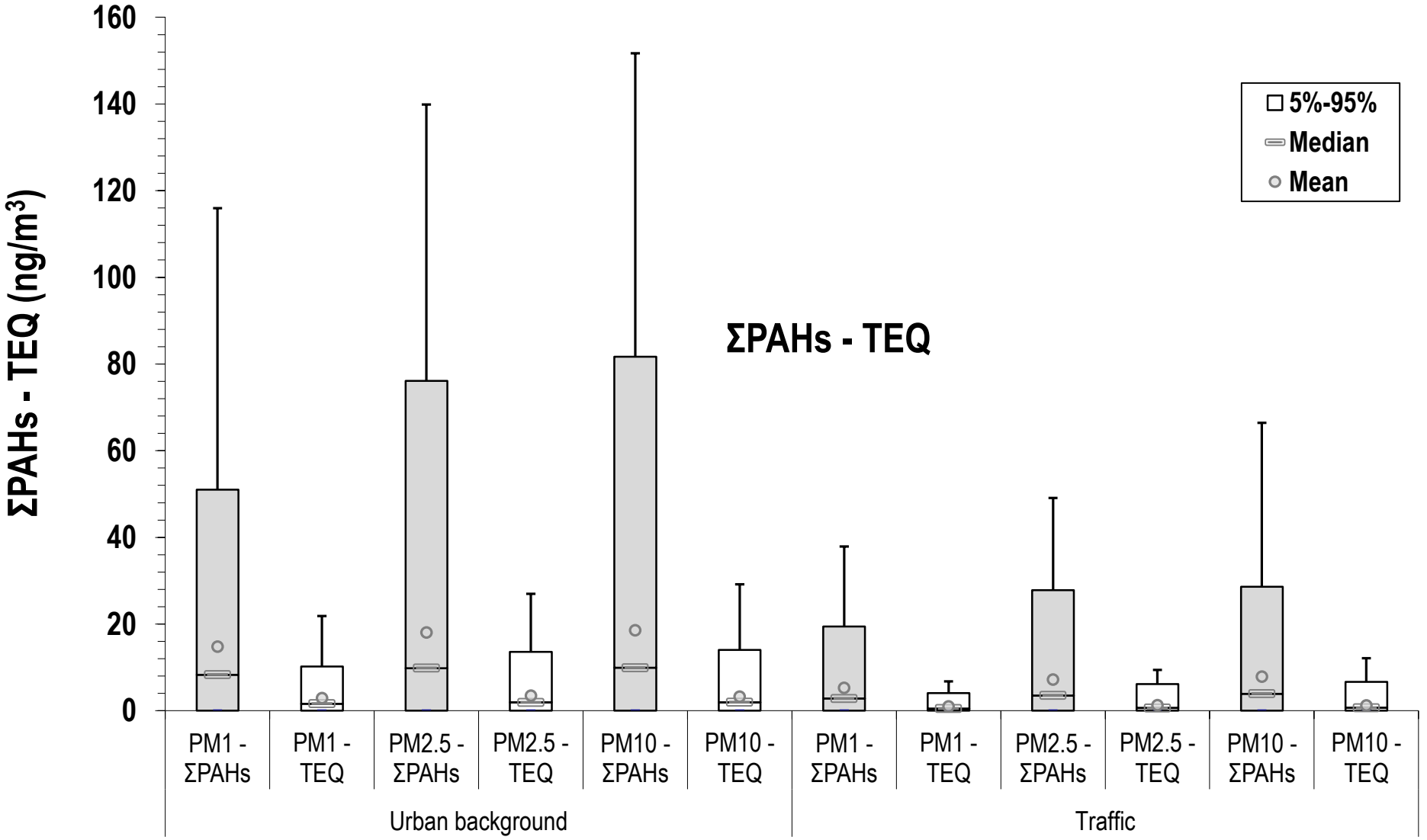


Time	Activity	Place	Vehicle
0:00	sleep	home	
8:10	commute	road	car
8:20	paidwork	work	
11:20	commute	road	car
12:00	eatdrink	home	
13:00	tvradio	home	
18:30	selfcare	home	
19:10	clean	home	
20:10	selfcare	home	
20:50	tvradio	home	



Results

Ambient air PAHs



Results

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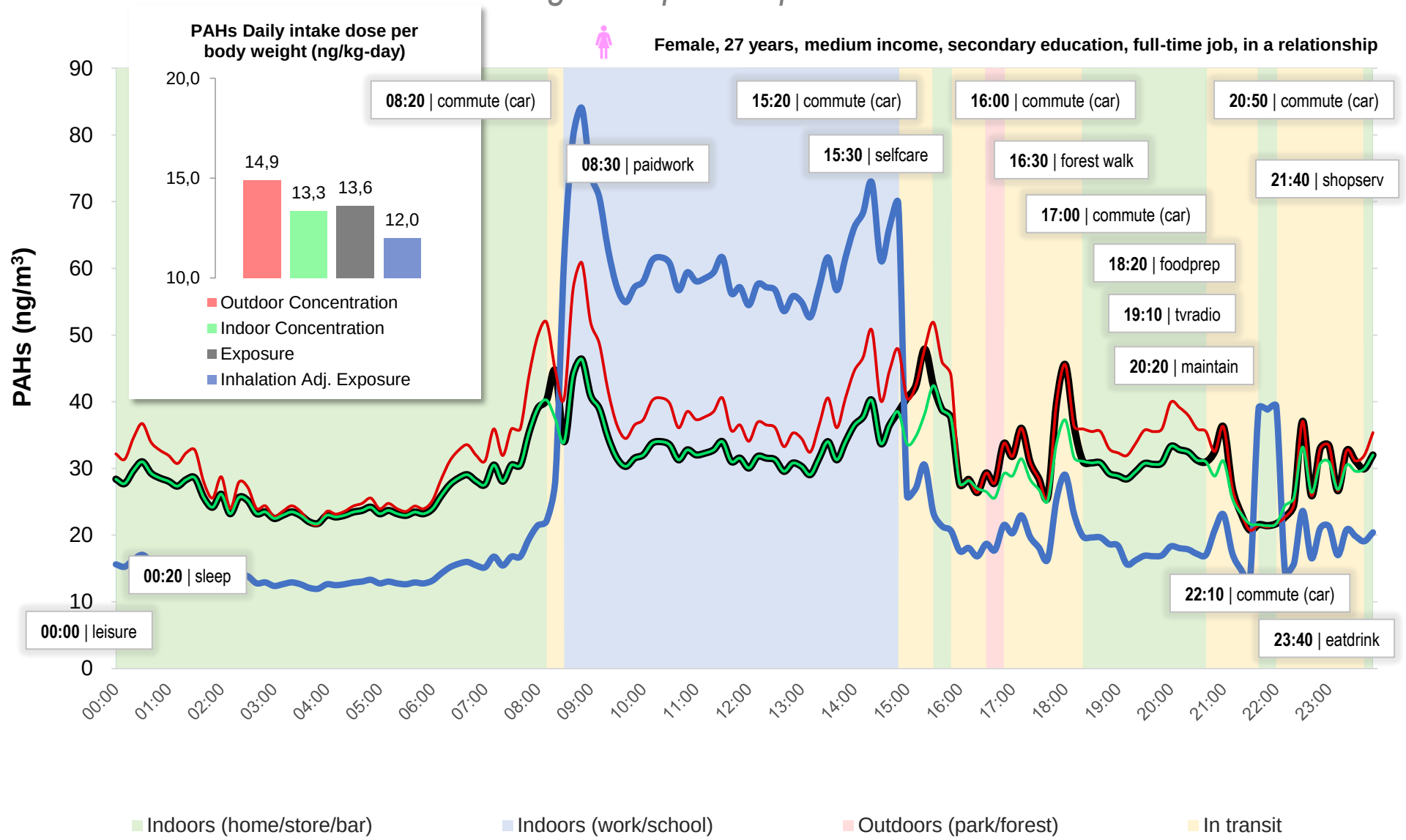
Human agent exposure profile – PAHs



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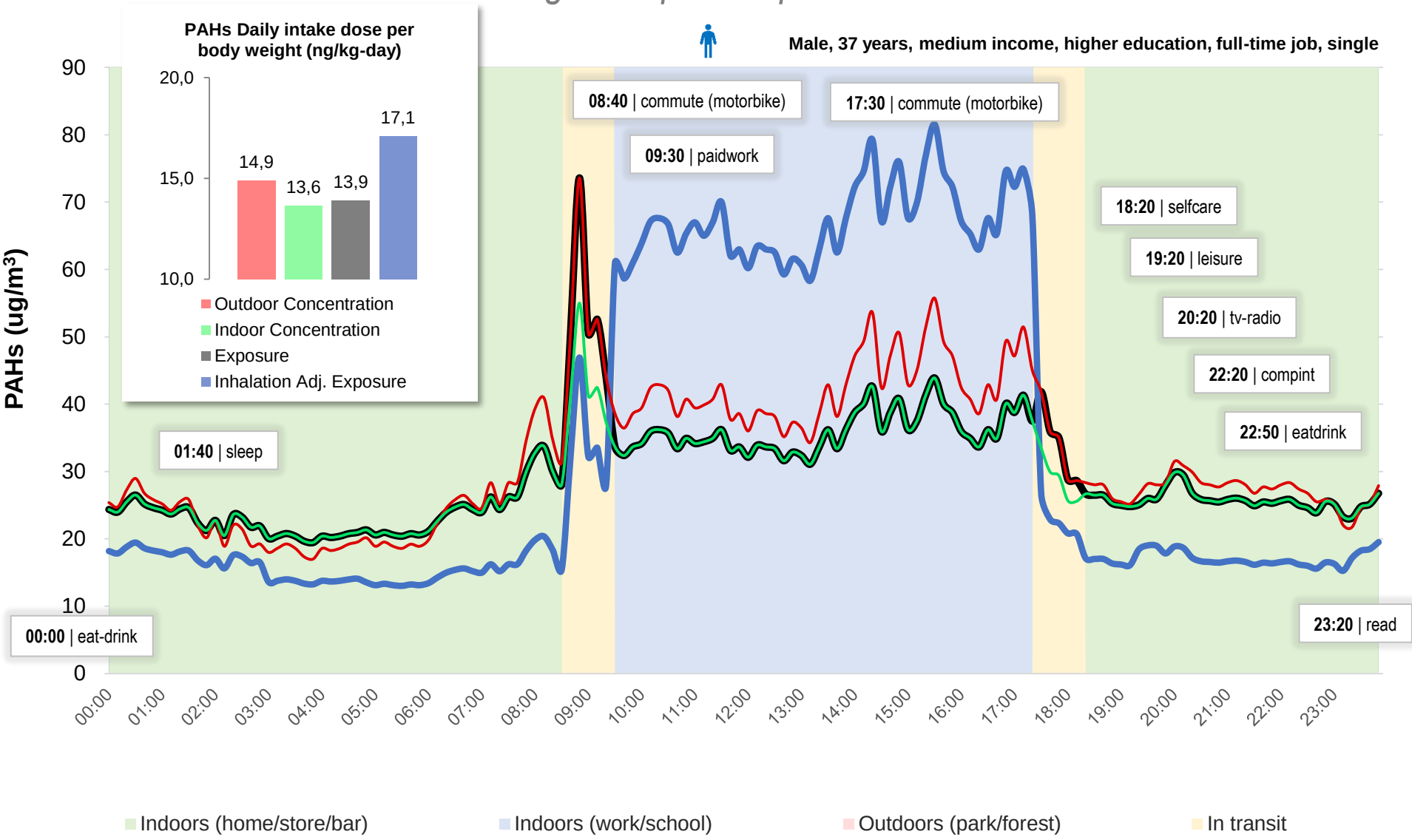

Results

Human agent population subgroups

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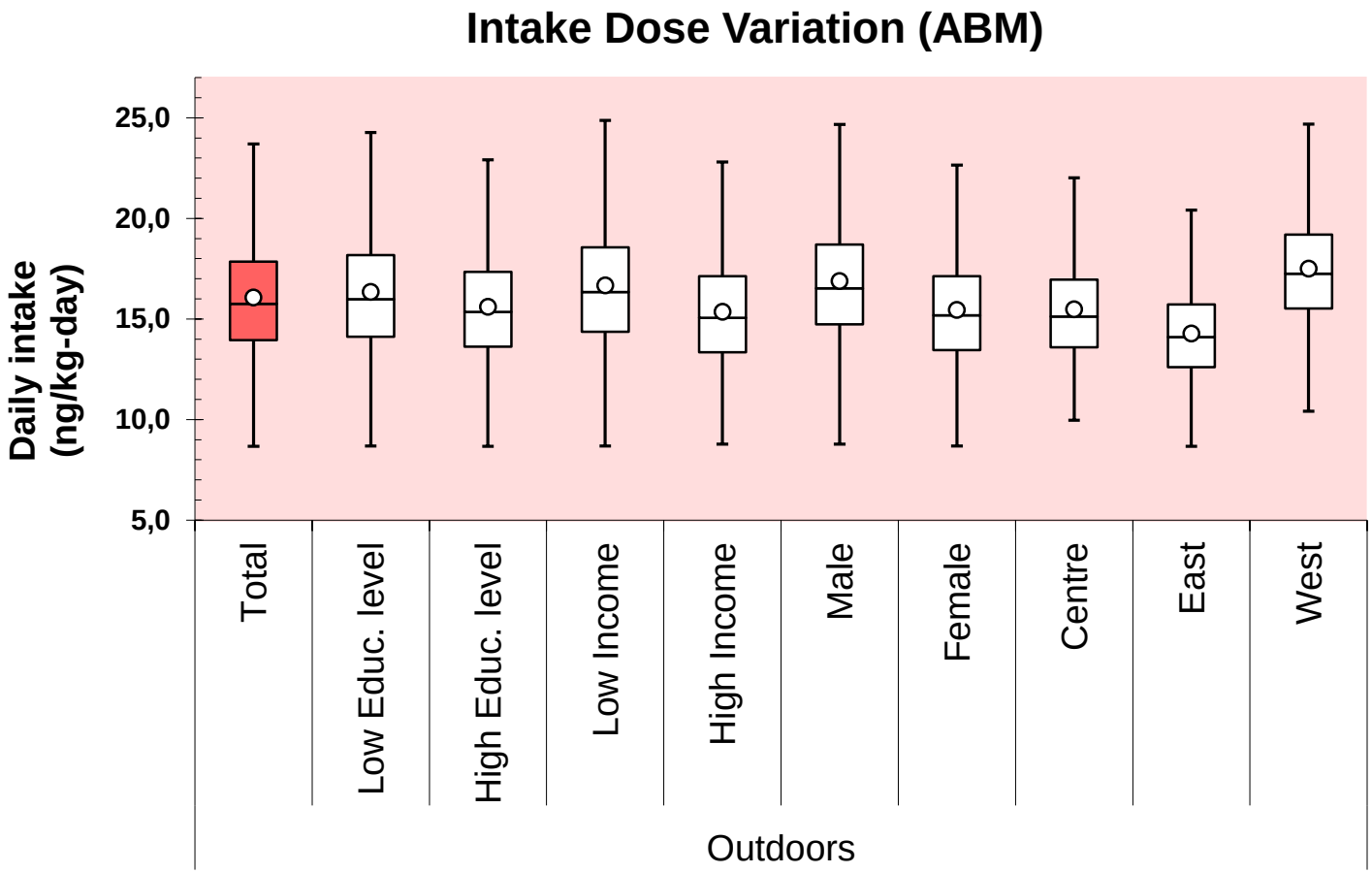
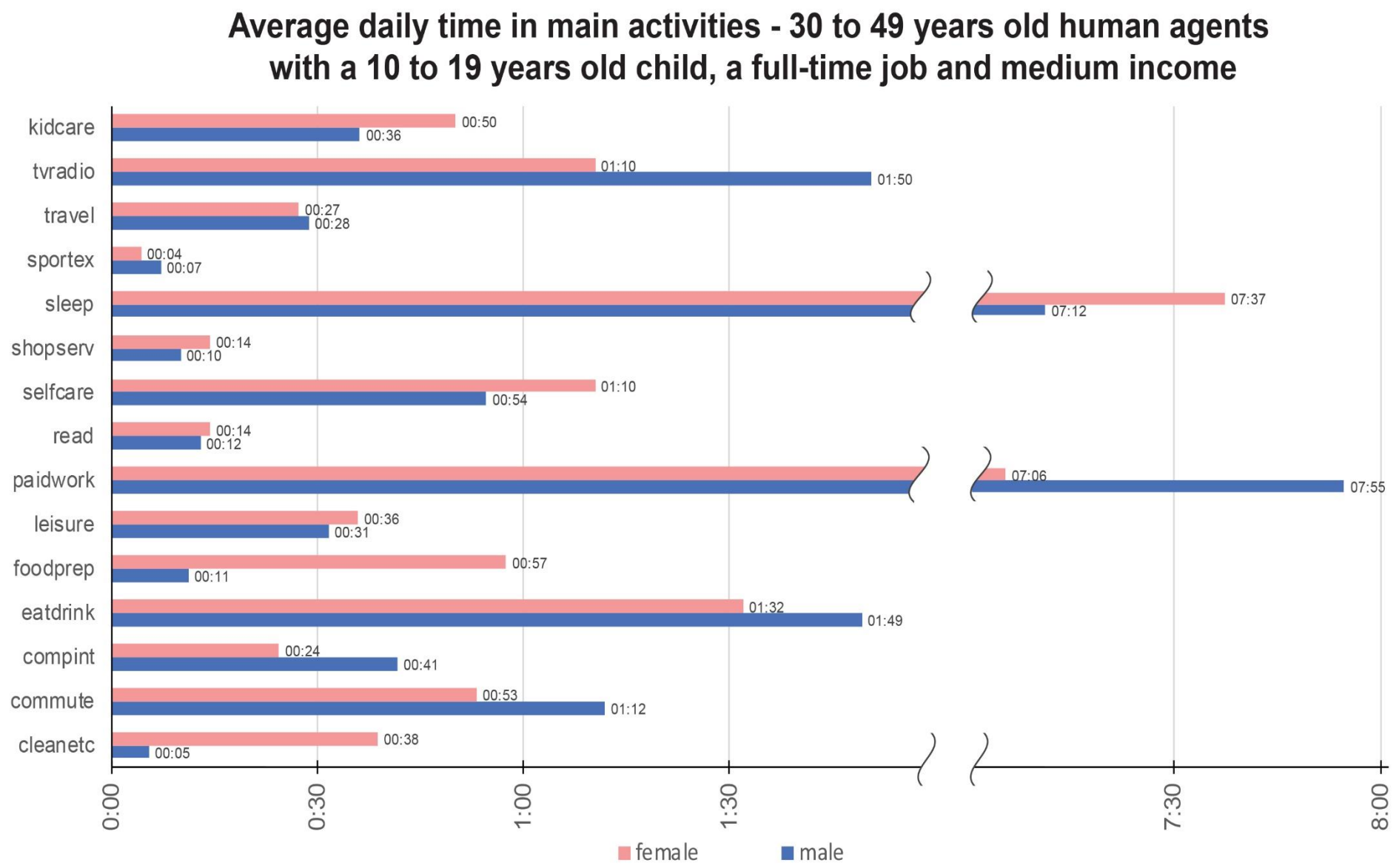
- Exposure can differ by 32% between housemates and up to 77% for neighbours
- Exposure was found to vary based on SES conditions



Results

Human agent population subgroups



Results

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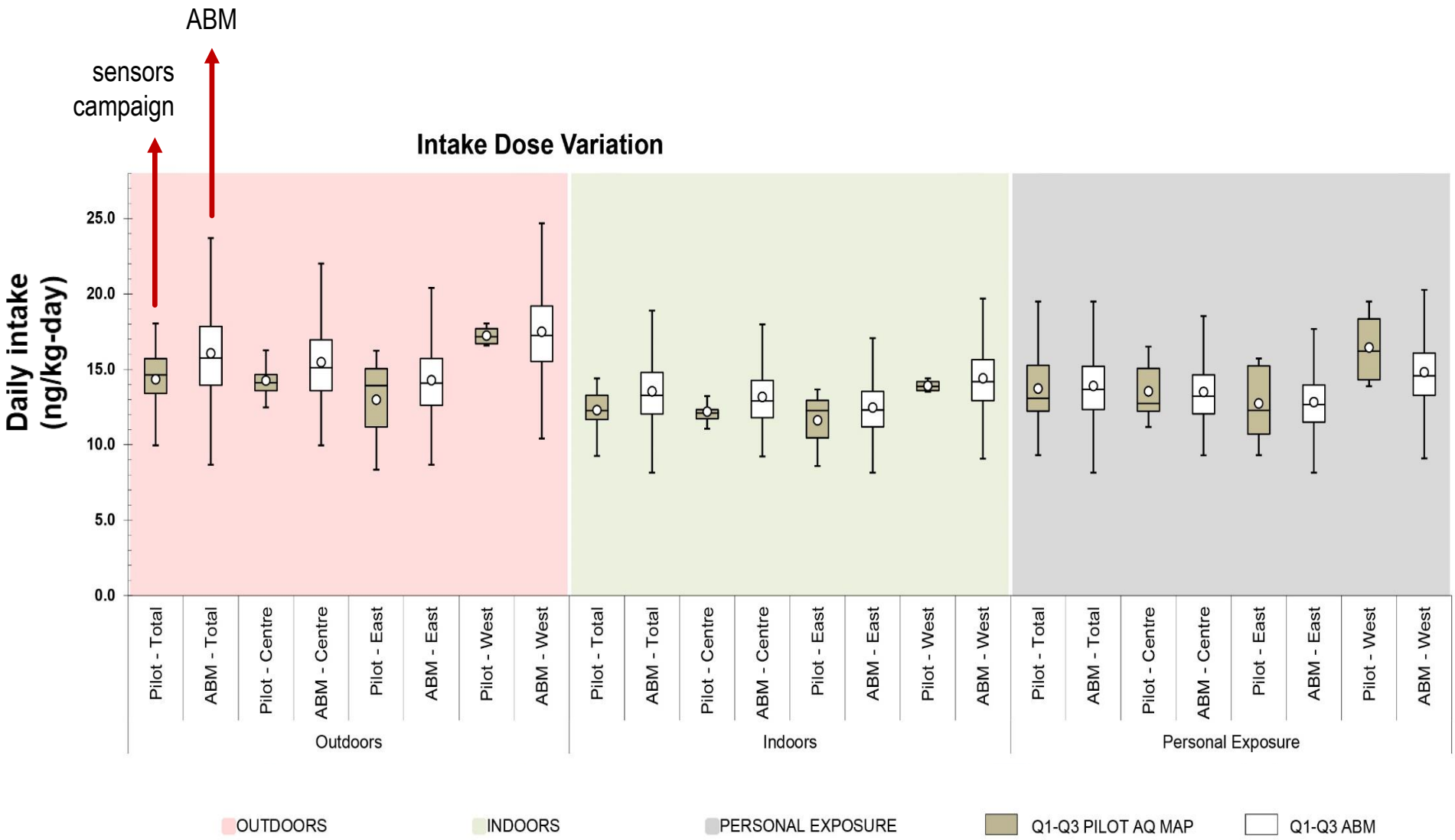
campaign exposure vs. ABM exposure data



Conclusions

- **cost-effective** construction of refined time-activity diaries & exposure profiles
- estimations based onto **emerging properties** of the agent system behaviour
- ABM model especially useful for **vulnerable groups** of population
- evaluation of the probable **impacts of different public health policies**, prior to implementation
- Combined data of **sensors**, **chemical analysis** and **advanced exposure modelling** are able to further elucidate differences among individuals and population groups

Acknowledgements

Funding

- HBM4EU project

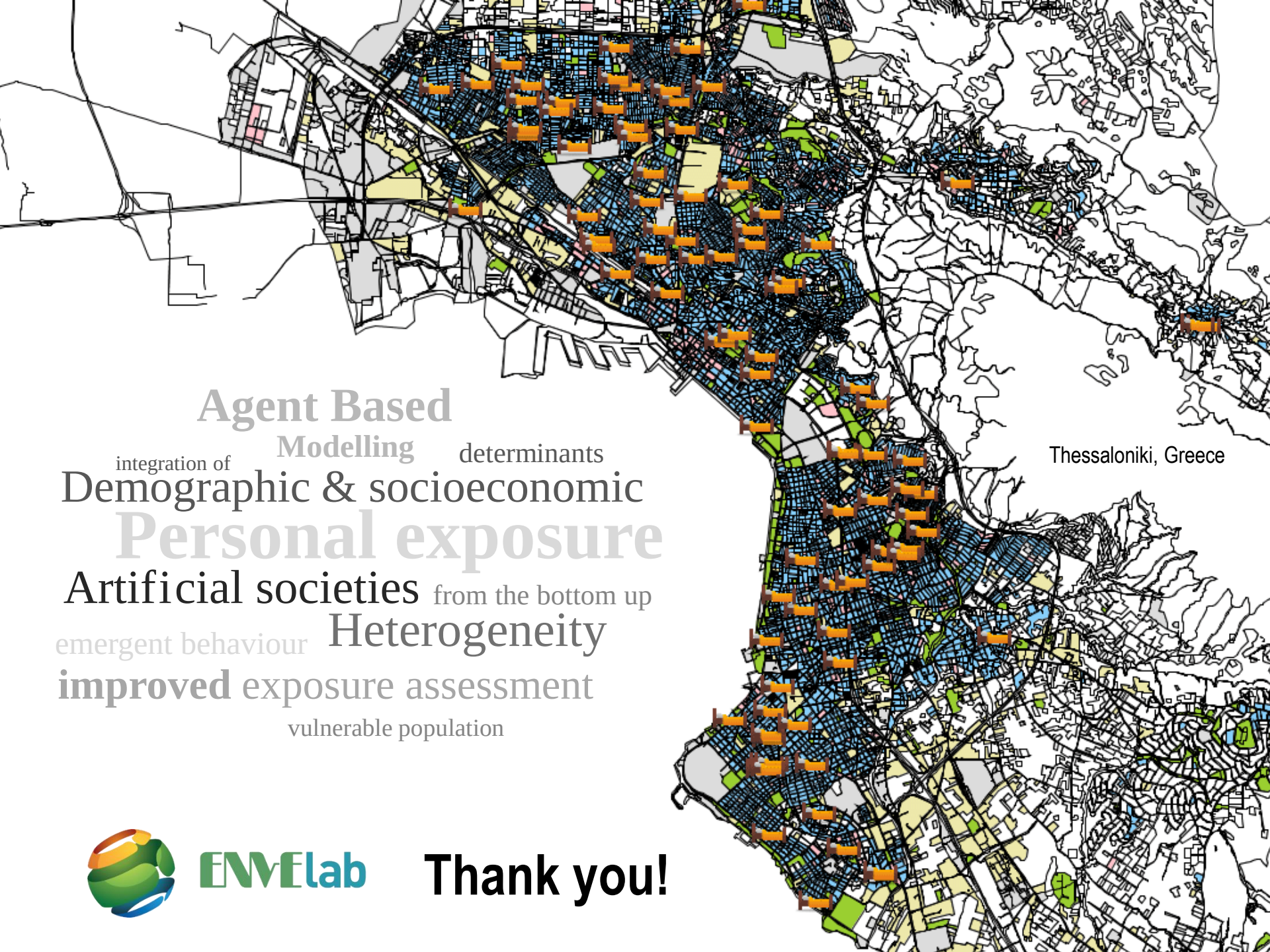
HBM4EU science and policy for a healthy future

The HBM4EU project has received funding from the Horizon 2020 Research and Innovation Programme under grant agreement No 733032

- ICARUS project

ICARUS

The ICARUS project has received funding from the European Union's H2020 Framework Programme under grant agreement No - 690105


Agent Based
Modelling
integration of
determinants
Demographic & socioeconomic
Personal exposure
Artificial societies
from the bottom up
Heterogeneity
emergent behaviour
improved exposure assessment
vulnerable population
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Thank you!