ERA ENVHEALTH Open Conference

Air quality, exposure and health of vulnerable groups

Carlos Borrego, Joana Ferreira, Sandra Rafael, Hélder Relvas

universidade de aveiro
theoria poiesis praxis

11 Sept 2018 | Berlin, Germany

world population: how are our cities today?

world population (% living in cities)

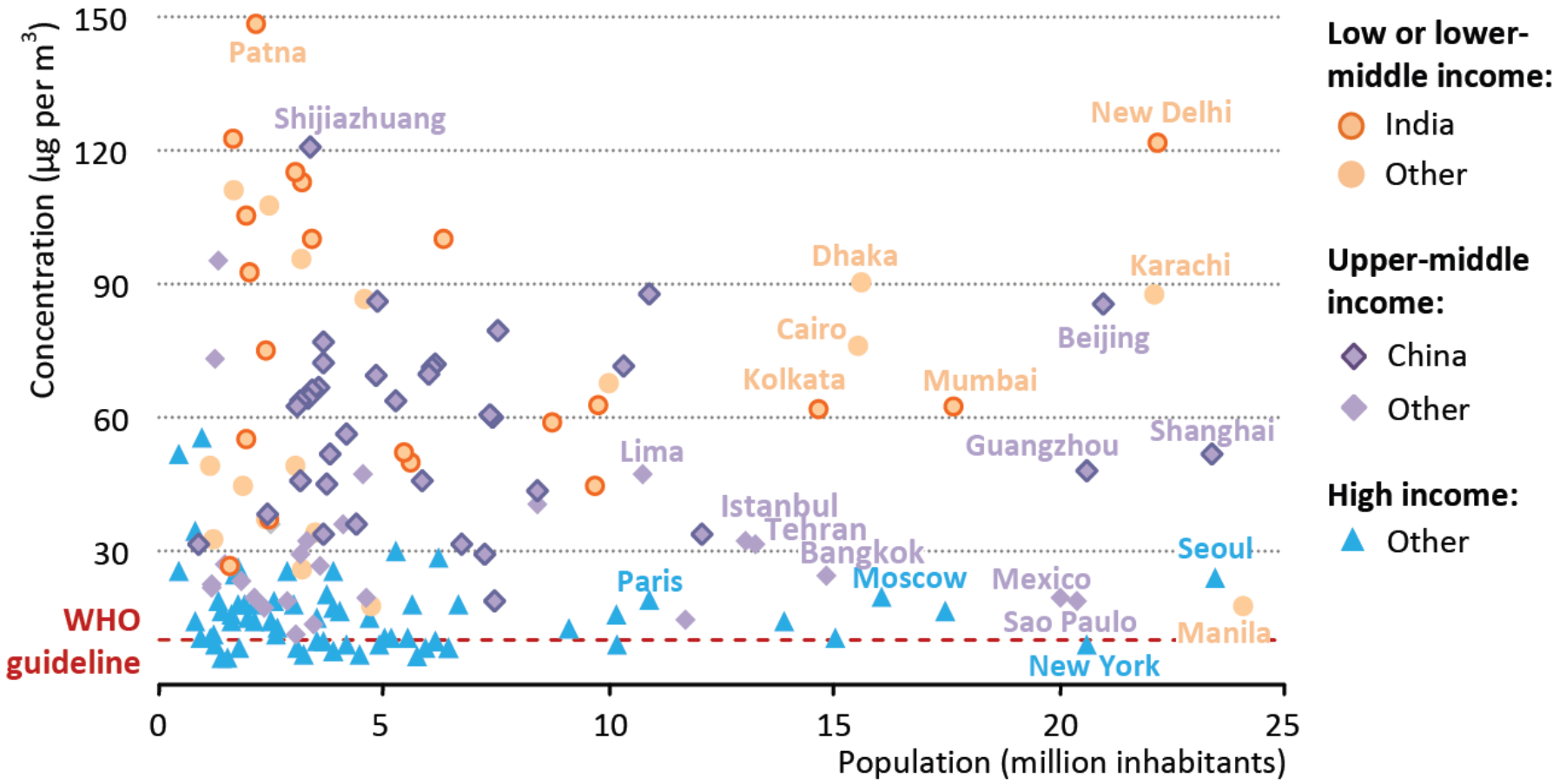
- **In 1900: < 2 billions (14%)**
- **In 2015: > 7 billions (50%)**

  In Europe we are: 75%
- **In 2030: ≈ 9 billions (60%)**


one of the major challenges and threats to urban sustainability and welfare is air pollution
Ozone
Particulate Matter
PM10 and PM2.5

Air pollution

Average annual outdoor PM2.5 concentrations in selected urban areas



Sources: WHO (2016) Global Urban Ambient Air Pollution Database; Demographia (2015) for population; country groups per income based on World Bank (2016).

Air pollution

In the last years, emissions from motorized vehicles and large point sources have been reduced…

… however, urban areas continue to show increasing signs of environmental stress

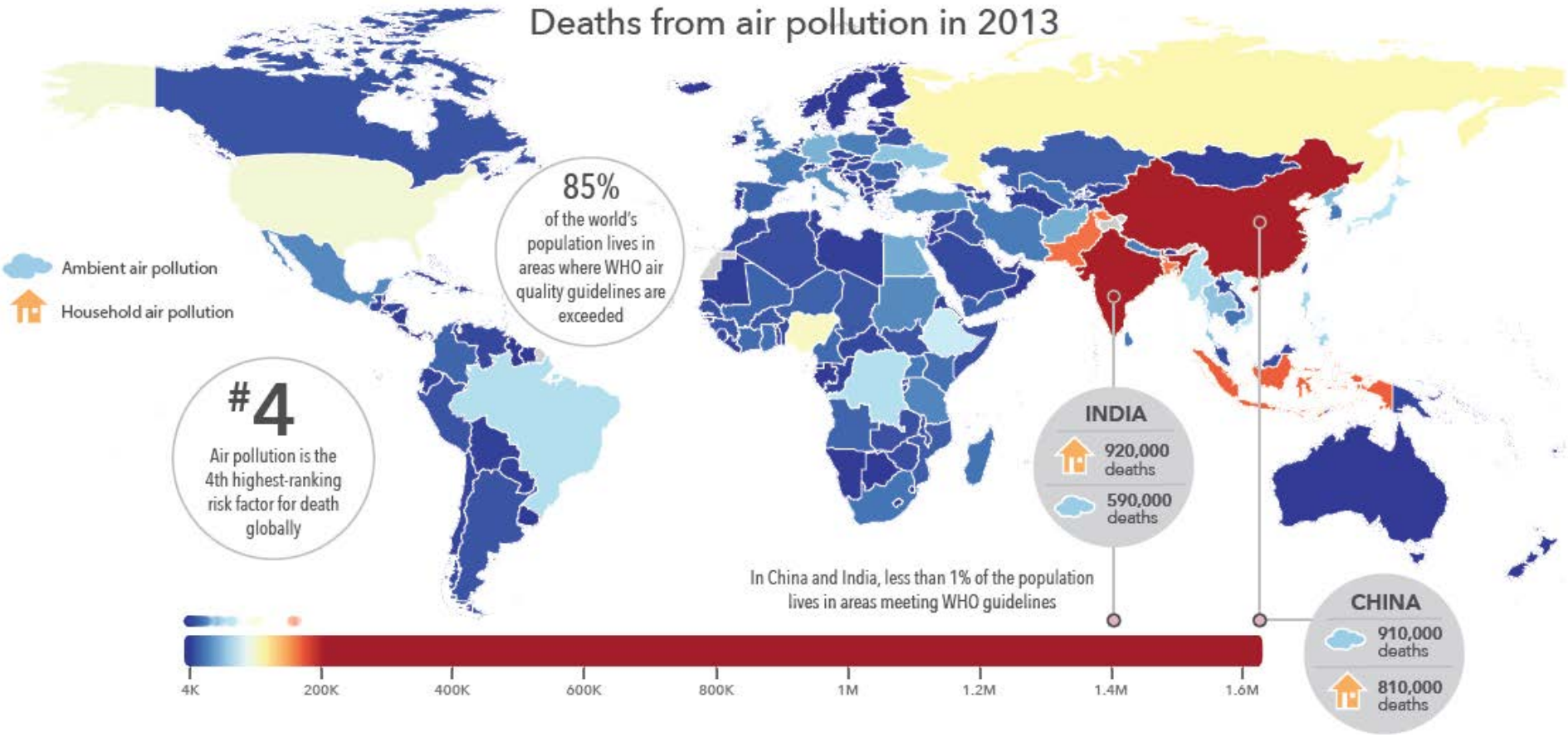
Worldwide: ± 1.5 billion people (25% of world population) are exposed to excessive concentrations of gaseous and particulate pollutants.

(World Health Organization)

In Europe: loss of 200 million working days per year due to diseases related to air pollution.

(European Environment Agency)

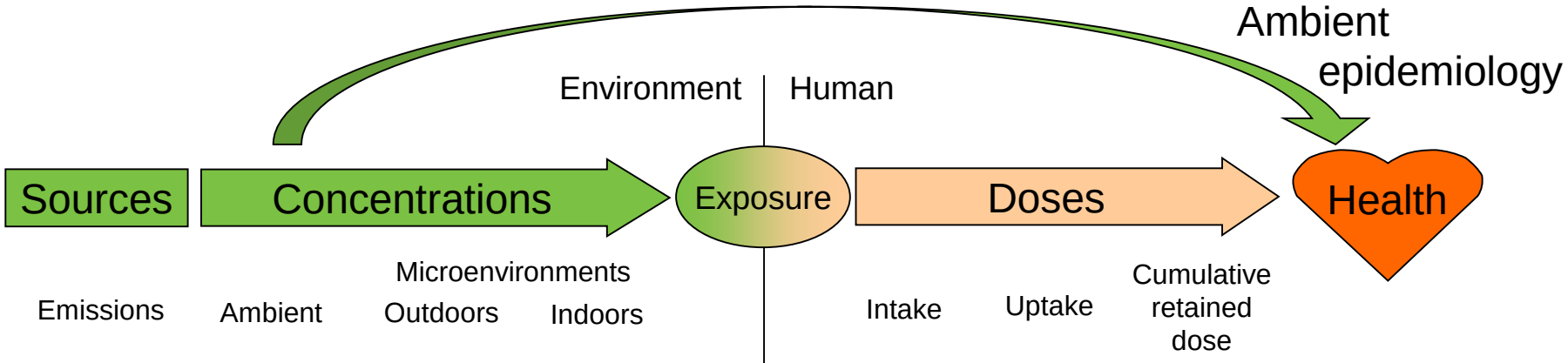
Air pollution & Health



Air pollution is the fourth highest risk factor for death globally and by far the leading environmental risk factor for disease

Air pollution & Health

exposure and effect chain



Atmospheric emissions — pollutants released to the atmosphere

Air pollutant concentrations — atmosphere characteristic depending on spatial and temporal patterns

Human exposure — interaction between air pollutant and the individual in a specific environment

Dose — pollutant intake through a physical barrier (skin, ingestion, inhalation)

?

how to get **Human Exposure**?

Direct - **measurements**

Indirect - **modelling**

$$\text{exposure}_i = \sum_{j=1}^{n} C_j t_{i,j}$$

Microenvironment Approach

$$\text{dose}_i = C_j * t_{i,j} * V_{i,j}$$

i: individual

j: microenvironment

C_j: pollutant concentration in microenvironment j

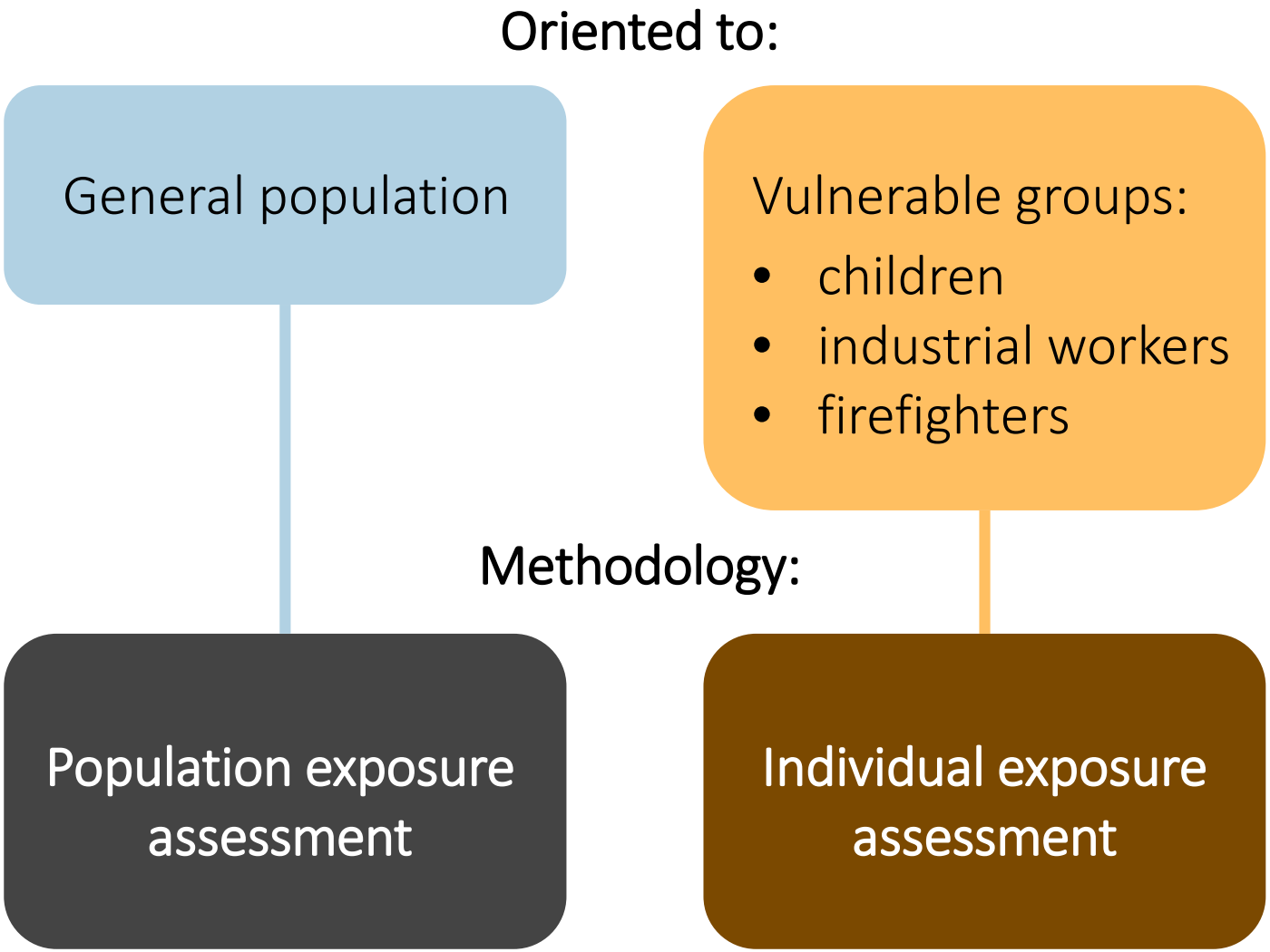
$t_{i,j}$: time individual i spends in microenvironment j

$V_{i,j}$: rate of ventilation of individual i in microenvironment j

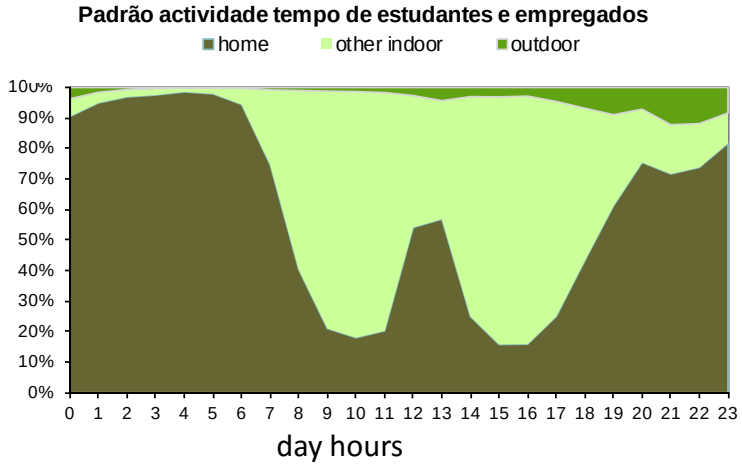
Concentration: air quality modelling and/or measurements

Time: statistical or individual time-activity profiles; GPS routing

Air pollution → Health research @ University of Aveiro



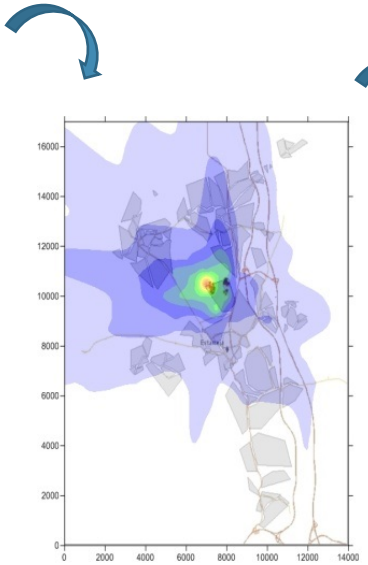
Population Exposure approach

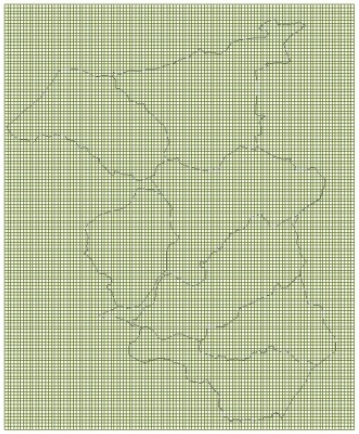


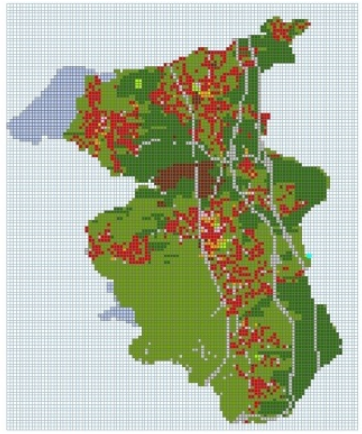
Time-activity patterns

↓

Population distribution for each hour of day







\+

Air pollutant concentrations in each microenvironment at each hour of day

(air quality simulations)

=

Population Exposure

Population Exposure in Porto region

exposure modelling at regional scale (for students over 15 and employees)

PM10 annual average - simulated outdoor concentrations

+

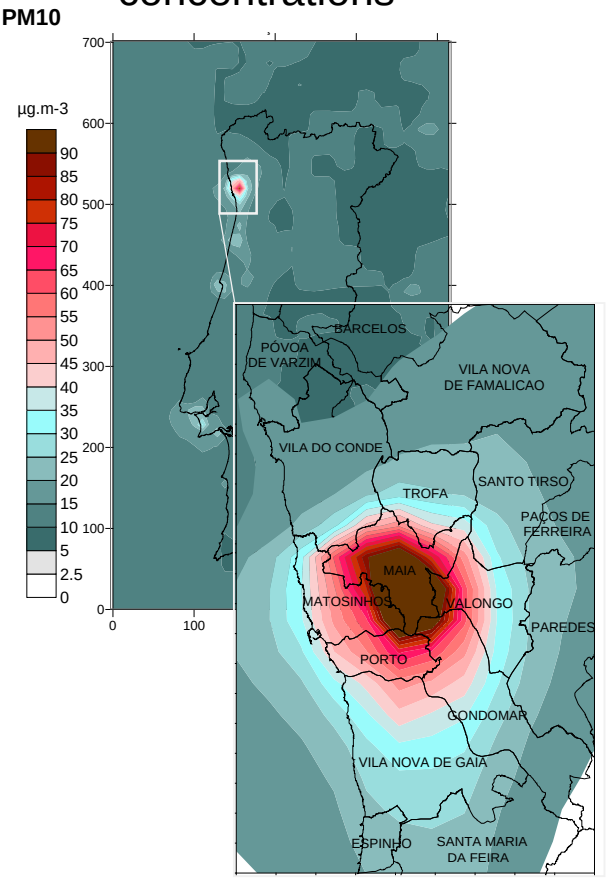
Employed population

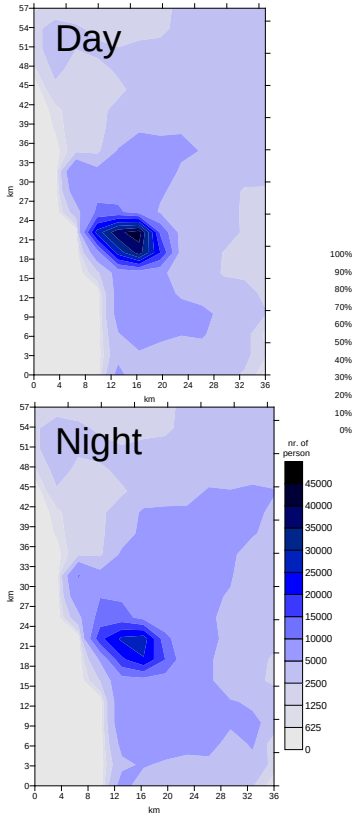
+

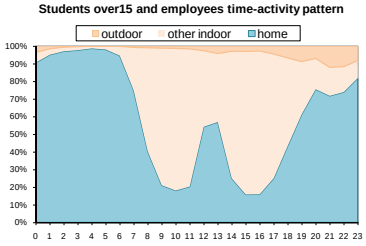
In / Out relations + Average population time activity patterns

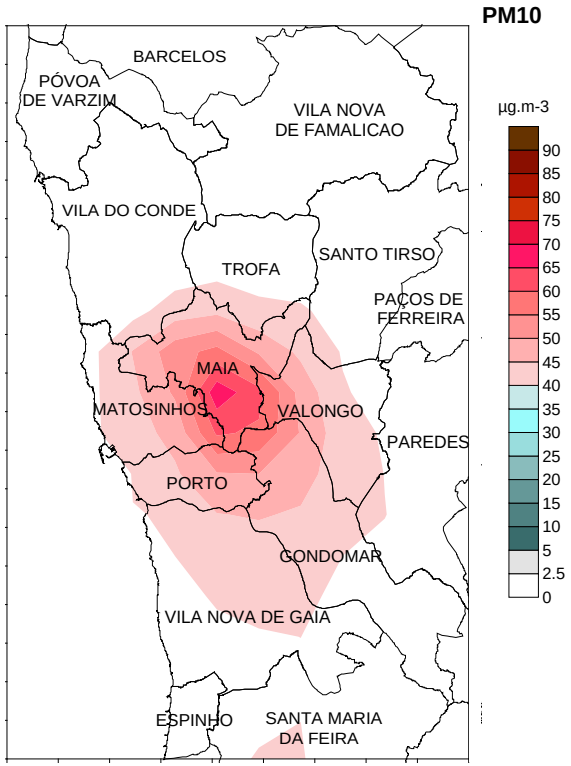
=

PM10 annual average Porto employee exposure









Population Exposure in Porto region

exposure modelling at regional scale (for students over 15 and employees)

PM10 annual average - simulated outdoor concentrations

+

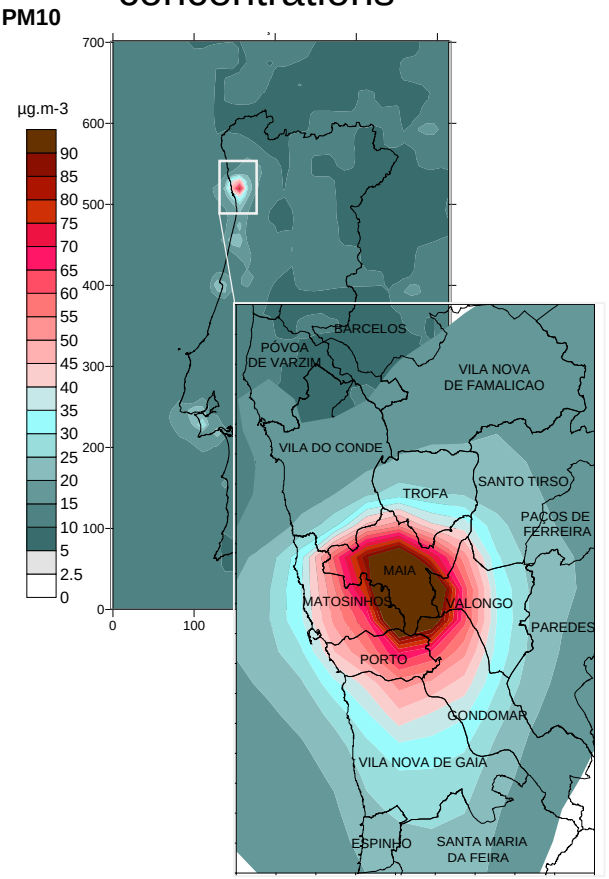
Employed population

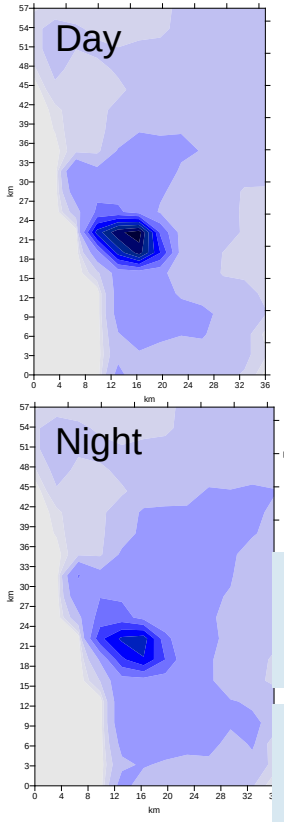
+

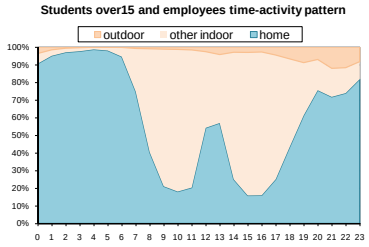
In / Out relations + Average population time activity patterns

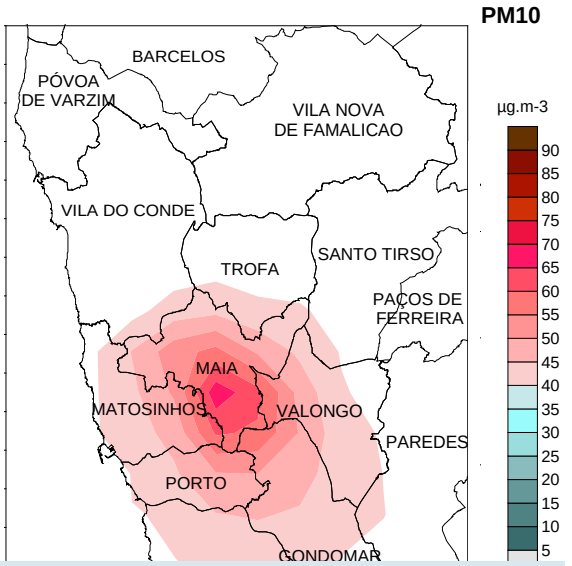
=

PM10 annual average Porto employee exposure









high PM10 concentrations in Porto urban area, decrease with the radius distance to the city

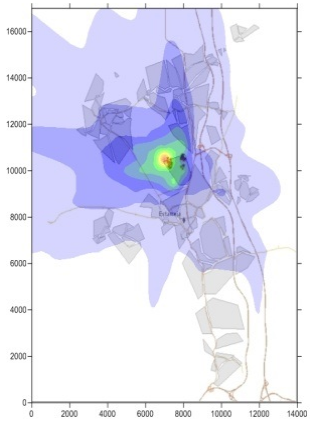
exposure levels follow the concentration field, however with lower levels

Individual Exposure approach

Individual time-activity profiles

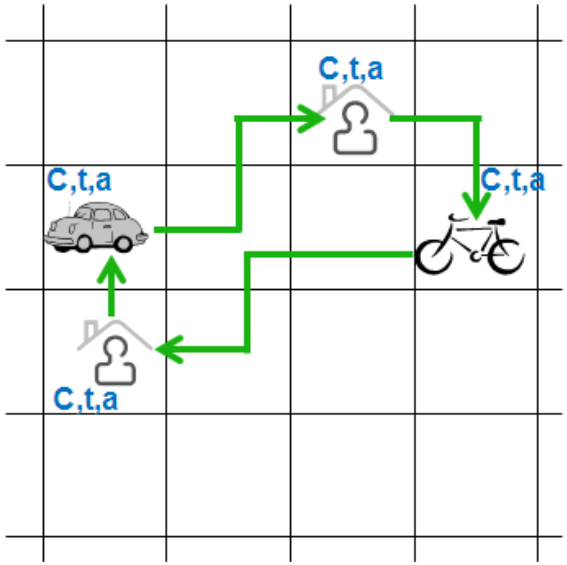
OR

GPS tracking



Air pollutant concentrations in each microenvironment at each hour of day

Individual Exposure

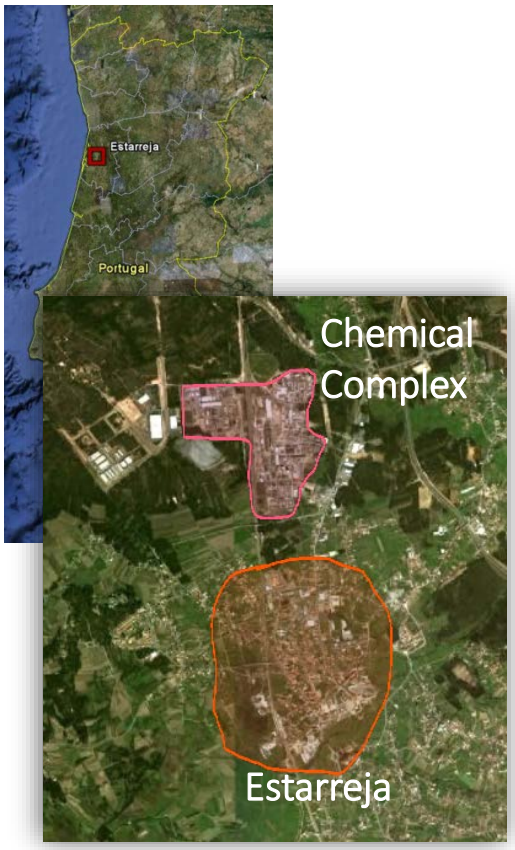


C: concentration
t: time
a: activity


Risk Group #1
Industrial workers

Industrial workers exposure to air pollution

Are industrial workers more exposed to air pollution?
Do they have worst health condition?



Study region characterization - air pollutants **emissions** and **air quality**

→ **Air quality** and **exposure** estimation

→ Human health characterization (industrial **workers** and **population**)

2 campaigns – Spring 2011, Winter 2012:

- Daily activity characterization
- Medical evaluation

Industrial workers exposure to air pollution

Time-activity profile for a typical week (7 days)

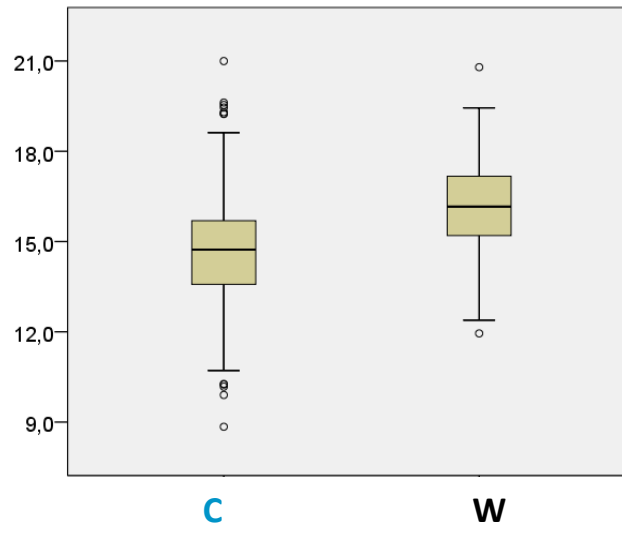
		N	Mean (%)	Std. Deviation	p
totalin	w	185	**87.5**	7.3	<0.05
	c	226	**90.8**	**8.6**	
totalout	w	185	**10.2**	7.3	<0.05
	c	226	**6.4**	7.9	
transport	w	185	**2.3**	1.5	
	c	226	**2.7**	**3.6**	
work	w	185	**24.6**	4.4	<0.05
	c	226	**19.1**	**8.4**	
sport	w	185	**1.1**	1.3	
	c	226	**1.3**	**2.3**	

- Population spends 90% of their time indoors
- Population is sedentary (1% of their time is dedicated to sport: 15 $min.day^{-1}$)
- No significant difference between the 2 campaigns: winter and spring

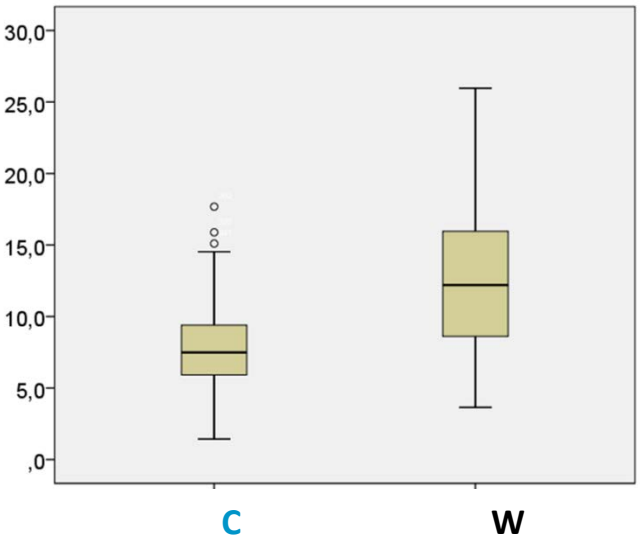
Industrial workers exposure to air pollution

Individual exposure

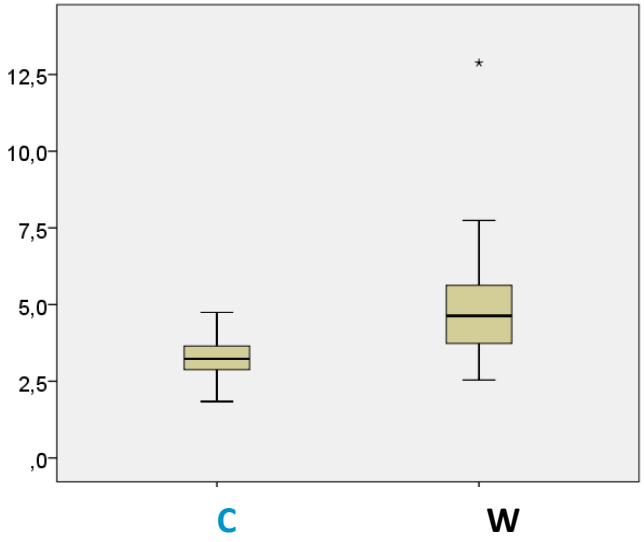
PM10 ($\mu g.m^{-3}.day^{-1}$)



NOx ($\mu g.m^{-3}.day^{-1}$)



SO_2 ($\mu g.m^{-3}.day^{-1}$)



- High variability of exposure values
- Low exposures
- Workers more exposed than control group (statistically significant differences)

Risk Group #2 Firefighters

Firefighters exposure to air pollution

What is the effect of forest fire smoke on firefighters health in Portugal?

Monitoring of firefighters exposure to air pollutants during experimental fires and wildfires

2008, 2009 and 2010 fire seasons

Experimental fires in 2008 and 2009

Meteorological and air quality measurements → Meteo parameters, PM2.5, CO, VOC and NO_2 concentrations ← Air quality limit values

Individual exposure monitoring → Firefighters equipped with personal monitoring devices for CO, VOC, PM2.5 and NO_2 ← Occupational exposure standards (OES)

Medical tests → Respiratory function through different spirometry parameters in 2008 and 2010;

NO, CO and COHb (carboxyhemoglobin) in the exhaled breath before and after every firefighting

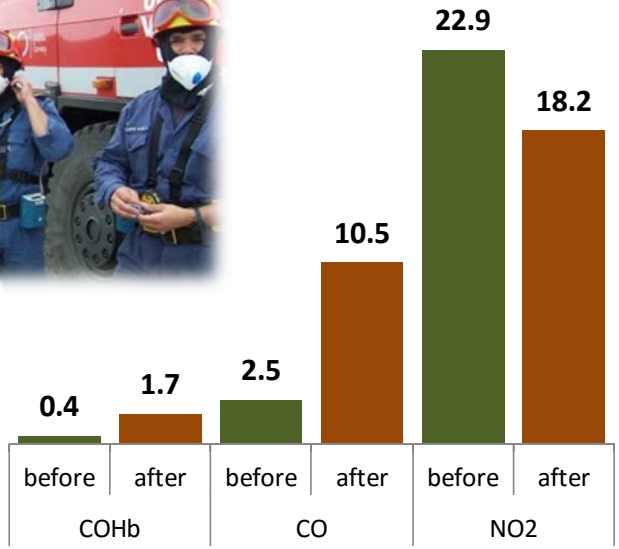
Firefighters exposure to air pollution

Air Quality → Exposure

	experimental fires	wildfires
Exposure	•OES surpassed for CO and NO_2	•exceedances of OES for CO •PM2.5 and NO_2 no exceedances

OES – occupational exposure standards

Exposure → Health Effects



firefighters can be exposed to high concentrations of CO, NO_2 and VOC, with potential harmful health effects

↗ CO exposure → ↗ exhaled CO

↗ NO_2 exposure → ↘ exhaled NO

inhibit the enzyme NO synthase

Risk Group #3 Children

Schoolchildren exposure to air pollution

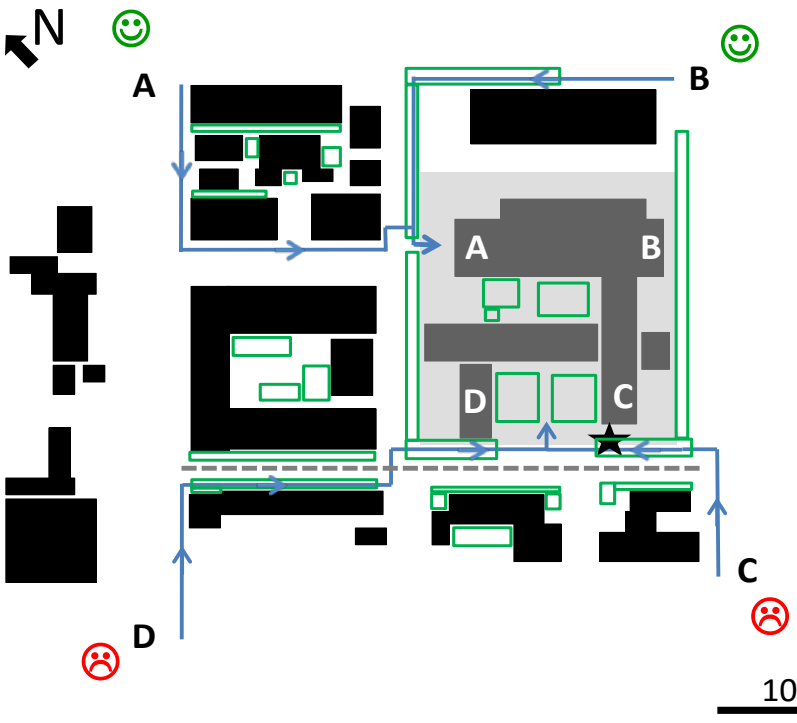
Aveiro town, Portugal

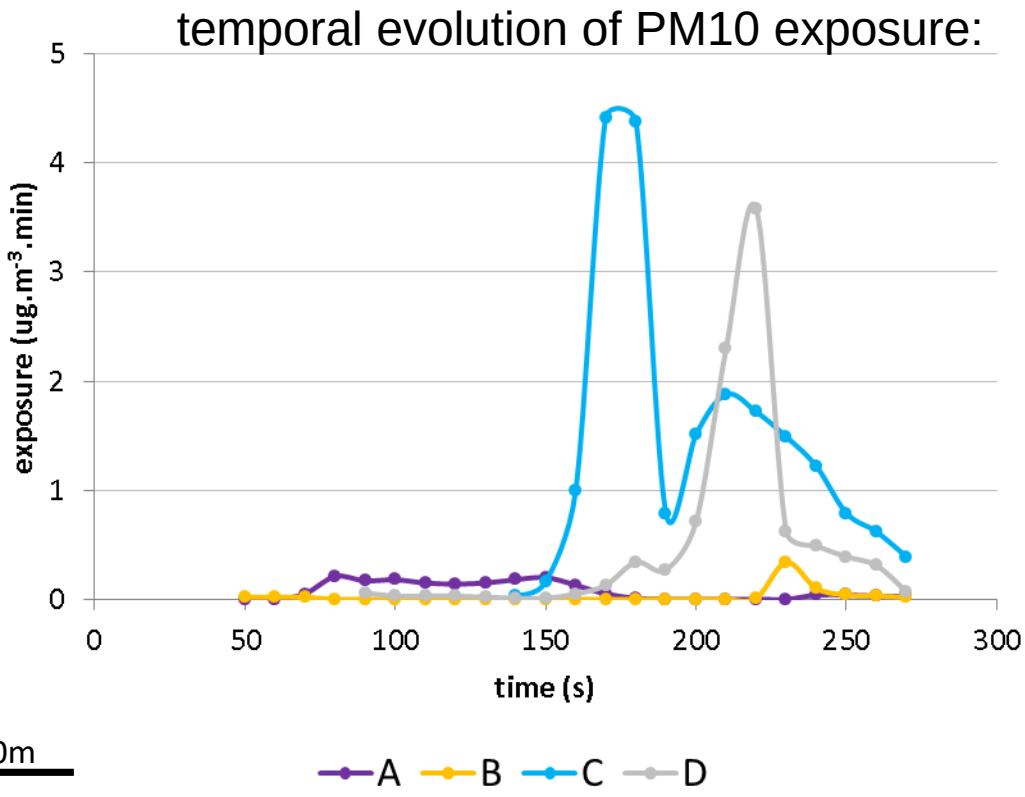
Study area **School**

- 8.4 ha with residential buildings and a school
- one of the most important thoroughfares of the town (“25 de Abril” Av.)
- main Avenue flanked by **dense tall trees**

Schoolchildren exposure to air pollution

human exposure during the walk to school

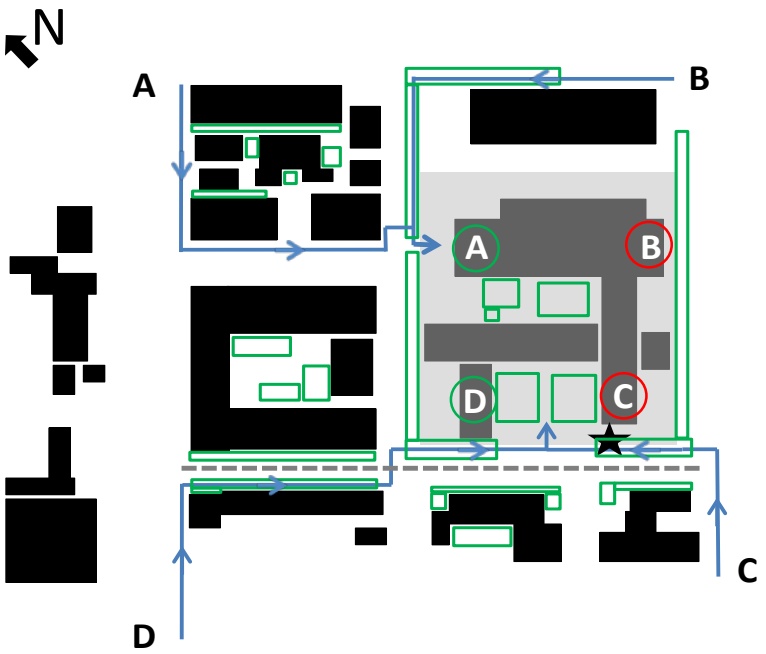


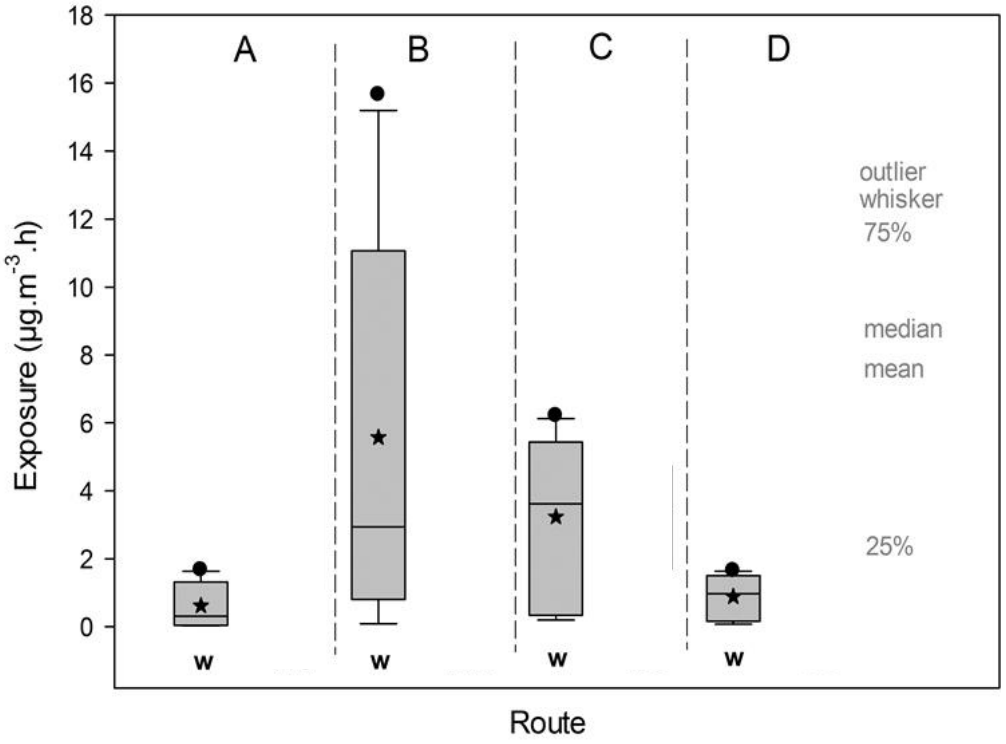


- PM10 exposure varies significantly with the route
- Children coming from South (**C** and **D**) have higher exposures on their walk to school

Schoolchildren exposure to air pollution

human exposure during the morning (outdoor + indoor)

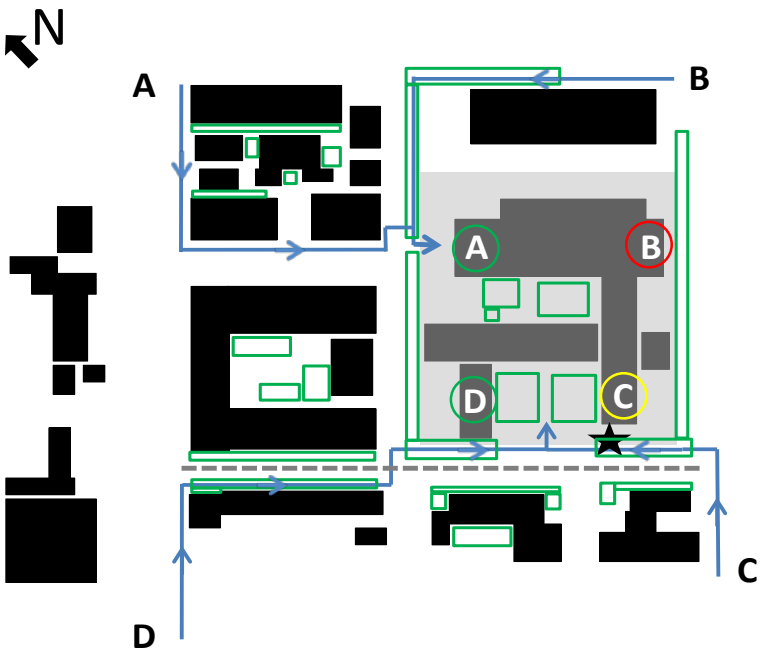


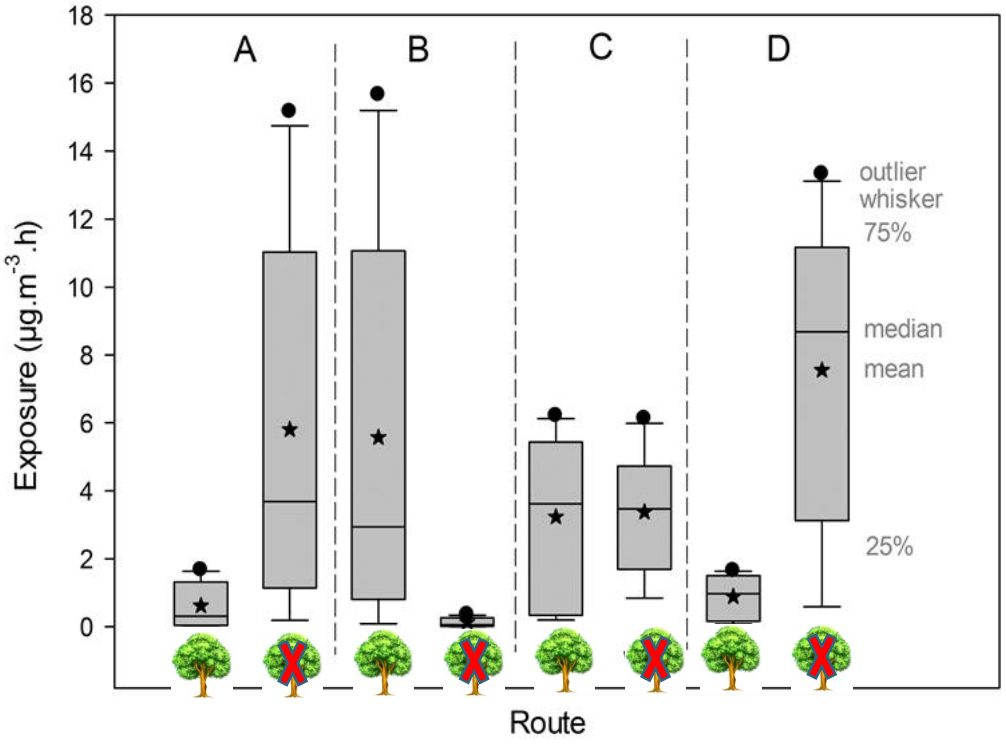


- PM10 mean exposure varies significantly (range: 0.6 – 5.6 µg.m^{-3}.h^{-1})
- Children (**A** and **D**) staying in classrooms on the west façade show lower exposure

Schoolchildren exposure to air pollution

the effect of trees





- when trees are introduced, a significant benefit is observed for children **A** and **D**, while for **B** the opposite occurs. No significant differences are found for **C**.

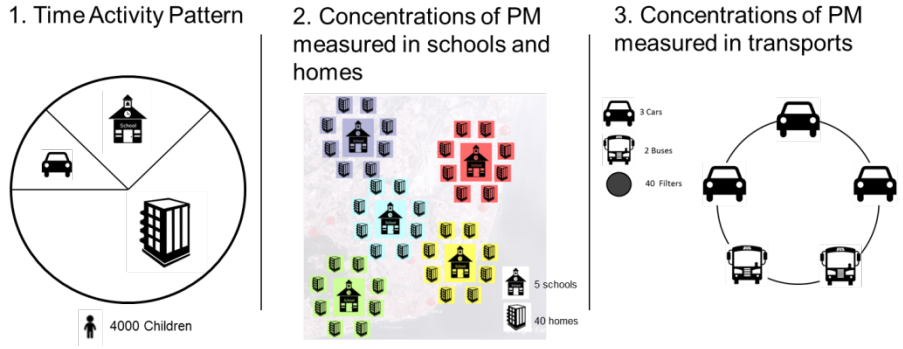
Schoolchildren exposure to air pollution

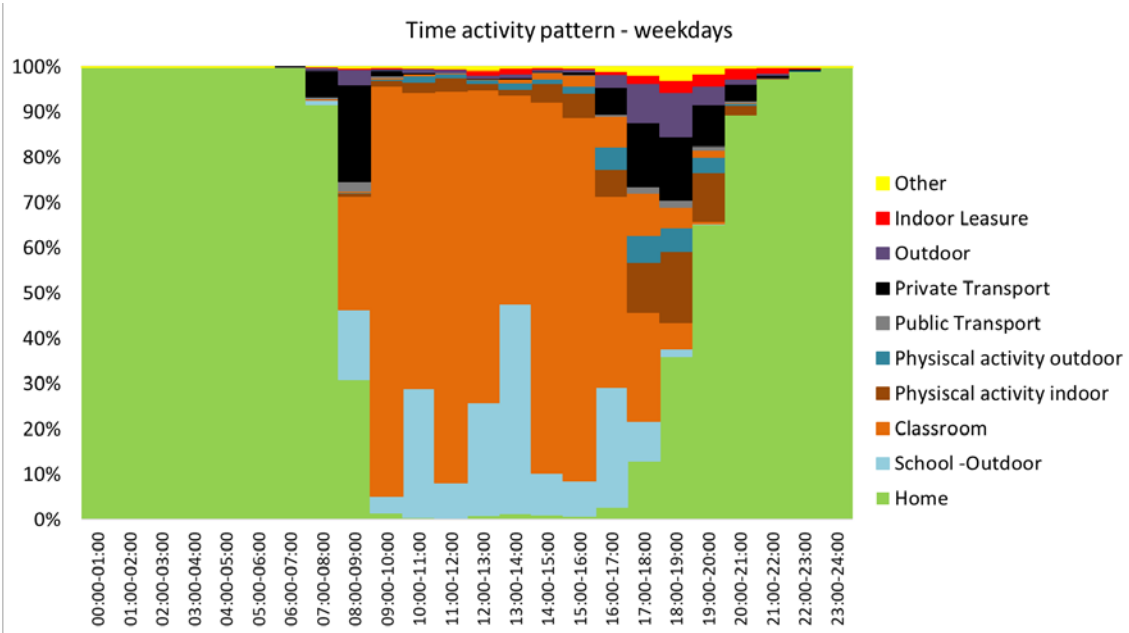
LIFEINDEXAIR

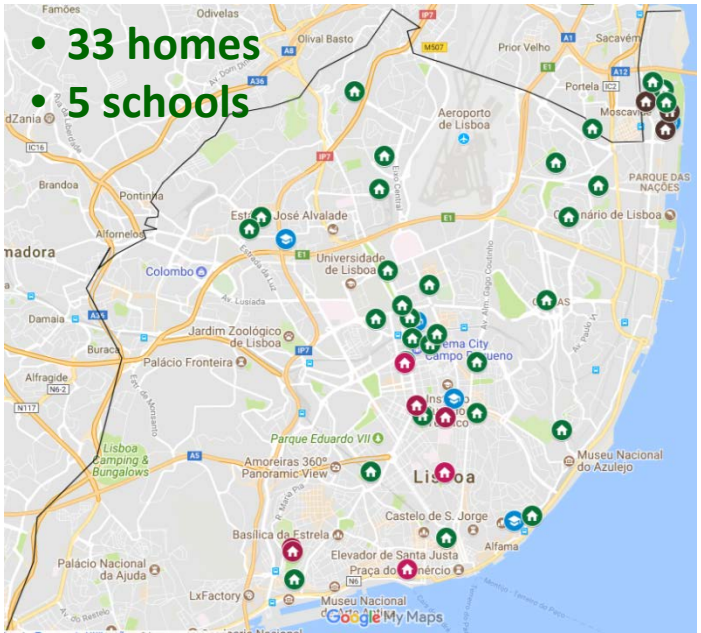
PROJECT FUNDED BY EUROPEAN UNION

Lisbon metropolitan area

Modelling Individual Exposure to PM



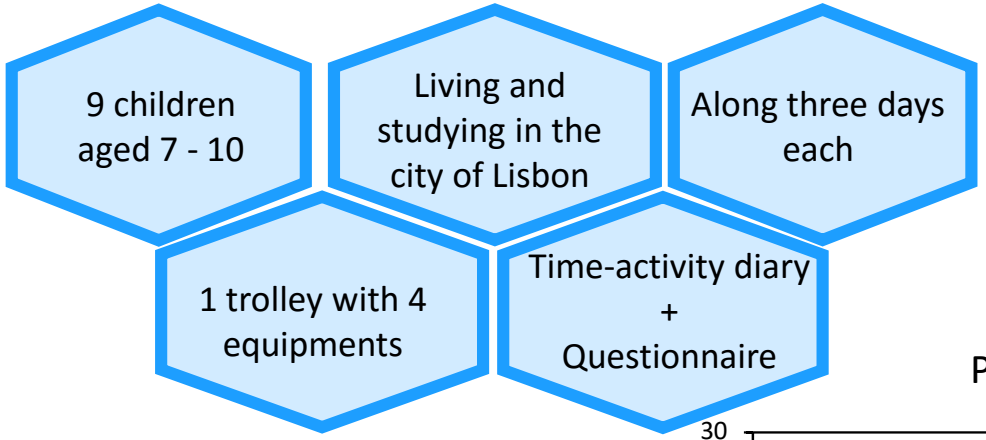


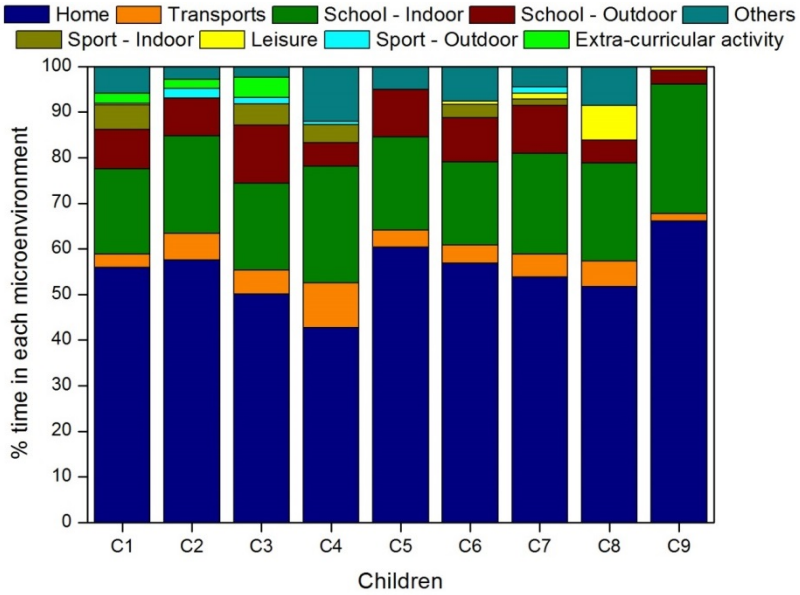


Schoolchildren exposure to air pollution

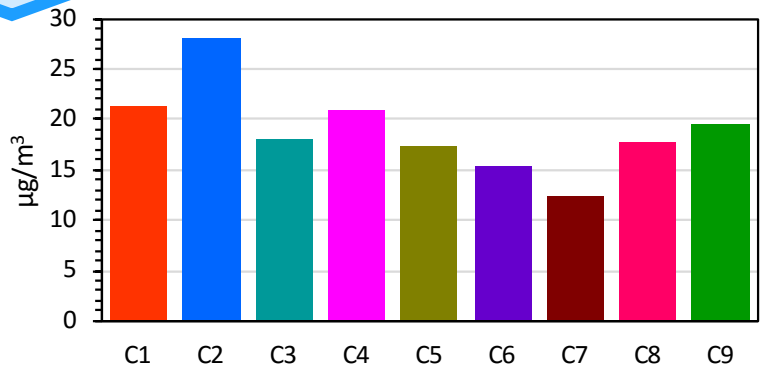
Lisbon metropolitan area

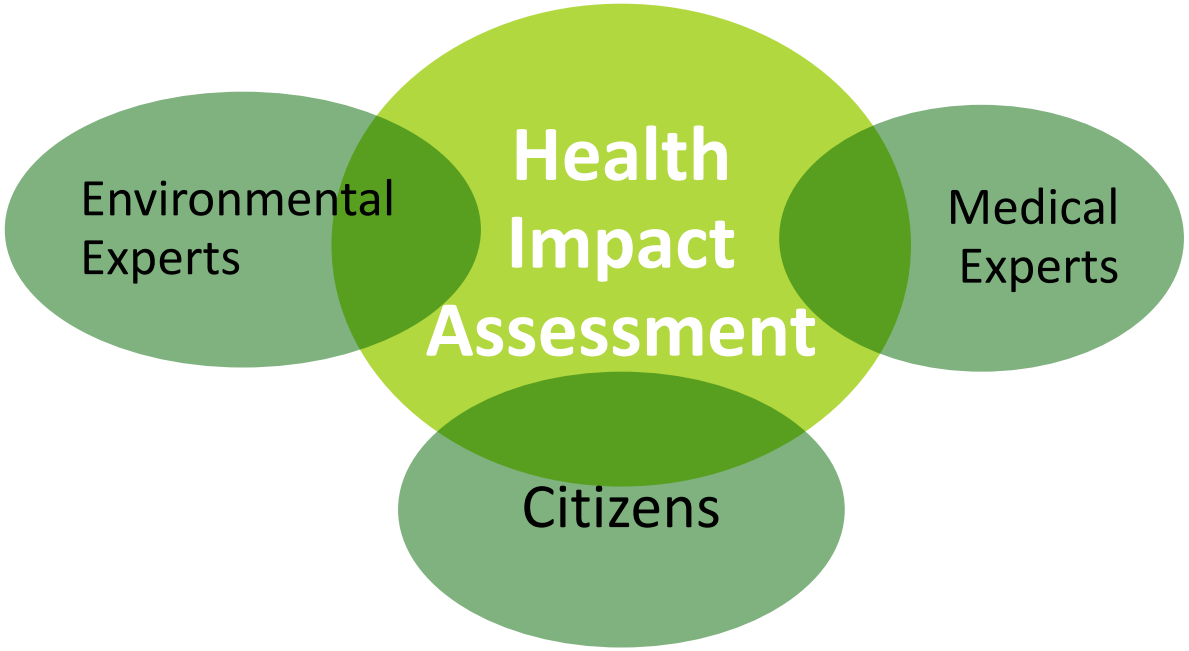
Monitoring Individual Exposure to PM





PM2.5





Cooperation between experts (environment and health field) and citizens towards cleaner and healthier cities should be considered in Environmental Health Impact Assessments.

Thank You

Carlos Borrego
University of Aveiro