OPC - Climate Change and Health: Challenges and Opportunities for Luxembourg

07/07/2026 – Workshop D

LONGEVITY AND HEALTHY LIFESTYLES FOR A CLIMATE-FRIENDLY AND CLIMATE RESILIENT LUXEMBOURG

WORKSHOP D

Camille Perchoux

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CLIMATE CHANGE, CITIES AND HEALTH

CITIES & CLIMATE CHANGE

Growing urbanisation trend :

- **75% of Europeans live in cities**
- + 2.5 Billion urban residents by 2050 (UN, DESA)

Increasing urban share in **GHG emission**:

- Cities account for **~70% of global energy-related CO_2 emissions** (IPCC AR6 WGIII)

CITIES & HEALTH

Urban environments, and related **daily exposures**, shape:

- Health behaviors
- Population health
- Socio-spatial inequalities in health

Need for integrated, climate-resilient and health-promoting urban strategies

A CLIMATE FRIENDLY AND RESILIENT LUXEMBOURG

THE GREEN CITY

Brings nature into the city

THE ACTIVE CITY

Supports mobility and active mobility

THE DENSE CITY

Maximizes access to amenities

CASE STUDIES

Source: Adapted from Roe, J., & McCay, L. (2021). *Restorative Cities: urban design for mental health and wellbeing*. Bloomsbury Publishing.

THE DENSE CITY & HEALTH

- Case 1: Urban densification and its impact on cardiometabolic heath
- Case 2: Densifying, but how ? Third places and their impact on chronic stress

THE DENSE CITY: MECANISMS AT PLAY

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THE DENSE CITY: MECANISMS AT PLAY

URBAN SPRAWL

- Car dependency
- Increased greenhouse gas and air pollutant emissions
- Unequal access to healthy resources and services
- Greater risk of social isolation

AI generated images

THE DENSE CITY: MECANISMS AT PLAY

URBAN SPRAWL

- Car dependency
- Increased greenhouse gas and air pollutant emissions
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URBAN DENSIFICATION

- Improved walkability and active mobility
- Lower transport-related emissions
- Better access to healthy ressources and services – Increased ressource efficiency
- Greater opportunities for social interaction

AI generated images

CASE 1: IMPACTS ON CARDIOMETABOLIC HEALTH

Cardio metabolic diseases account for **73% of global deaths** (2020)

Metabolic Syndrome (MetS) is associated with a **high risk** of cardio metabolic diseases

Prevalence of the MetS in Western populations = **20 – 30%**

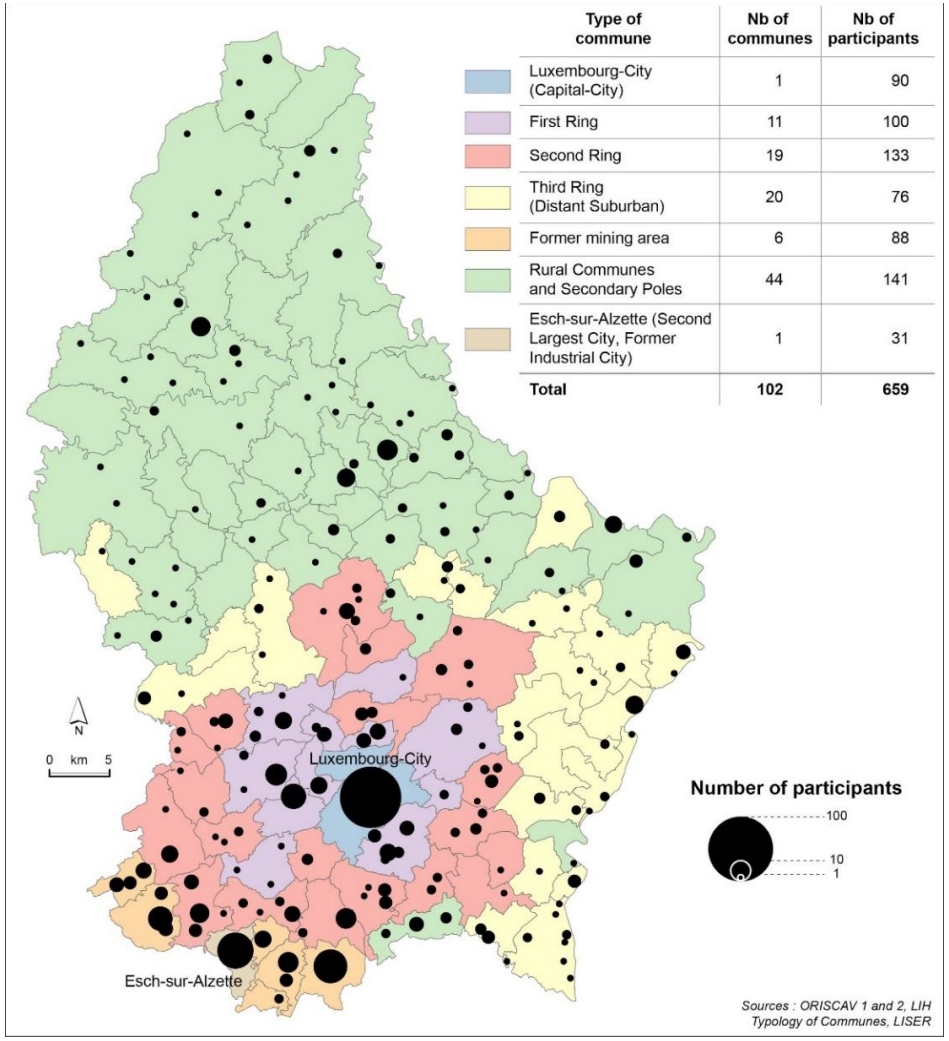
Prevalence of the MetS in Luxembourg > 25% (Alkerwi *et al*. 2011)

URBAN DENSIFICATION & THE METABOLIC SYNDROME

A LUXEMBOURG CASE STUDY

ORISCAV-LUX 1 (2007-09) & ORISCAV-LUX 2 (2016-17)

N= 659 participants in both waves 1 & 2



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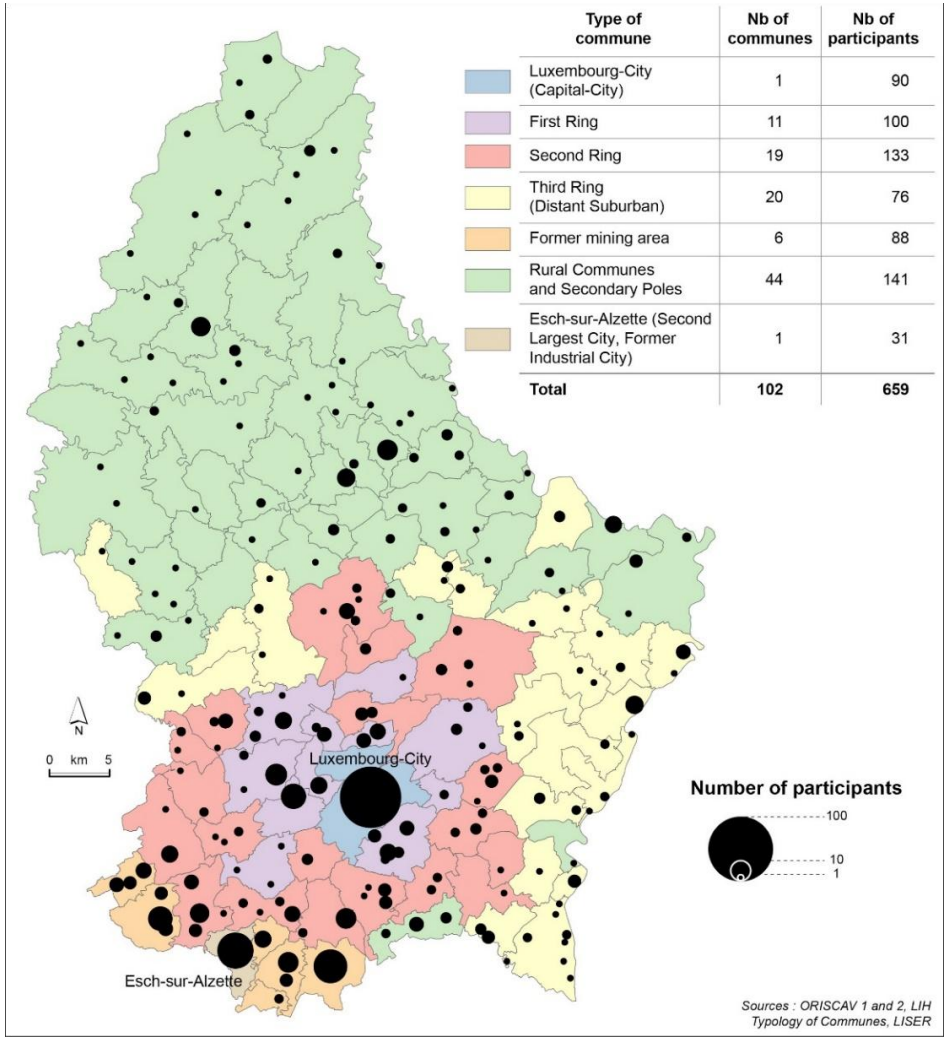
METABOLIC SYNDROME

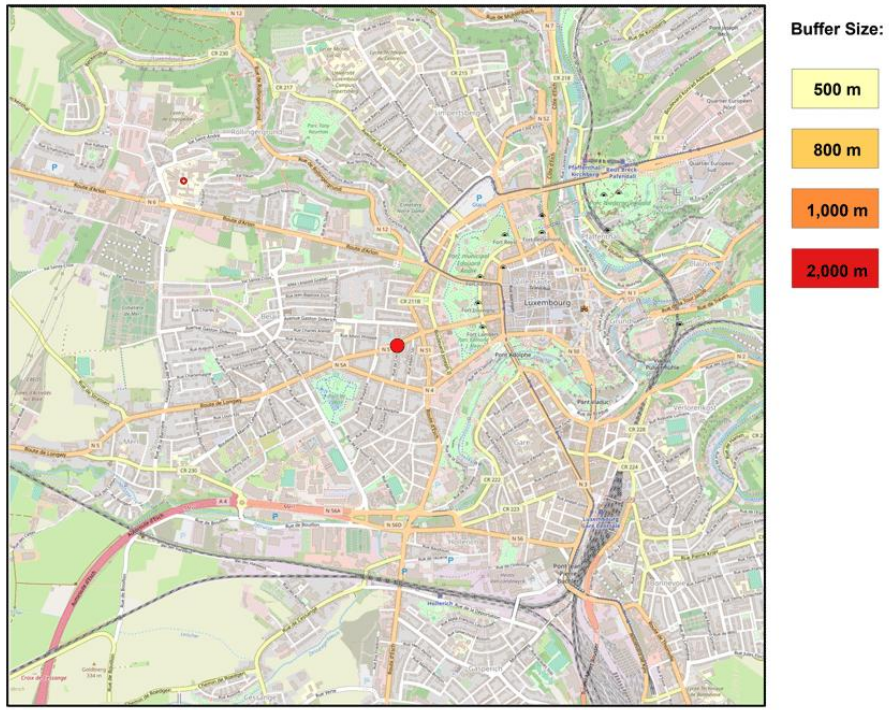
Continuous score to quantify the spectrum of metabolic abnormalities *(Soldatovic et al., 2016)*



LUXEMBOURG INSTITUTE OF HEALTH

URBAN DENSIFICATION & THE METABOLIC SYNDROME

URBAN DENSIFICATION



Index of urban densification (UDI)

DESIGN

Street characteristics

Connectivity of the road/pedestrian network

DIVERSITY

Land use mix index

Land use **categories**

PUBLIC TRANSPORTATION

Access & density of **Bus** stops, **Train** stations, Public **bike** sharing stations

DENSITY

Density of Amenities

Services (Bank, Post, tec.), **Health** (Doctors), **Education** (Schools), **Cultural** (Cinemas, Libraries, etc.), **Sport** (Swimming pools, Sports fields, etc.), **Food** (supermarkets, fast foods, etc.)

Population density

URBAN DENSIFICATION & THE METABOLIC SYNDROME

n = 510

Mean age : 43.8 y
51% women
33% living in low neighbourhood SES

Increased Urban Densification over 10 years was associated with:

- **Higher risk** of developing the Metabolic Syndrome
- **Poorer cardiometabolic risk factors** (triglycerides, HDL-Cholesterol)

Models are controlled for baseline UDI, time, sex and country of birth, age, educational level, working status and marital status, neighbourhood SES (average housing price in the municipality), neighbourhood food environment (modified Retail Food Environment Index)

(Tharrey et al. 2023, Health and Place)

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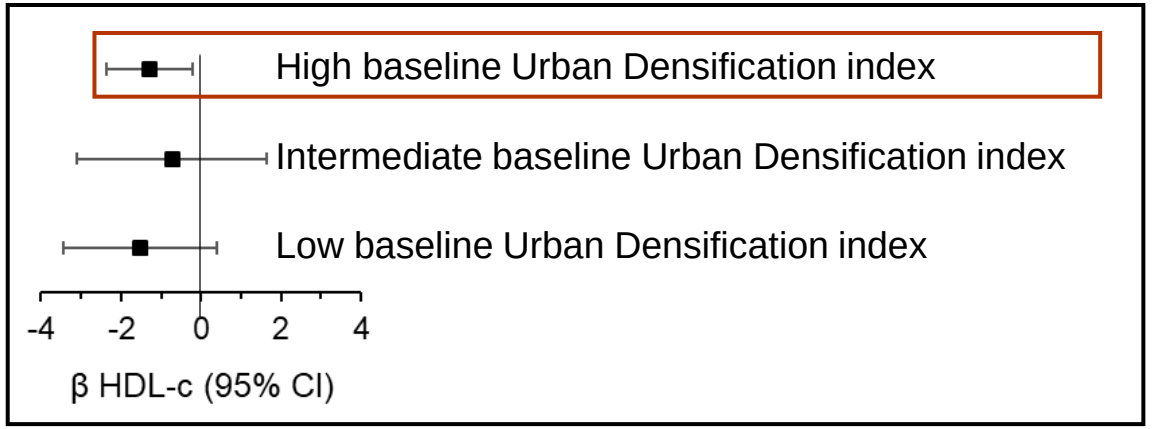
Who is the more vulnerable ?

Individuals living in neighbourhood with already high level of urban densification 10 years ago ***(for HDL-c only)***



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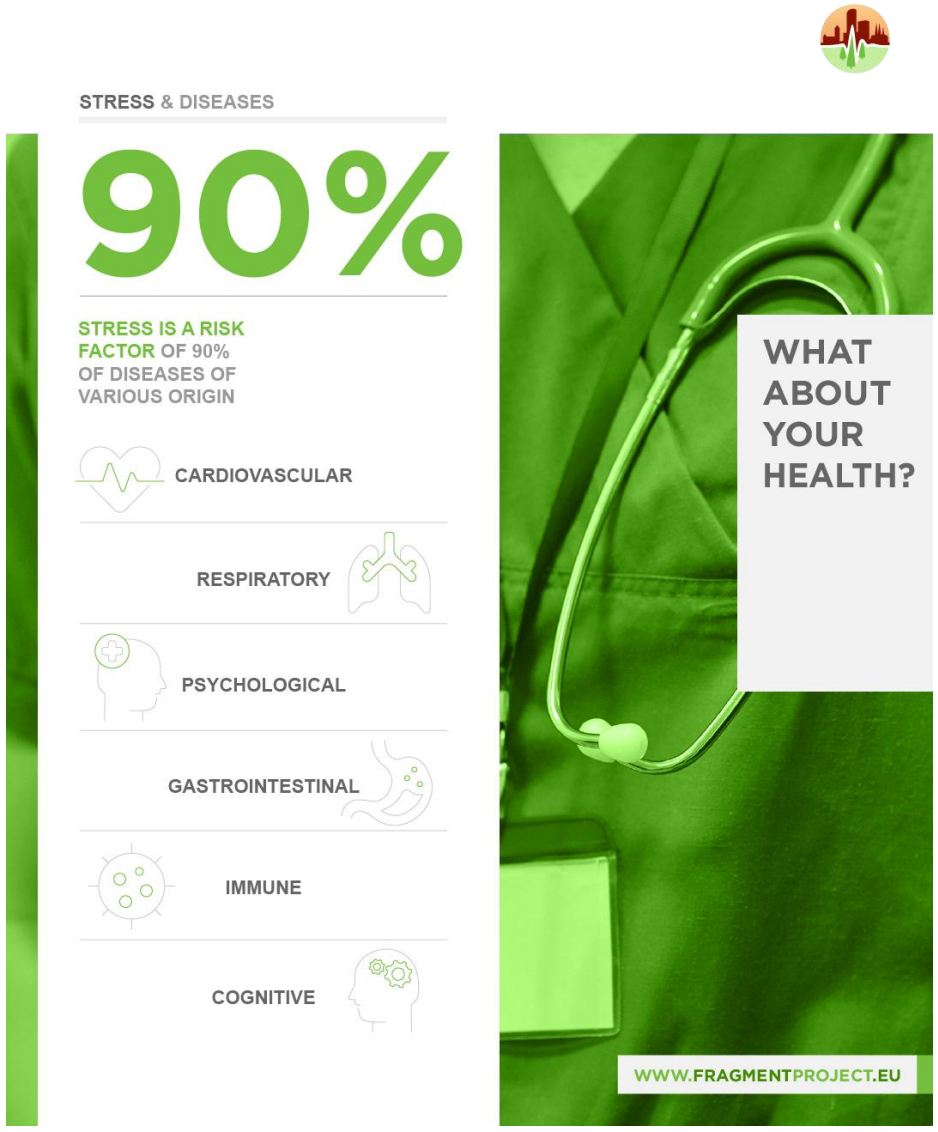
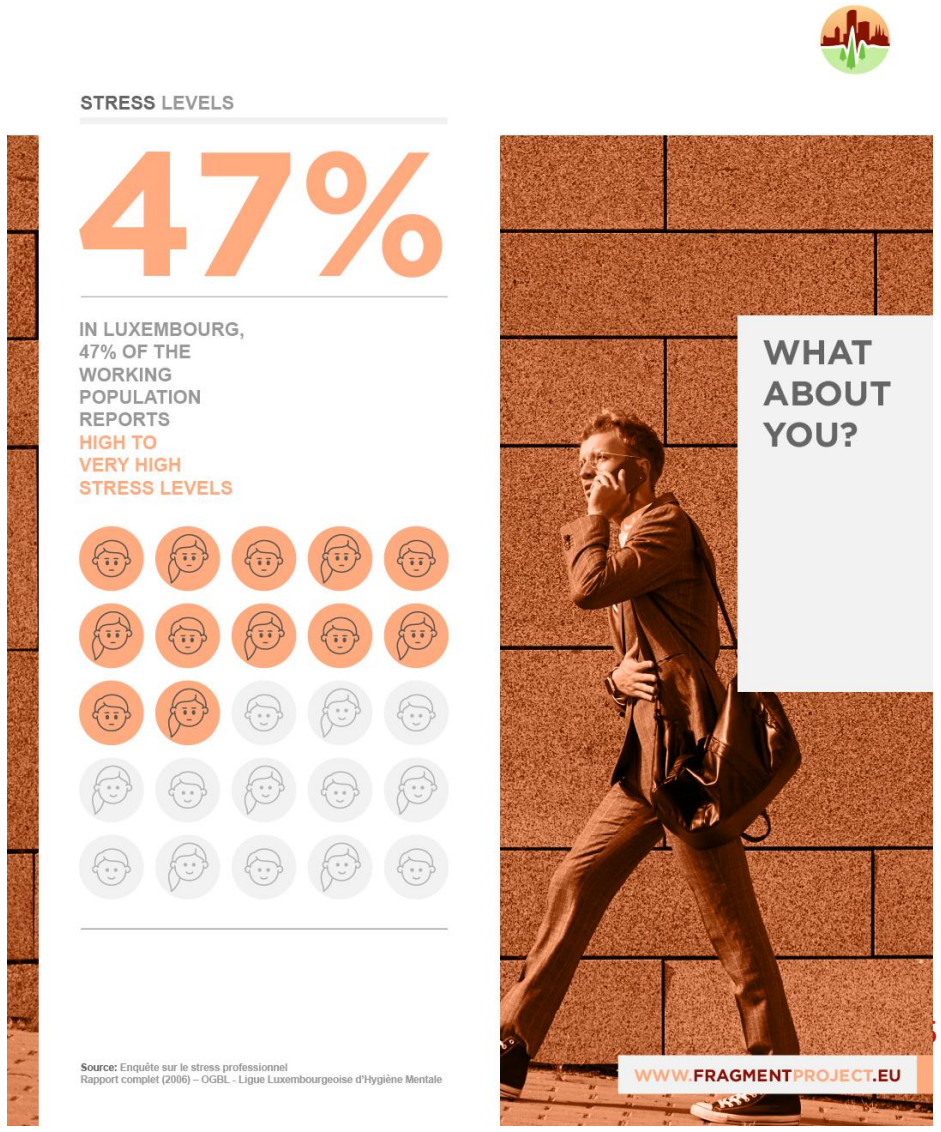
THE DENSE CITY & HEALTH

- Case 1: Urban densification and its impact on cardiometabolic heath
- Case 2: Densifying, but how ? Third places and their impact on chronic stress

CASE 2: IMPACT ON CHRONIC STRESS





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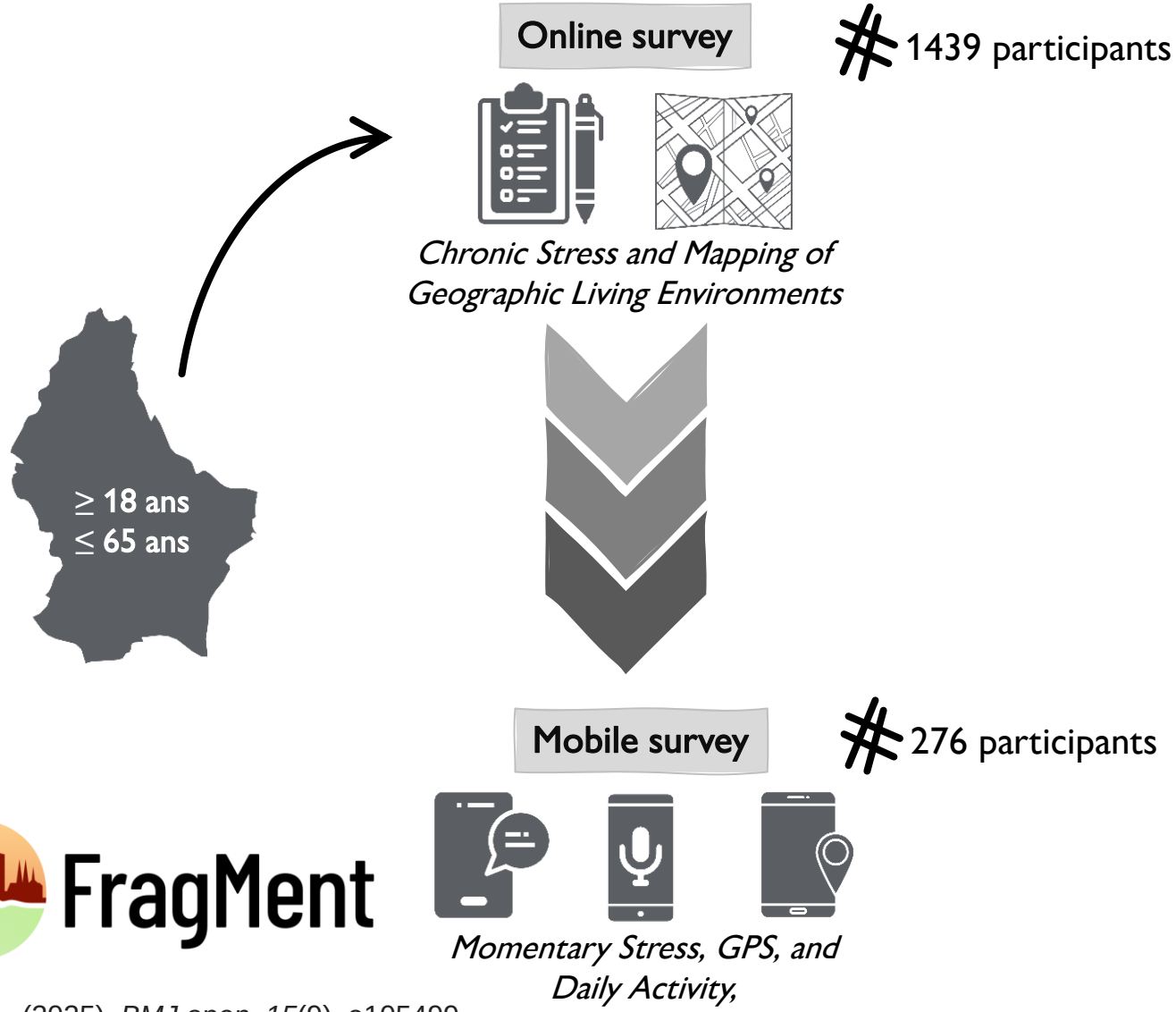
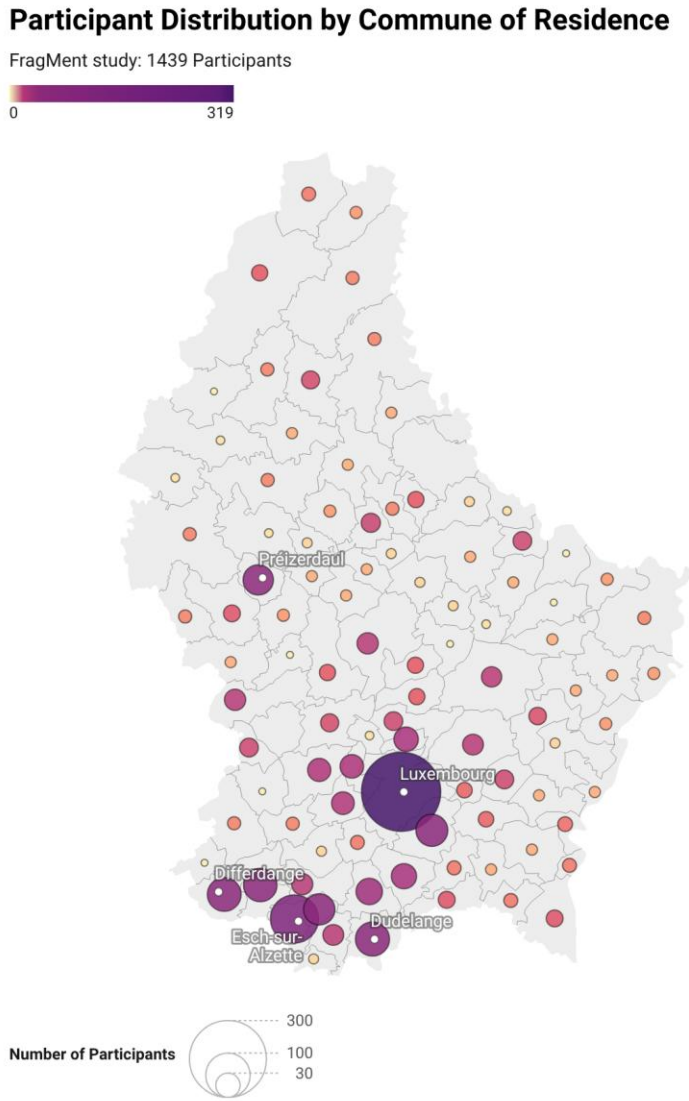
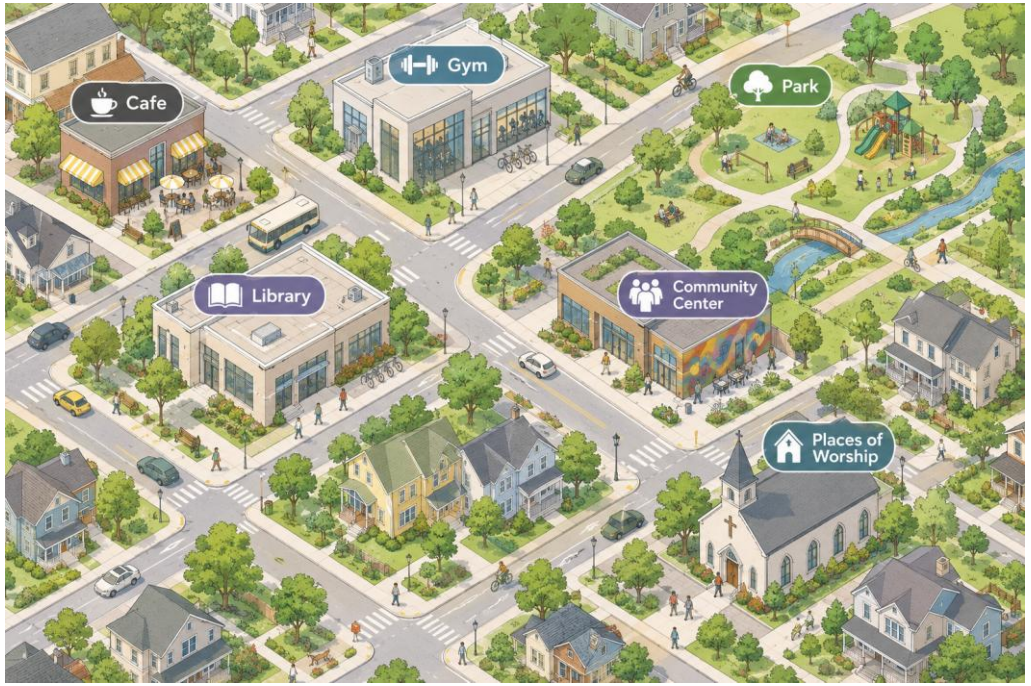




Perchoux, et al., (2025). *BMJ open*, *15*(9), e105499.

THIRD PLACES AND CHRONIC STRESS



1 in 5 participants have high chronic stress

What are "Third Places" ?

- **Informal,** and **public** spaces outside the home and workplace – where people can gather, relax, and connect without an agenda

The intuition: **these places *should* reduce stress** – but do they?

Missling, Klein, Fagherazzi, Chaix, Rocke, Perchoux (ongoing work) Not All Third Places Are Equally restorative: Type-Specific Associations Between Activity-Space based Exposure to Third Places and Chronic Stress

NOT ALL THIRD PLACES ARE THE SAME

Function *What is the primary purpose?*	**Financial accessibility** *What is the cost to use?*	**Spatial context** *What is the physical setting?*
Commercial *Cafes, bars, shops*	Open Access *Free, no spending expectation*	Outdoor *Parks, plazas, waterfronts*
Leisure *Gyms, cultural centers*	Implicit Transactional *Encouraged to spend*	Hybrid *Markets*
Community *Libraries, places of worship*	Fee-based *Spending required*	Indoor *Restaurants, supermarkets*

Missling, Klein, Fagherazzi, Chaix, Rocke, Perchoux (ongoing work) Not All Third Places Are Equally restorative: Type-Specific Associations Between Activity-Space based Exposure to Third Places and Chronic Stress

WHAT PROTECTS? AND WHAT DOESN'T?

ASSOCIATED WITH LOWER STRESS	ASSOCIATED WITH HIGHER STRESS
Parks and outdoor spaces *Outdoor*	**Cafes, bars, restaurants** *Implicit Transactional*
Gyms, theaters, sport facilities *Leisure*	**Shops and malls** *Commercial*
Libraries and places of worship *Open Access*	

Free-to-use places inviting disengagement are stress-reducing. Spaces structured around consumption are not.

Missling, Klein, Fagherazzi, Chaix, Rocke, Perchoux (ongoing work) Not All Third Places Are Equally restorative: Type-Specific Associations Between Activity-Space based Exposure to Third Places and Chronic Stress

THE ACTIVE CITY & HEALTH

- Case 1: Street-level environmental characteristics and affective responses while walking

THE ACTIVE CITY: MECHANISMS AT PLAY

ACTIVE FRIENDLY NEIGHBORHOODS

- Improve walkability
- Reduce car dependency
- Reduce negative externatilites (air & noise pollution)

ACTIVE NEIGHBORHOOD EXPOSURE

- Promote physical activity
- Reduce sedentary time
- Improve mental health

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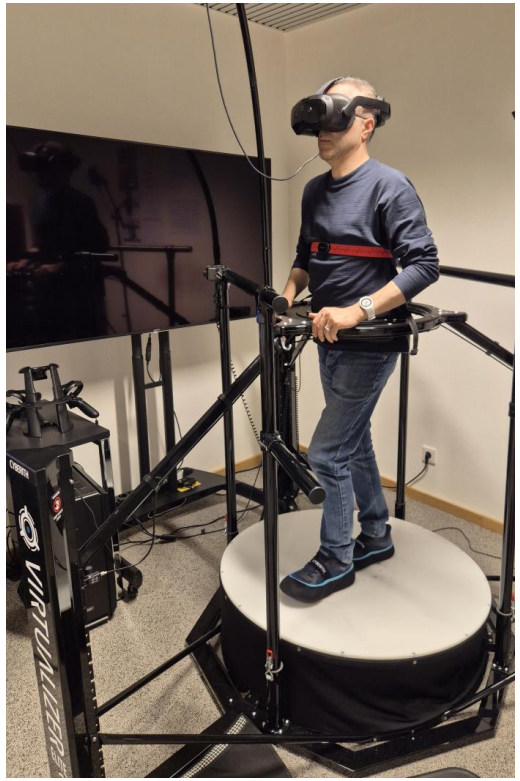
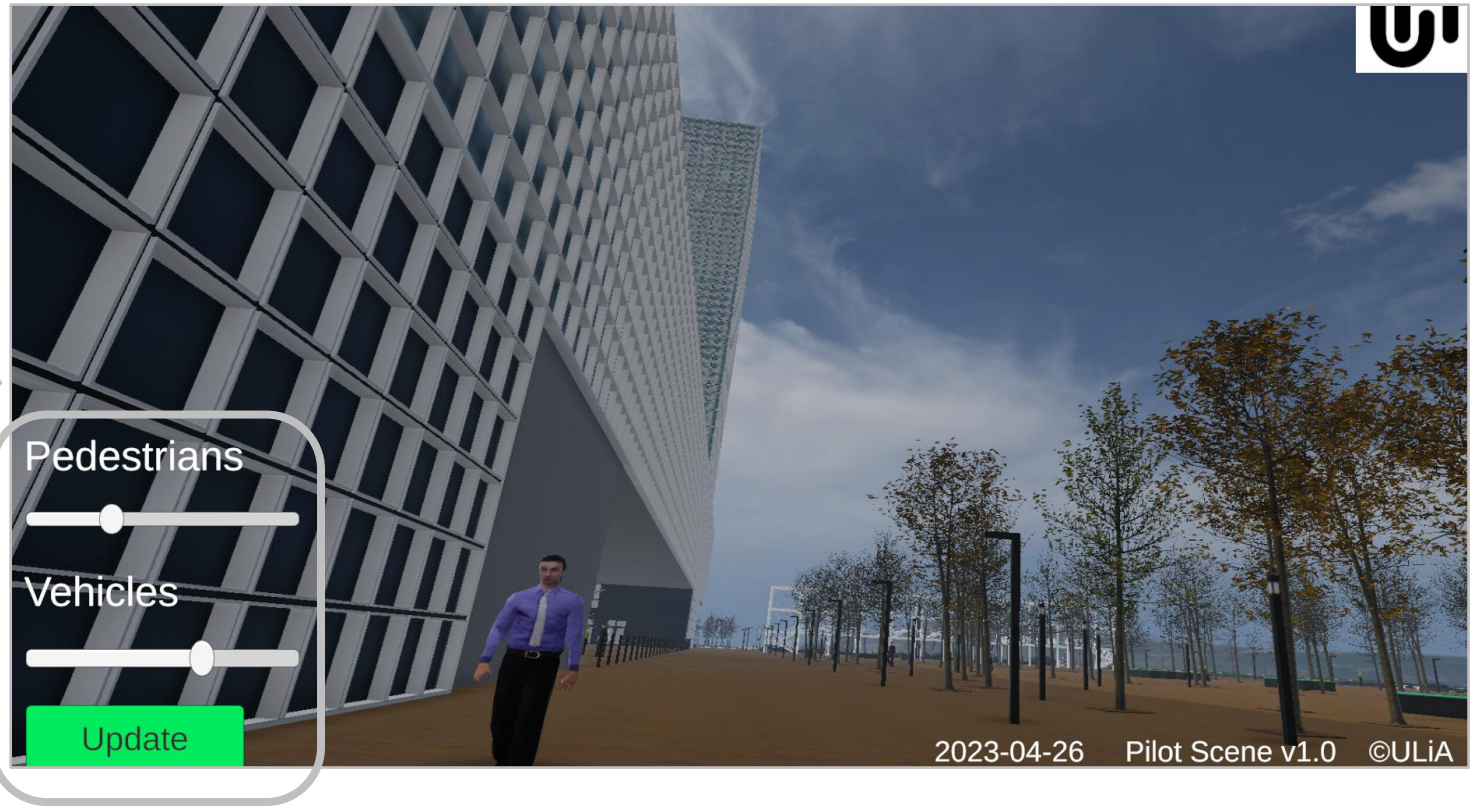
VIRTUAL REALITY TO STUDY URBAN HEALTH

Virtual reality experimentation makes it possible to systematically manipulate and test controlled virtual environments, while maintaining a high level of realism to ensure strong ecological validity.

(Birenboim, 2021)





Manipulation and decomposition of the attributable fraction to each factor

MANIPULATION OF 8 ENVIRONMENTAL FACTORS IN VR

- Greenness
- Building height
- The use of sidewalk
- Landuse functionality
- Sidewalk connectivity
- Width of sidewalk
- Pedestrian density
- Car traffic intensity

Source: Ghanbari et al., (under review), Walking through virtual reality: exploring neighborhood characteristics that influence individual's preferences and affectives responses to Urban environments

TWELVE VARIATIONS OF LUXEMBOURG

Source: Ghanbari et al., (under review), Walking trhough virtual reality: exploring neighborhood characteristics that influence individual's preferences and affectives responses to Urban environments

HOW DOES IT LOOK LIKE IN VR ?

WHICH ENVIRONMENTAL FACTORS MATTER?

MOST FAVORITE SENARIO :

- **Tree lines of both side of the street**
- Low building height (1-3 stories)
- **Large sidewalks (4 m)**
- **Outdoor activities on the sidewalk/open space**
- Ordinary street crossing
- **Mixed Land use/buildings (résidentiel + commercial)**
- High car traffic
- **Low pedestrian density**

LEAST FAVORITE SENARIO :

- **Tree line of one side of the road**
- Low building height (1-3 stories)
- **Narrow sidewalks (2 m)**
- **No outdoor activities on the sidewalk/open space**
- Ordinary street crossing
- **Residential landuse/buldings only**
- High car traffic
- **High pedestrian density**

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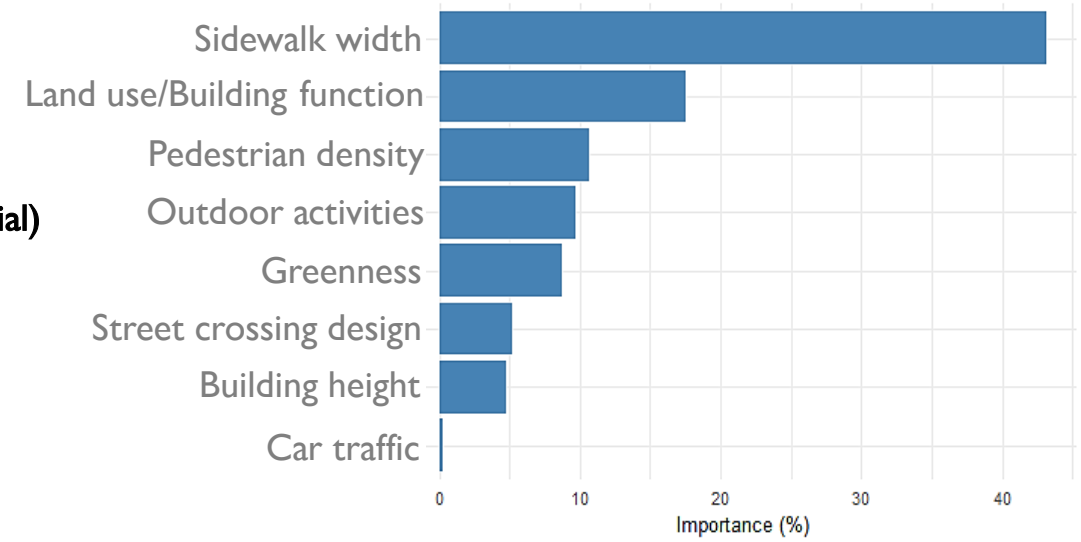
RELATIVE IMPORTANCE OF EACH FACTOR:



Sidewalk width and **land use mix** are the main factors that influence walking preferences

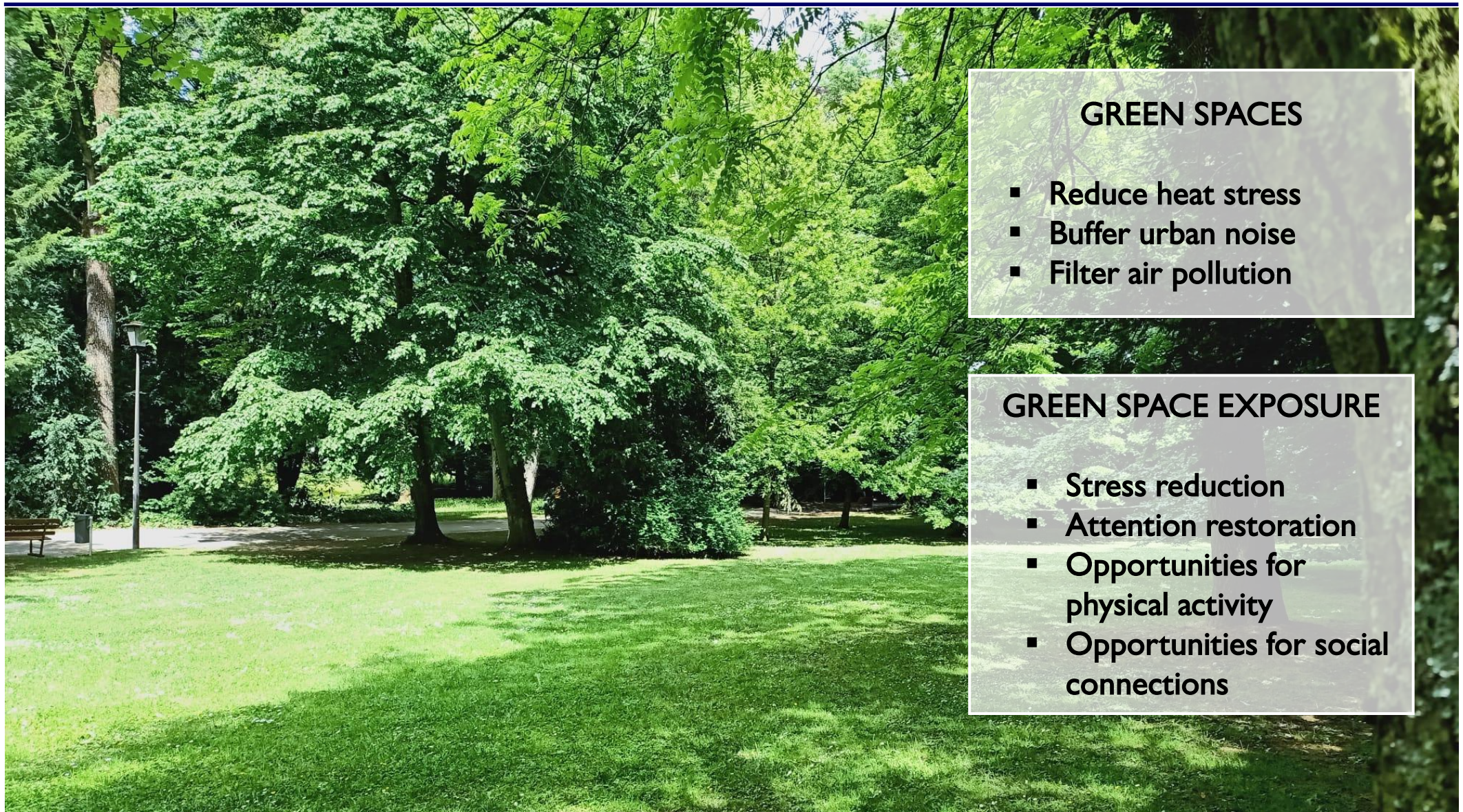
Source: Ghanbari et al., (under review), Walking trhough virtual reality: exploring neighborhood characteristics that influence individual's preferences and affectives responses to Urban environments

THE GREEN CITY & HEALTH

Case 1: Street-level greenness and its impact on stress

Case 2: Green spaces, trees and their impact on cardiometabolic health

THE GREEN CITY: MECANISMS AT PLAY



GREEN SPACES

- Reduce heat stress
- Buffer urban noise
- Filter air pollution

GREEN SPACE EXPOSURE

- Stress reduction
- Attention restoration
- Opportunities for physical activity
- Opportunities for social connections

CASE 1: STREET-LEVEL GREENNESS AND ITS IMPACT ON STRESS

EIGHT SCENARIOS

Each corresponding to a different combination of traffic, pedestrian density, and vegetation.

Traffic
- **Low** ≈ 7.5 veh/min
- **High** ≈ 30 veh/min

Crowdedness
- **Low** ≈ 2.5 ped/min
- **High** ≈ 10 ped/min

Greenness
- **Non-green**: No green features
- **Green**: 1-m-wide planting strip with trees and bushes and bird singing sound

Aghanejad, Birenboim, Poppe and Perchoux (ongoing work), Impact of greenness, crowdedness and traffic on stress while walking: A dose-response experiment in virtual urban environments

MEASURING PHYSIOLOGICAL STRESS IN VR

Pupil Size

Heart Rate Variability

Interbeat Interval

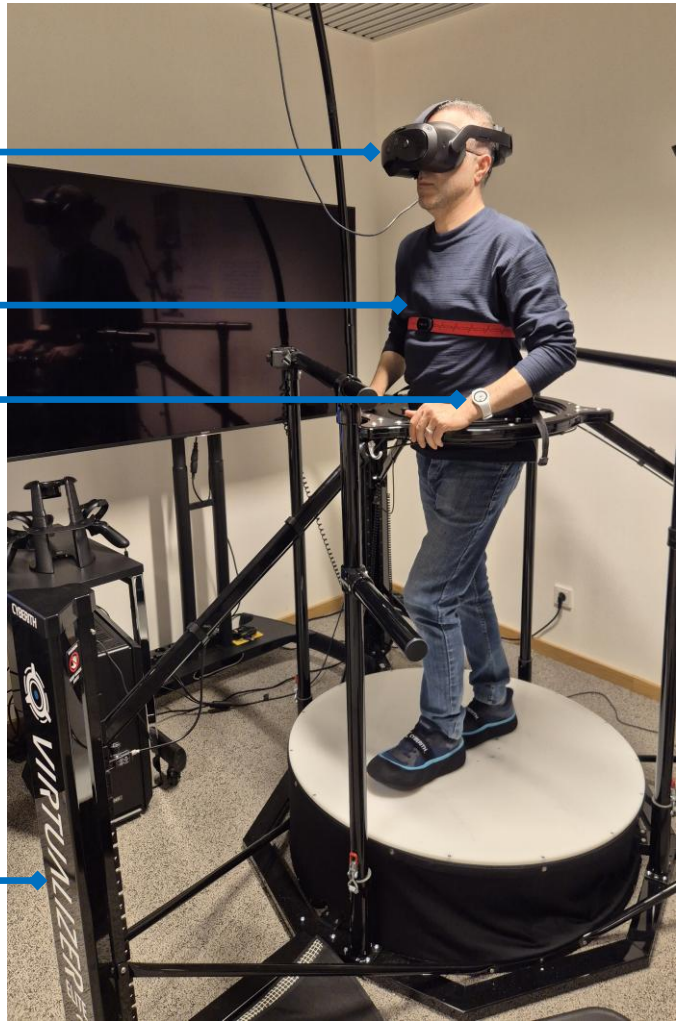
Skin Conductance Level

Electrodermal activity

In-VR Self-reported stress response

How stressed are you now?

Virtualizer Elite 2 Omnidirectional treadmill



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TREES AND GREENERY HELPED REDUCE STRESS

Participants walking along greener streets showed lower physiological stress responses.

20% lower skin conductance level

Aghanejad, Birenboim, Poppe and Perchoux (ongoing work), Impact of greenness, crowdedness and traffic on stress while walking: A dose-response experiment in virtual urban environments

THE BENEFITS DEPENDED ON PEDESTRIAN LEVELS

Greenery reduced physiological stress when pedestrian density was low.

This benefit was not observed when more pedestrians were present.

41% lower skin conductance level in **greener streets with fewer pedestrians**

Aghanejad, Birenboim, Poppe and Perchoux (ongoing work), Impact of greenness, crowdedness and traffic on stress while walking: A dose-response experiment in virtual urban environments

THE BENEFITS APPEARED QUICKLY AND REMAINED STABLE

The benefits of greenery were already visible within the **first two minutes of walking.**

However, we did not find evidence that the benefits continued to increase during the 10-minute walk.

Aghanejad, Birenboim, Poppe and Perchoux (ongoing work), Impact of greenness, crowdedness and traffic on stress while walking: A dose-response experiment in virtual urban environments

THE GREEN CITY & HEALTH

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Case 2: Green spaces, trees and their impact on cardiometabolic health

CASE 2: GREEN SPACES & THE METABOLIC SYNDROME

GREEN SPACES

Greenness Density

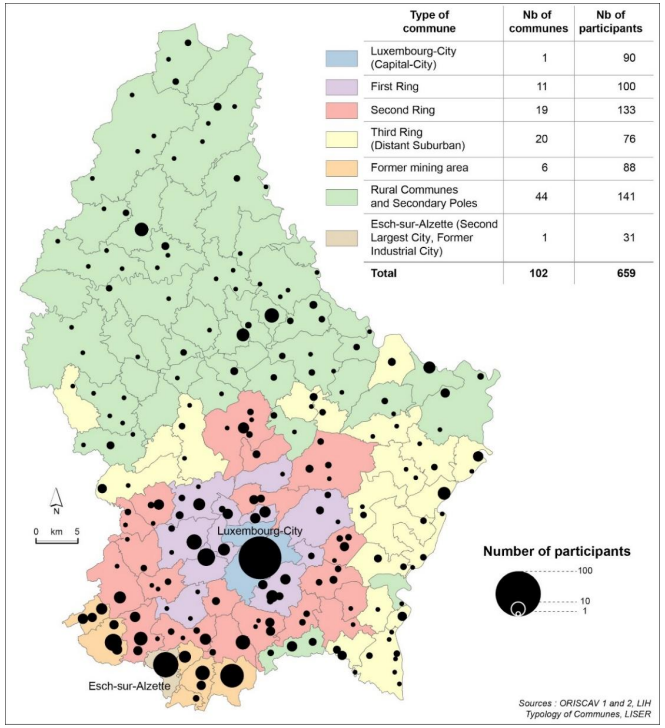
aka Soil-Adjusted Vegetation Index

Source: Landsat surface reflectance
Spatial resolution : 30 m
Range : 0-100%

Tree Canopy

aka Tree Cover Density

Source: Copernicus Land Monitoring
Spatial resolution : 20 m
Range : 0-100%



METABOLIC SYNDROME

Continuous score to quantify the spectrum of metabolic abnormalities *(Soldatovic et al., 2016)*

ORISCAV-LUX

ORISCAV-LUX

GREEN SPACES & THE METABOLIC SYNDROME

n = 395

Mean age : 41.9 y
55% women
32% living in low neighbourhood SES

- **10% increase in Greenness Density** over 10-year was associated with an improved **Cardio-Metabolic outcomes (HDL-cholesterol)**

- **No associations** between change in **Tree Canopy** and the cardio metabolic outcomes

Models are controlled for baseline greenness, time, sex and country of birth, age, educational level, working status and marital status, neighbourhood SES (average housing price in the municipality), degree of urbanity and residential self-selection.

(Tharrey et al. 2023, Social Science and Medicine)

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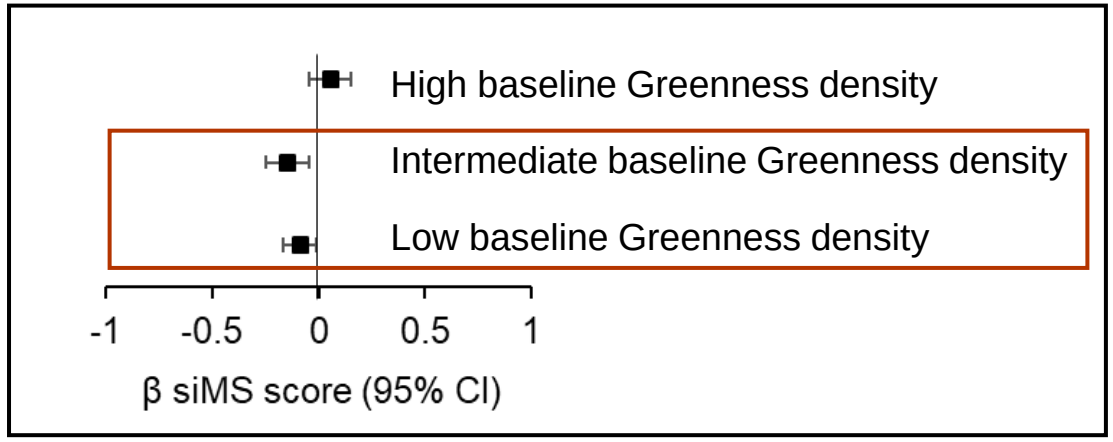
Who benefits the most from this protective effect ?

Individuals living in neighborhoods with a low to intermediate greenness density level 10 years ago !



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SYNERGIES IN HEALTH & CLIMATE-FRIENDLY INITIATIVES

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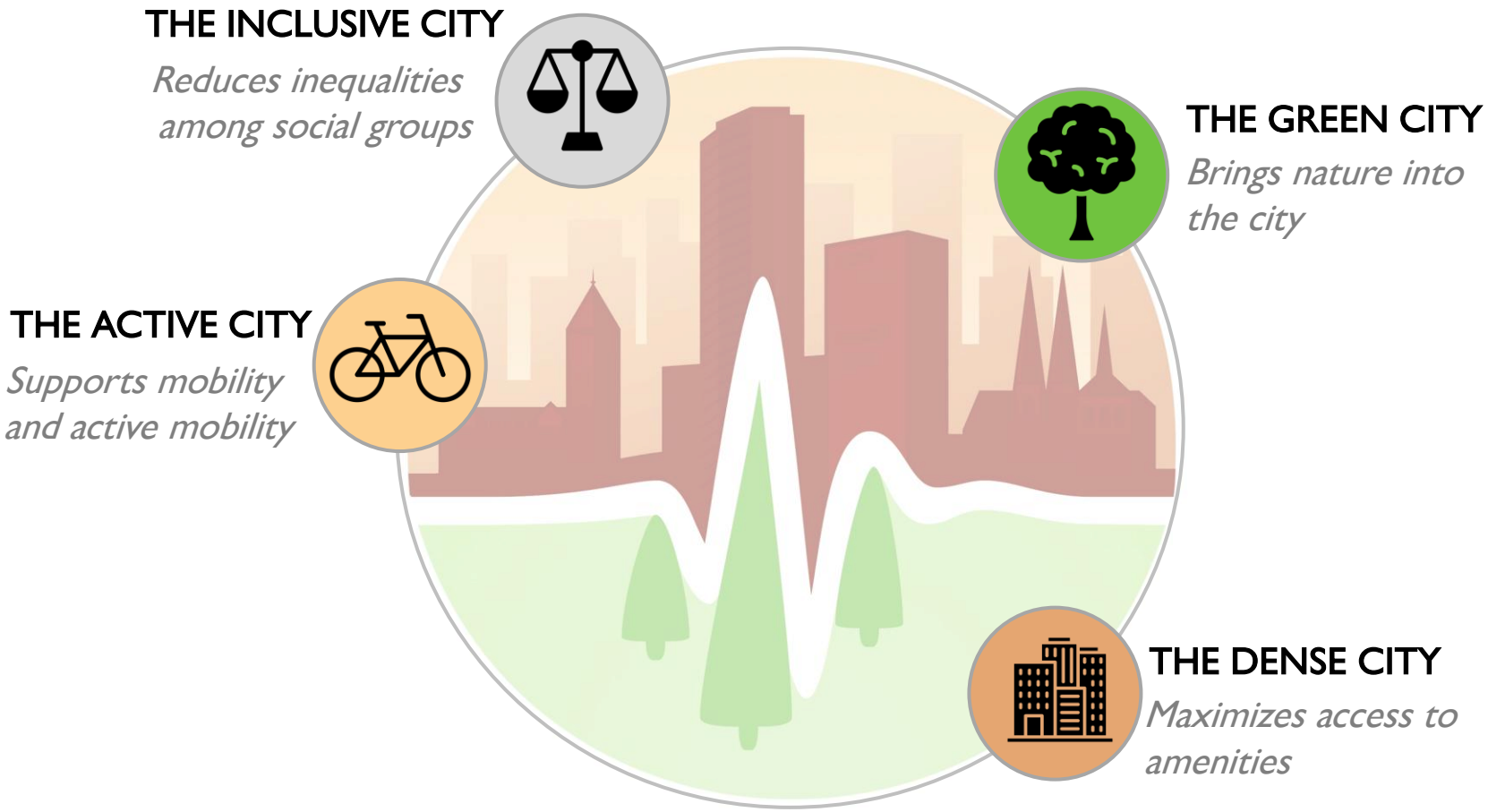

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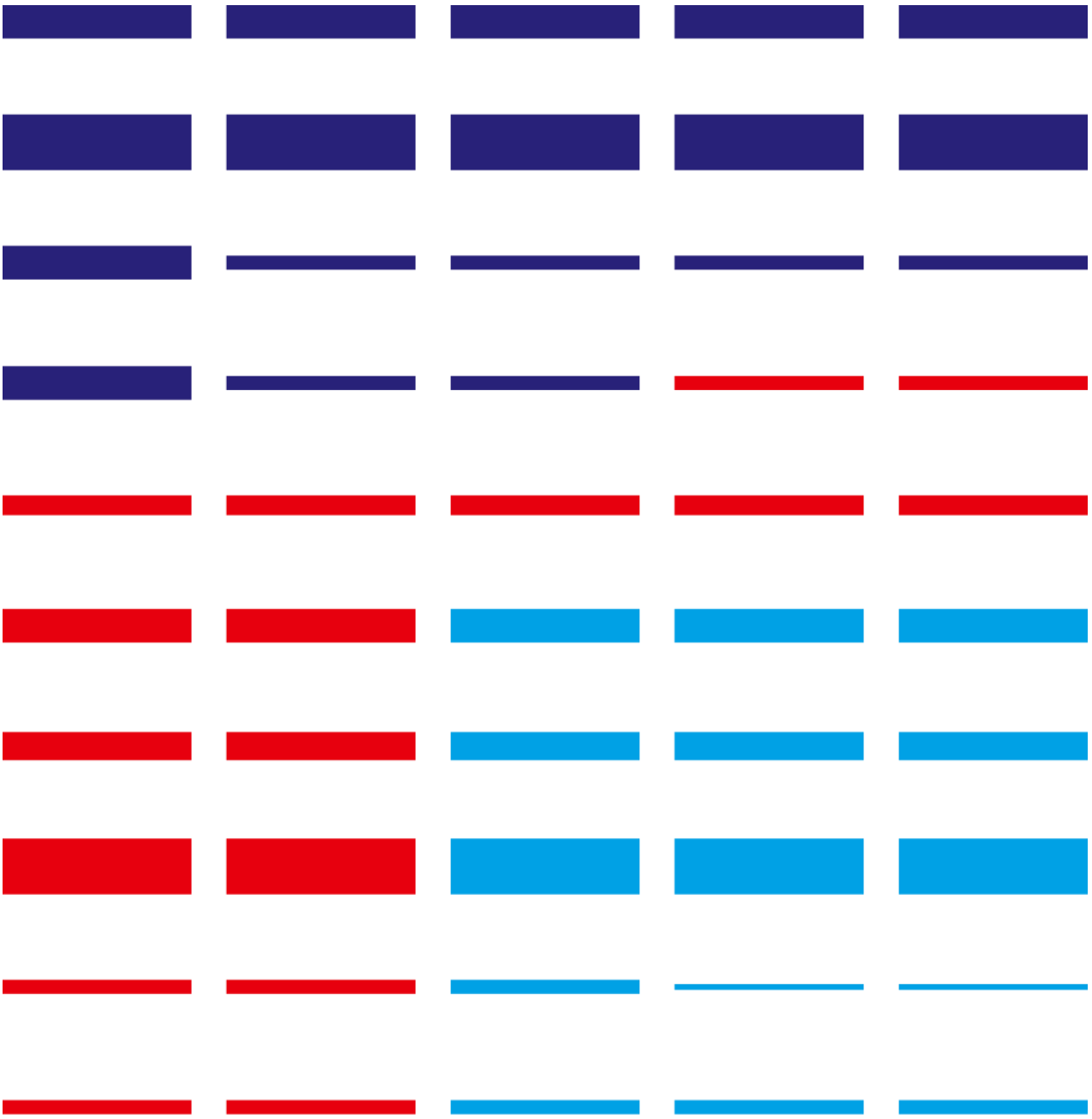

THANK YOU