Disentangling the environmental impact on mental health

An integrated approach using the UK Biobank cohort
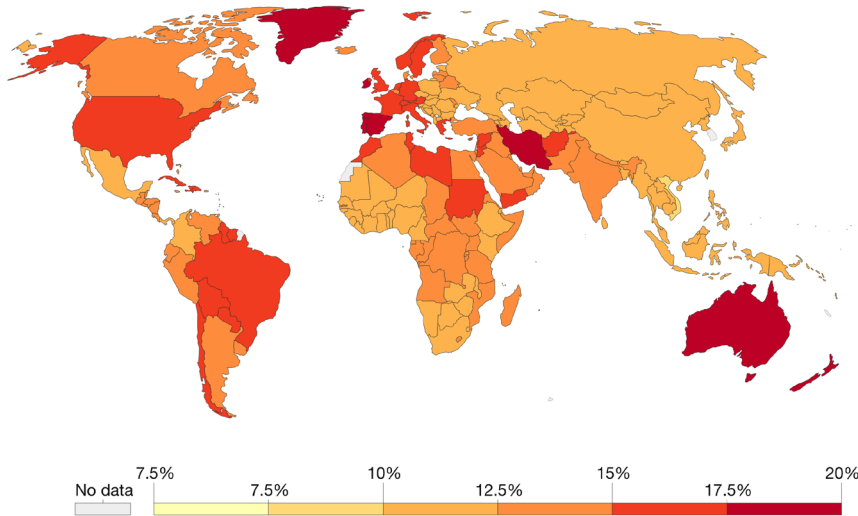
Gunter Schumann, Elli Polemiti

EnvironMENTAL seminar series – Seminar 1
08.04.2022

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Introduction
Global burden of mental health disorders

Prevalence of mental health disorders, 2019
Figure produced by Our World in Data https://ourworldindata.org/mental-health.
Data source: IHME, Global Burden of Disease.

- Mental health disorders are among the three leading causes of disability globally

- **10.7%** of the global population live with a mental health disorder (970 million)

- The prevalence of mental illness is higher in Europe, estimated at **14%** of the population

Introduction
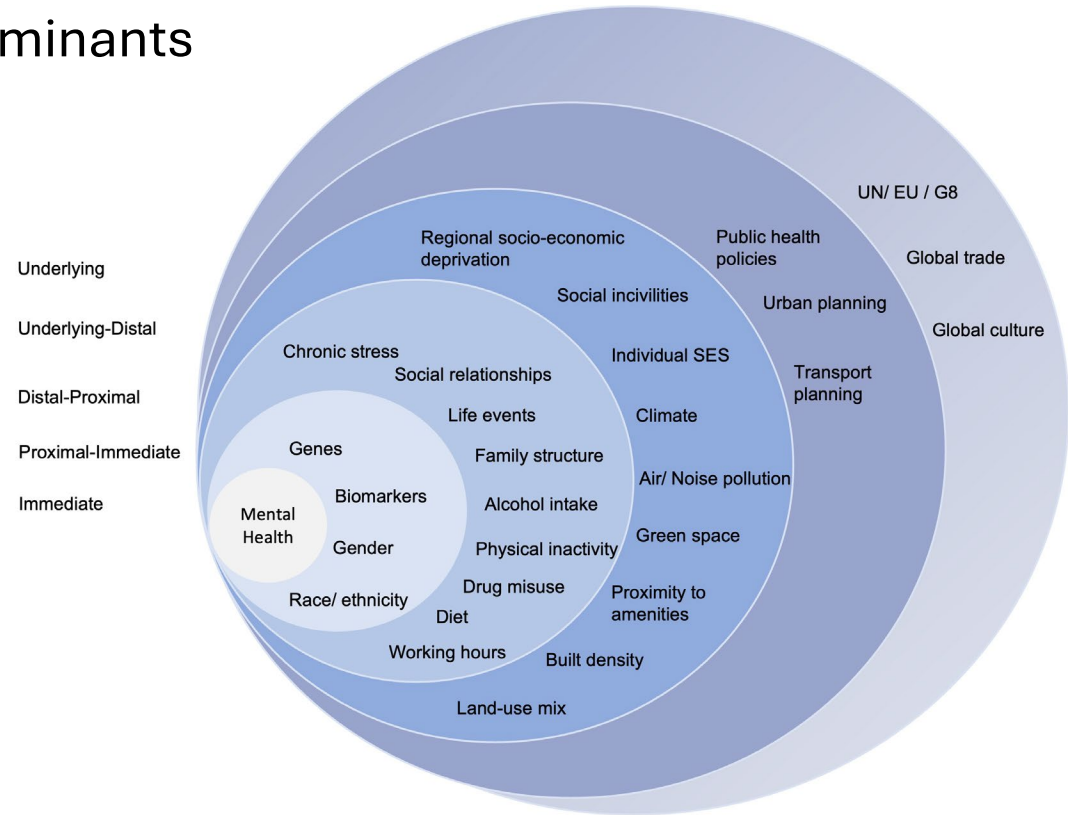## Environmental effects on mental health

- > **50**% of the burden of mental health disorders is attributed to environmental factors

  - Existing literature on mental health is limited.

  - Positive association between particulate matter and depression

  - Inconclusive findings regarding
    - Air pollution (O_3, NO_2, SO_2)
    - Green and blue space
    - Temperature

Introduction
Hierarchical web of determinants

Underlying

Underlying-Distal

Distal-Proximal

Proximal-Immediate

Immediate

Mental Health

Genes

Biomarkers

Gender

Race/ ethnicity

Chronic stress

Social relationships

Life events

Family structure

Alcohol intake

Physical inactivity

Drug misuse

Diet

Working hours

Regional socio-economic deprivation

Social incivilities

Individual SES

Climate

Air/ Noise pollution

Green space

Proximity to amenities

Built density

Land-use mix

Public health policies

Urban planning

Transport planning

UN/ EU / G8

Global trade

Global culture

Introduction
Hierarchical web of determinants

Urbanicity

- Among the most important environmental challenges

- **55%** of the population lives in urban areas ↗ **68%** by 2050

- The physical, social and service dimensions form a complex relation
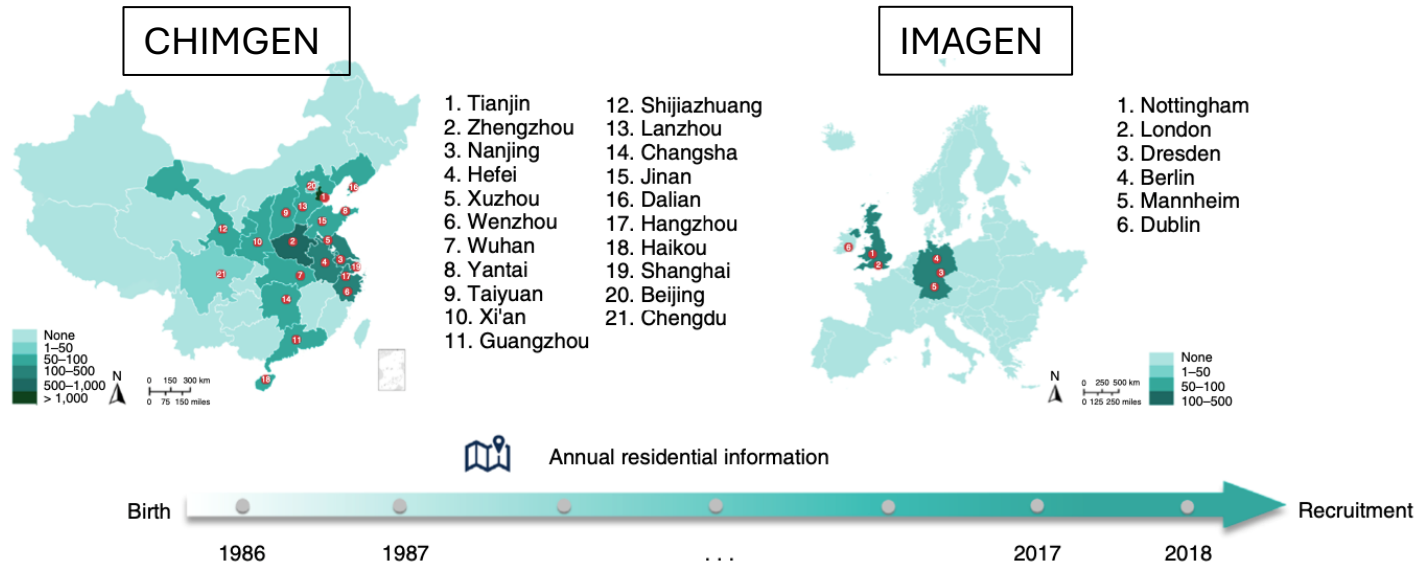
Goal and approach

Investigate the relationship between environment and mental health outcomes, focusing on:

- Individual level data

- Objective measures of environment

- Combined environmental exposures
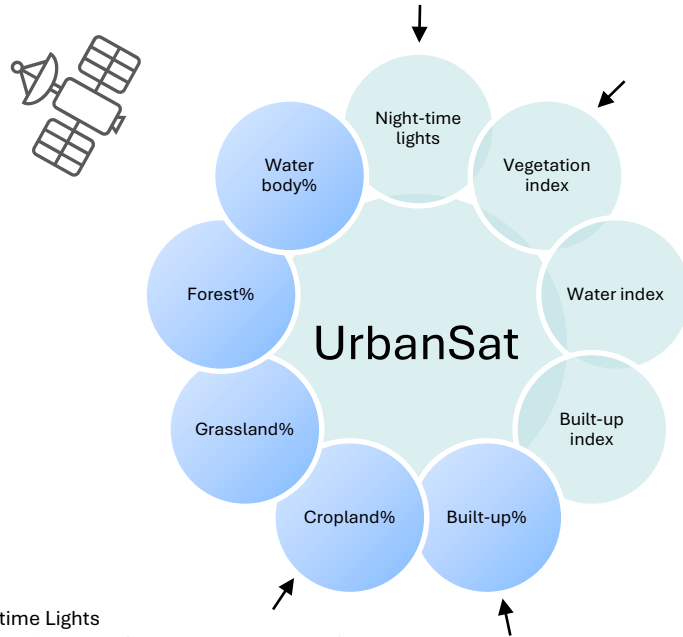
- Longitudinal assessment
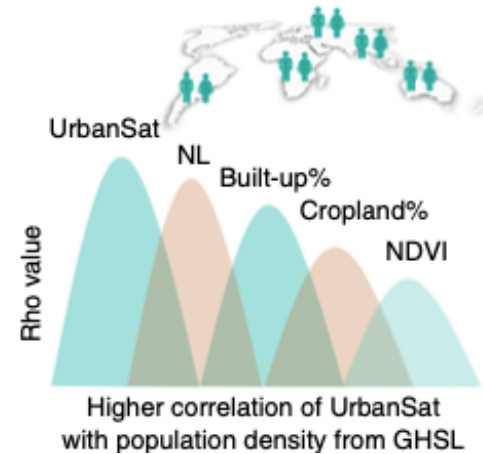
The UrbanSat
Study cohorts

CHIMGEN

1. Tianjin
2. Zhengzhou
3. Nanjing
4. Hefei
5. Xuzhou
6. Wenzhou
7. Wuhan
8. Yantai
9. Taiyuan
10. Xi'an
11. Guangzhou
12. Shijiazhuang
13. Lanzhou
14. Changsha
15. Jinan
16. Dalian
17. Hangzhou
18. Haikou
19. Shanghai
20. Beijing
21. Chengdu

None
1–50
50–100
100–500
500–1,000
> 1,000

0   150   300 km
0   75   150 miles

IMAGEN

1. Nottingham
2. London
3. Dresden
4. Berlin
5. Mannheim
6. Dublin

None
1–50
50–100
100–500

0   250   500 km
0   125   250 miles

Annual residential information

Birth

1986   1987   . . .   2017   2018

Recruitment

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The UrbanSat
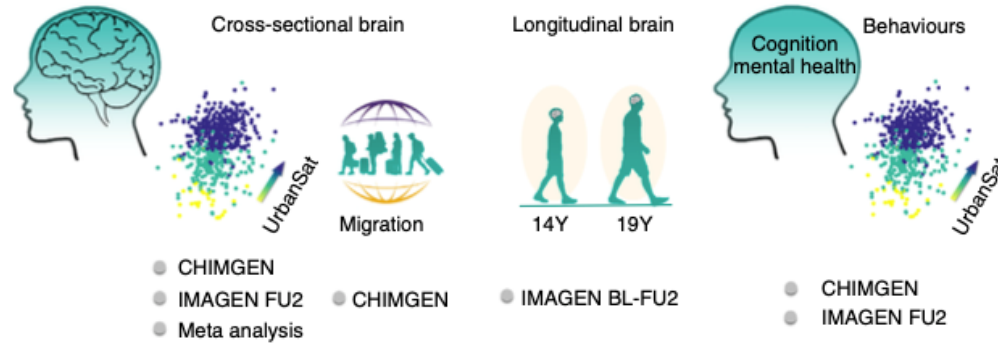## Satellite data

NL; Night-time Lights
NDVI; Vegetation Index (Normalised Difference)
CT; Cortical Thickness
SA; Surface Area
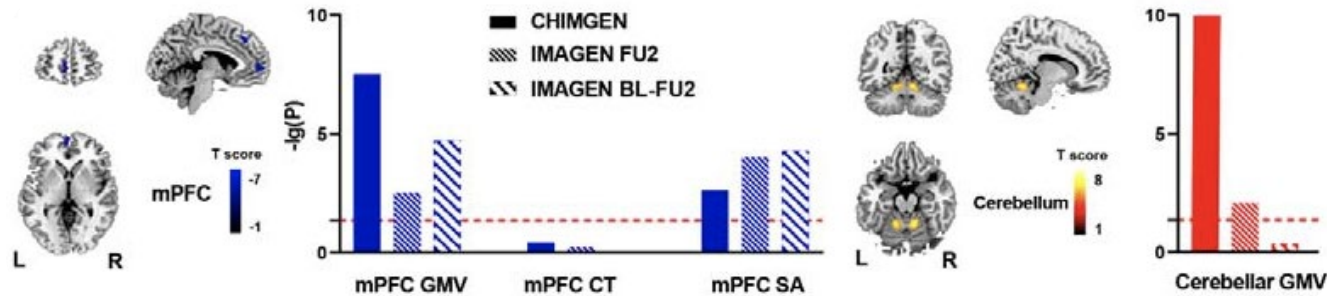
Xu *et al*. Nat Hum Behav. 2022

The UrbanSat
Study design

Xu *et al*. Nat Hum Behav. 2022

The UrbanSat
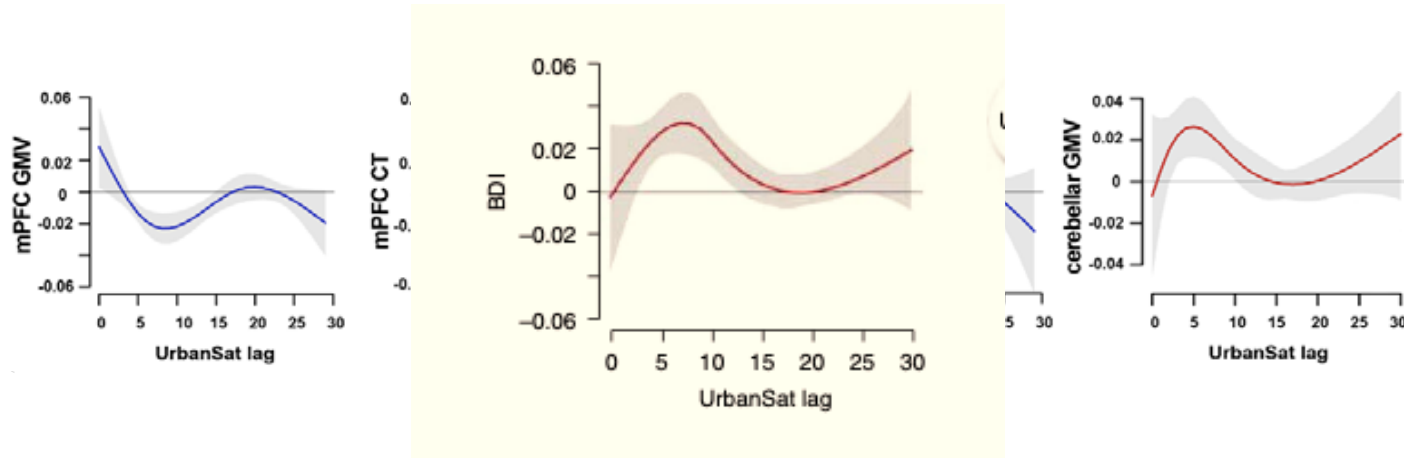## Correlations with brain volume

mPFC; medial Prefrontal cortex
GMV; Grey Matter Volume
CT; Cortical Thickness
SA; Surface Area

Xu *et al*. Nat Hum Behav. 2022

The UrbanSat
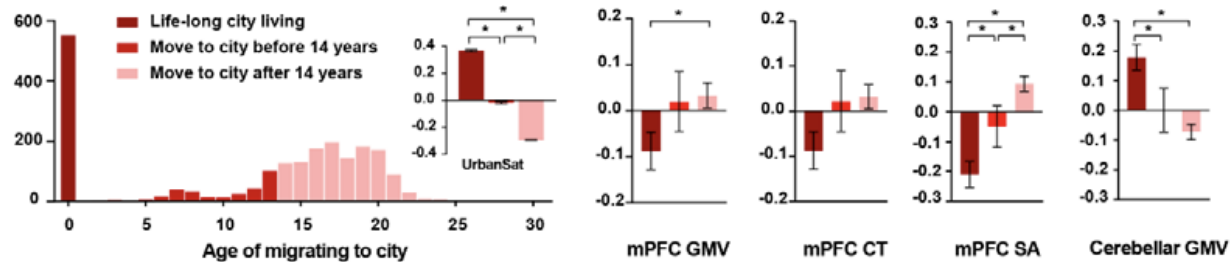## Developmental sensitivity periods for urbanicity

mPFC; medial Prefrontal cortex
GMV; Grey Matter Volume
CT; Cortical Thickness
SA; Surface Area

Xu *et al*. Nat Hum Behav. 2022

The UrbanSat

Changes in brain volume correlate with age of migration to the city

mPFC; medial Prefrontal cortex
GMV; Grey Matter Volume
CT; Cortical Thickness
SA; Surface Area

Xu *et al*. Nat Hum Behav. 2022

The UK Biobank
The cohort and

- 500.000 participants recruited, aged 40–69 years

- ~40.000 participants with imaging data

- Data framework:
    - Socio-demographics
    - Lifestyle
    - Medical history
    - Psychosocial measures
      (personality, affective and anxiety disorders)
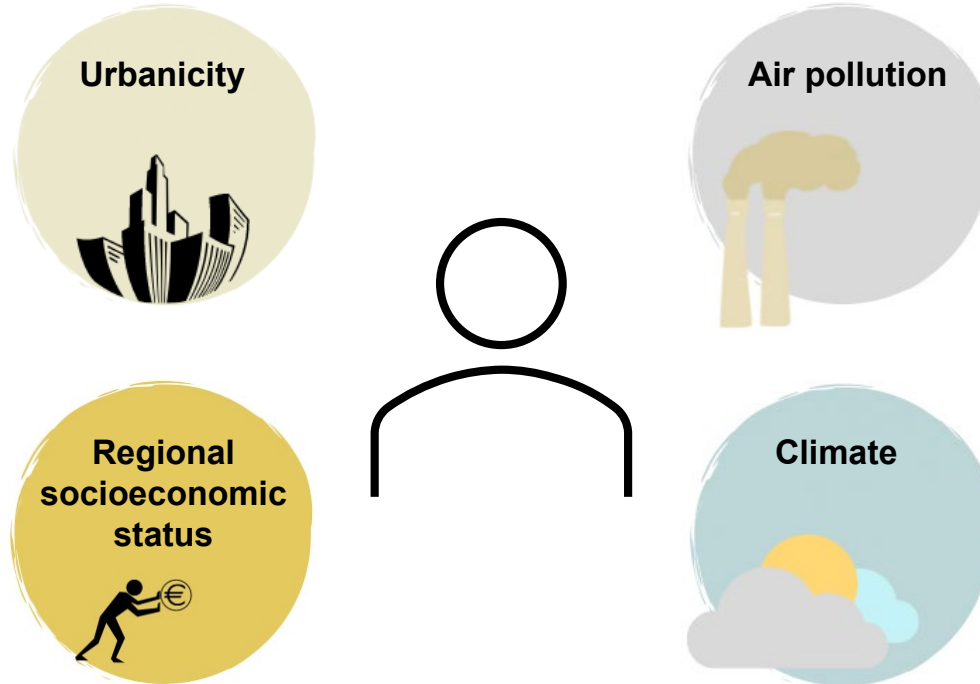   - Environmental information
    - Blood samples

Locations of UK Biobank baseline centers
Source: https://www.ukbiobank.ac.uk

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Future perspectives
Expansion of environmental indicators

Future perspectives
Environmental indicators

Urbanicity[a]
- Land cover type
- Normalised difference vegetation index
- Normalised difference built-up index
- Building footprints
- Impervious surface
- Normalised difference water index
- Elevation/ Slope
- Night-time lights
- Population density

Air pollution[b]
- Fine particulate matter (PM2.5)
- Ambient ozone (O3)
- Carbon monoxide (CO)
- Carbon dioxide (CO2)
- Nitrogen dioxide (NO2)
- Sulphur dioxide (SO2)

Climate[c]
- Temperature
- Wet-bulb globe temperature
- Precipitation
- Cloud cover (low- & middle-level)
- Sunshine duration

- Urban heat islands

Regional socioeconomic status
- Income
- Employment
- Education
- Health
- Housing
- Crime/ safety

Future perspectives
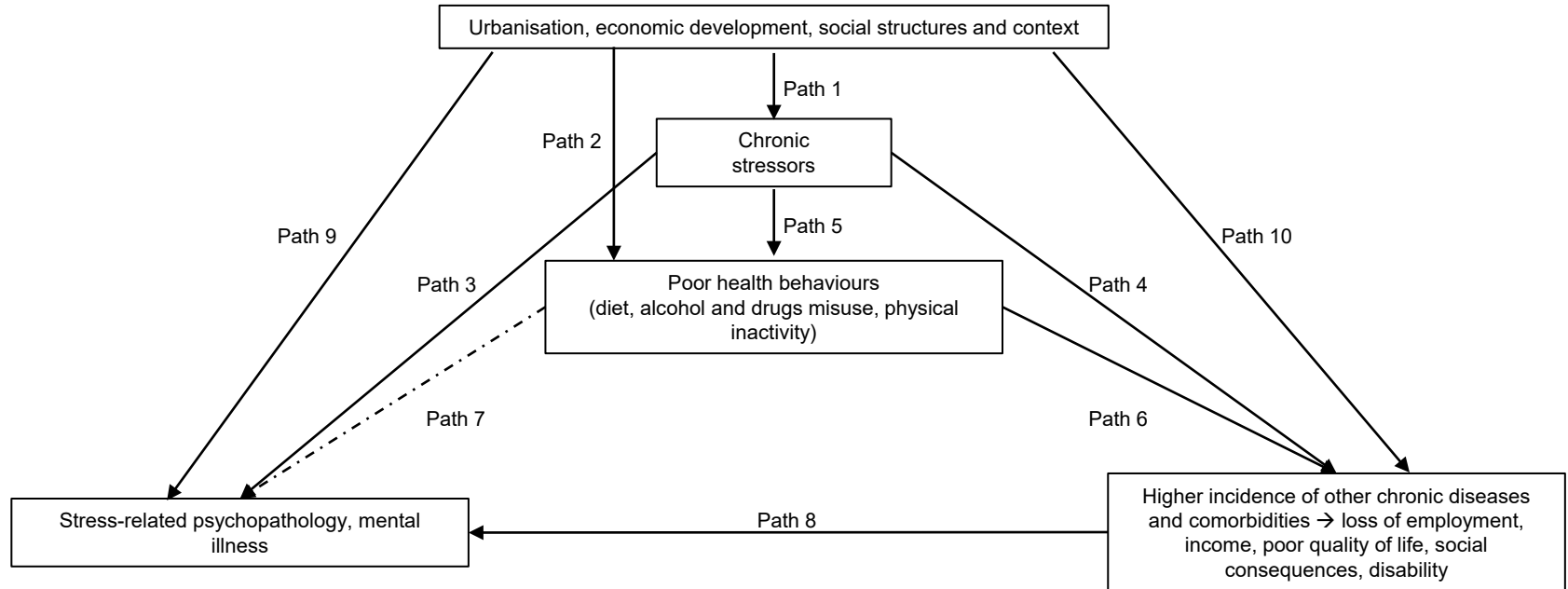## Conceptual framework for epidemiological analyses

Figure adapted from Mezuk *et al. Soc Ment Health. 2013*

Future perspectives
Analytical steps

1 • Identify and map adverse environmental exposures by regional socioeconomic status

2 • Hypotheses testing of the effect of environment on mental health

3 • Identification of interrelated processes and pathways that link environment, social context and health behaviours to mental health

4 • Investigation of the mediating effect of the structural and functional brain on the association between environment and mental health

Thank you!

Supplements – Built environment

| Measurable Indicators	UK (2006 – 2010)	Germany (2012 – 2016)	Spatial Resolution	Type of Analysis
Land cover type (area)	MCD12Q1 (2010)	MCD12Q1 (2015)	500m	Total area/land cover type
NDVI (Sum)	Landsat 7 (2010)	Landsat 8 (2015)	30 m	Sum of NDVI per buffer area
NDBI (Sum)	Landsat7 (2010)	Landsat 8 (2015)	30m	Sum of NDBI per buffer area
Building footprints (World Settlement Footprint)	WSF (2010)	WSF (2015)	30m (2010), 10m (2015,2019)	Sum of building footprints per buffer area
Impervious Surface (total area)	GISA (2010)	GISA (2015)	30m	Sum of Impervious surface area
NDWI (Sum)	Landsat7 (2010)	Landsat 8 (2015)	30m	Sum of NDWI per buffer area
Elevation (average)	SRTM (2000)	SRTM (2000)	30m	Average elevation of the buffer area
Slope (average)	SRTM (2000)	SRTM (2000)	30m	Average elevation of the buffer area
Night-time lights (Sum, Std) **[NOTE: DMSP_OLS and VIIRS are not comparable]**	DMSP_OLS (2010)	VIIRS (2015)	1km / 750m	SOL (Sum of Lights) + Std
Population density	WorldPop (2010)	WorldPop (2015)	100mx100m grid	Sum per buffer area
	Landscan (2010)	Landscan (2015)	1km	Persons/km2

Supplements – Climate

Measurable Indicators	UK (2006 – 2010)	Germany (2012 – 2016)	Spatial Resolution	Type of Analysis
Temperature	ERA5 (2000 – 2010)	ERA5 (2000 – 2010)	25km	Several variables to describe weather patterns (aggregated as yearly seasonal periods) and extremes
Wet-bulb globe temperature	ERA5 (2000 – 2010)	ERA5 (2000 – 2010)	25km	Several variables to describe weather patterns (aggregated as yearly seasonal periods) and extremes
Precipitation	ERA5 (2000 – 2010)	ERA5 (2000 – 2010)	25km	Several variables to describe weather patterns (aggregated as yearly seasonal periods) and extremes
Cloud cover	ERA5 (2000 – 2010)	ERA5 (2000 – 2010)	25km	Fraction of sky covered aggregated as annual seasonal periods
Sunchine duration	SARAH-2 (2000 – 2010)	SARAH-2 (2000 – 2010)	5km	Aggregated as yearly seasonal periods

Supplements – Air pollution

Measurable Indicators	UK (2006 – 2010)	Germany (2012 – 2016)	Spatial Resolution	Type of Analysis
PM2.5	MODIS, MISR and SeaWiFS AOD with geographically weighted regression, using the GEOS-Chem chemical transport model (2005 – 2010)	MODIS, MISR and SeaWiFS AOD with geographically weighted regression, using the GEOS-Chem chemical transport model	0.01degrees (~1.02km)	Annual mean concentration for each year and 5-year interval
O3	TES/Aura (2005 – 2010)	TES/Aura	5x8km	Annual mean concentration for each year and 5-year interval
CO	TES/Aura (2005 – 2010)	TES/Aura	5x8km	Annual mean concentration for each year and 5-year interval
CO2	TES/Aura (2005 – 2010)	TES/Aura	5x8km	Annual mean concentration for each year and 5-year interval
NO2	OMI/Aura (2005 – 2010)	OMI/Aura	13x24km	Annual mean concentration for each year and 5-year interval
SO2	OMI/Aura (2005 – 2010)	OMI/Aura	13x24km	Annual mean concentration for each year and 5-year interval

Supplements – The UrbanSat

Mediating effects of the brain
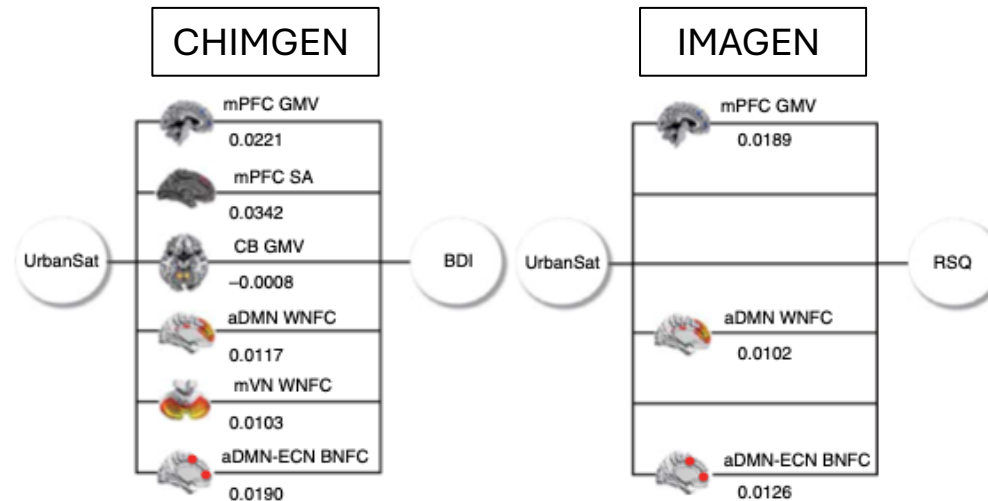
mPFC; medial Prefrontal cortex
GMV; Grey Matter Volume
SA; Surface Area
CB; cerebellar
aDMN; antrior default mode network
WNFC; within-network funtional connectivity
mVN; medial visual network
ECN; executive control network

Xu *et al*. Nat Hum Behav. 2022