

The background is a stylized landscape illustration. On the left, there are dark blue mountains with several dark green evergreen trees. In the center, a bright yellow sun is partially obscured by a dark silhouette of a forest. To the right, there are reddish-brown mountains with white outlines. The sky is a light beige color with soft, wavy purple and blue clouds.

Contextual Environmental Factors & Mental health

Aaron Reuben, PhD, MEM

Assistant Professor | Neuropsychology & Environmental Health

University of Virginia

HEI Annual Meeting | May 5th, 2025

Outline

01

Short primer on mental health

02

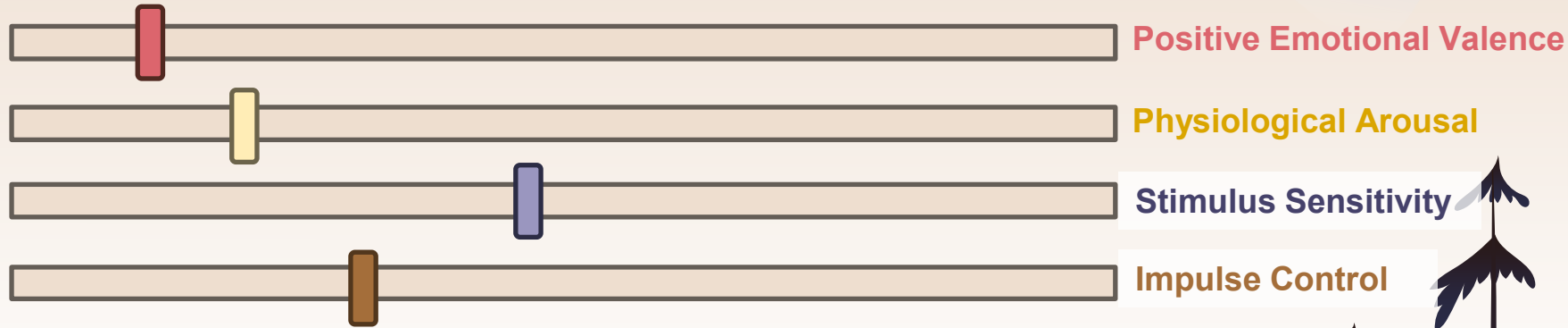
Contextualizing the Air pollution -
Mental Health interplay

The background is a stylized landscape. At the top, a large yellow circle containing the number '01' is centered. Below it, the title 'A Short primer on mental health' is written in a dark red, serif font. The bottom of the image features dark blue and black silhouettes of jagged mountains on the left and right. On the right side, there are three dark blue evergreen trees of varying heights. The sky is a light beige color with soft, purple and blue clouds. The overall aesthetic is calm and artistic.

01

A Short primer on mental health

“Mental Health” reflects a dynamic interplay of thoughts, experiences, feelings, and behaviors

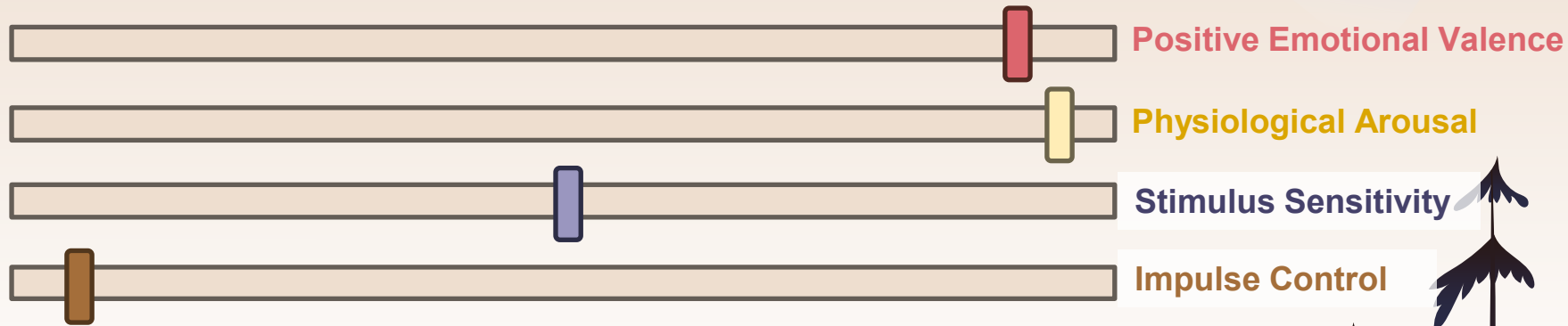


“Mental Health” reflects a dynamic interplay of thoughts, experiences, feelings, and behaviors



Major Depressive Disorder?

“Mental Health” reflects a dynamic interplay of thoughts, experiences, feelings, and behaviors



Manic Episode?

```
graph TD; A[General Psychopathology (p)] --> B[Externalizing]; A --> C[Internalizing]; A --> D[Thought disorder];
```

General
Psychopathology
(p)

Externalizing

Internalizing

Thought
disorder

Externalizing Disorders

Internalizing Disorders

Thought Disorders

ADHD



Conduct Disorder



Alcohol Dependence



Tobacco Dependence



Cannabis Dependence



Drug Dependence



Anxiety



Depression



Fears / Phobias



Eating Disorder



PTSD



OCD



Mania

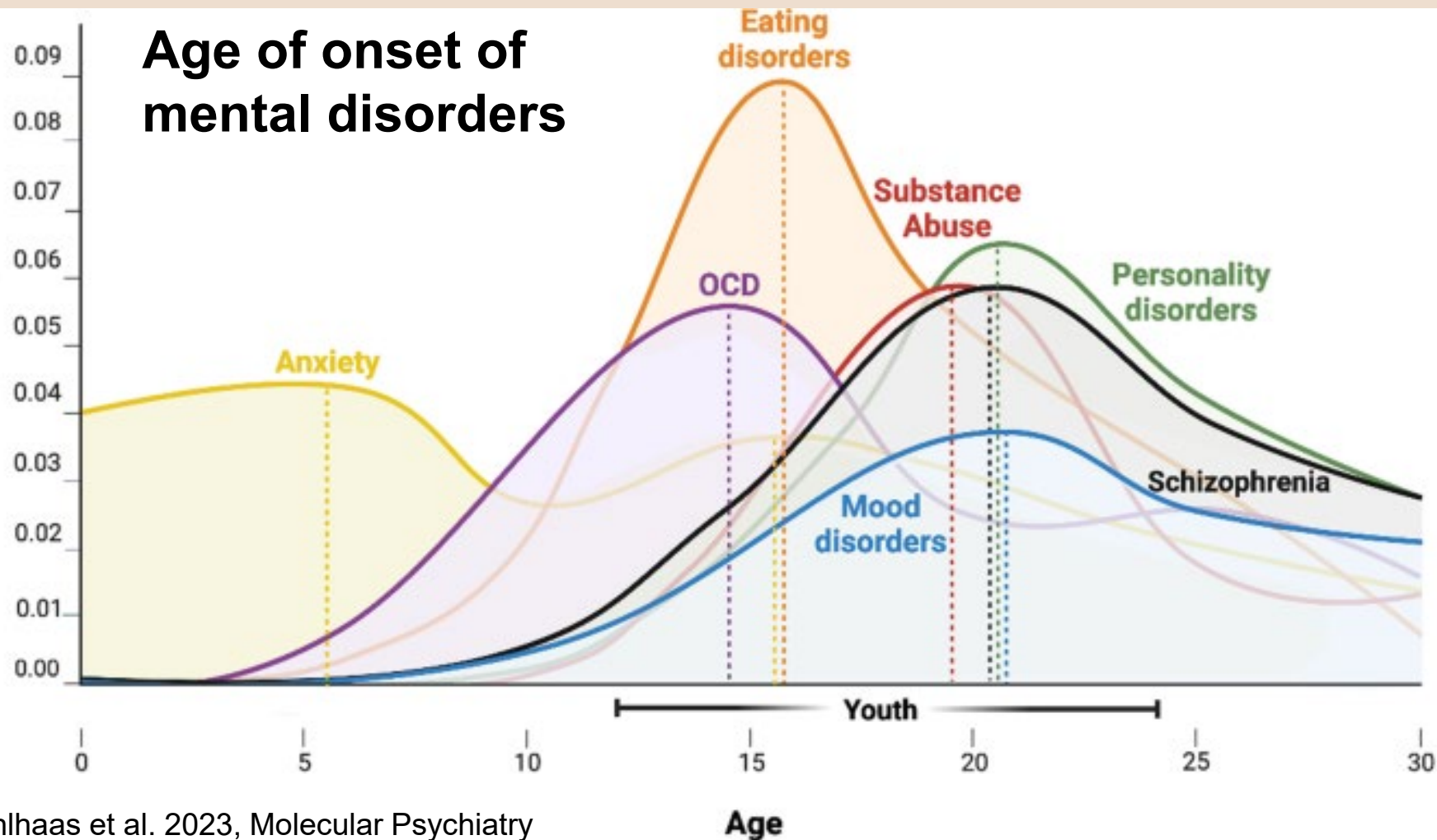


Schizophrenia

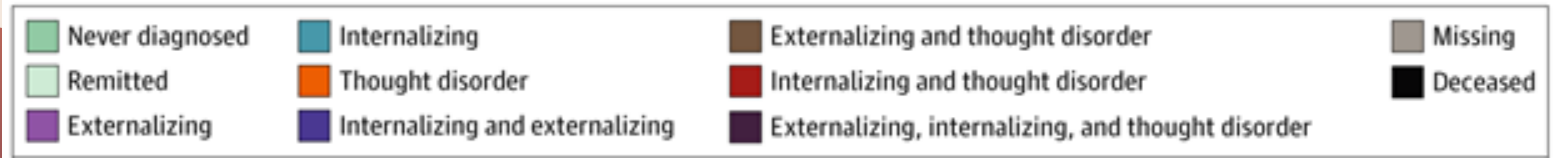
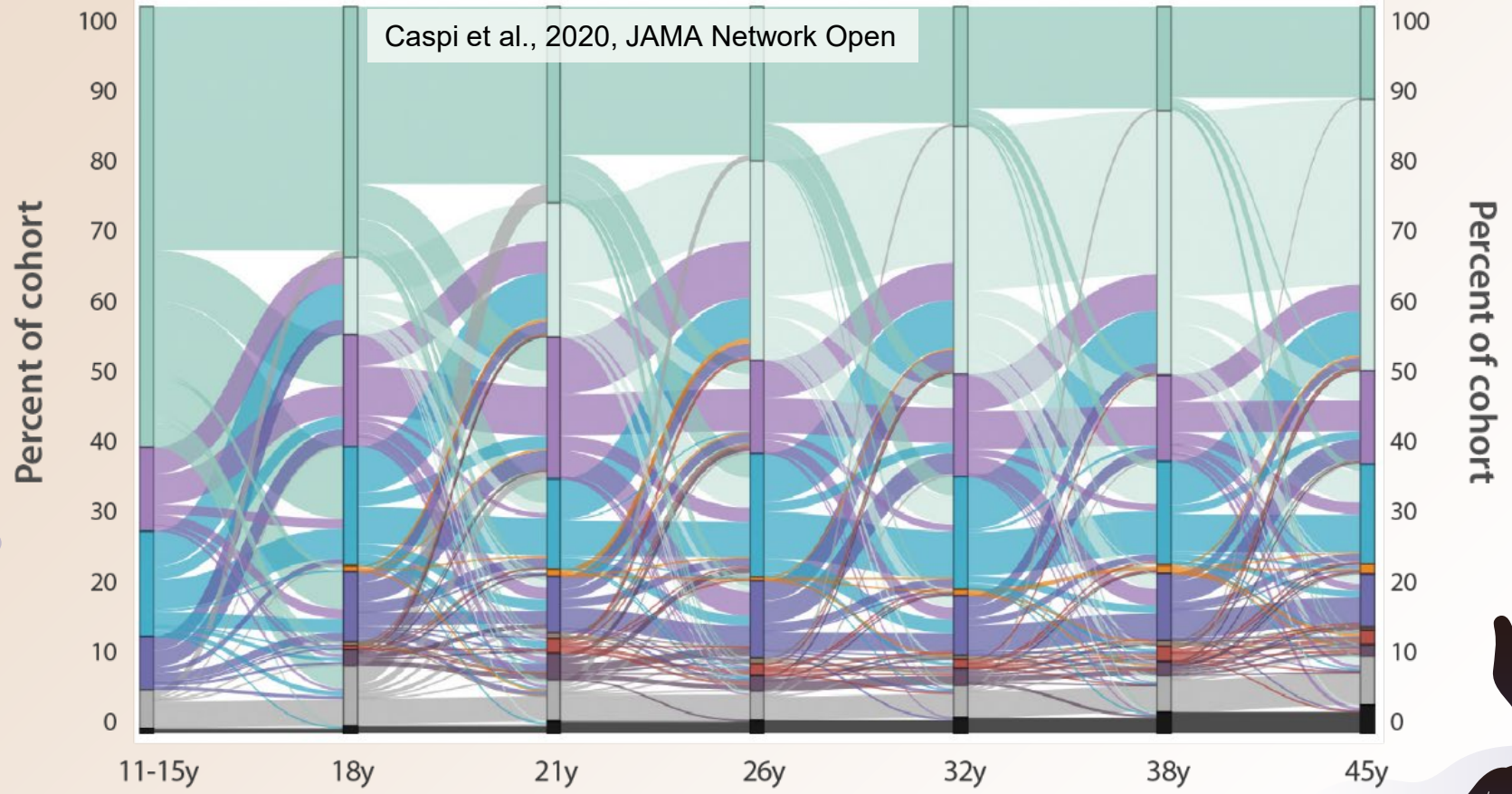


Age of onset of mental disorders

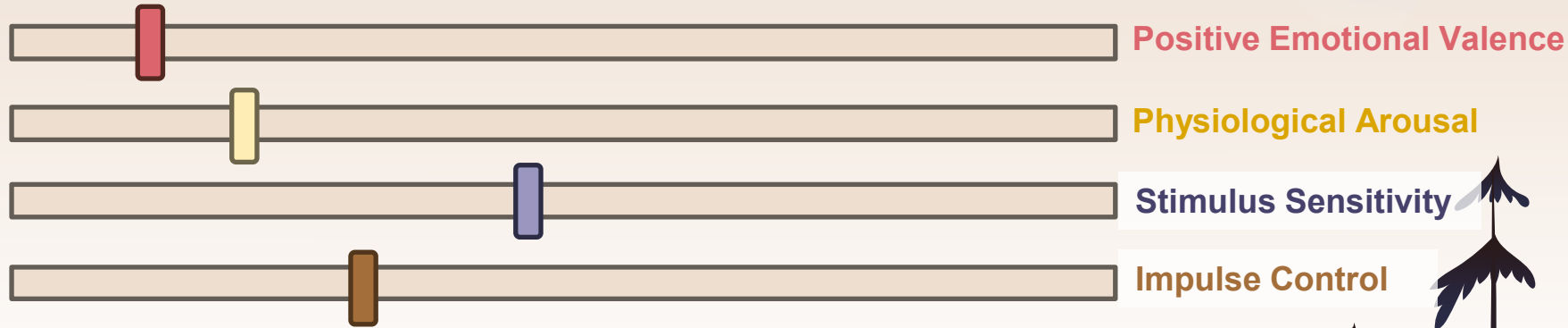
Meta-Analytic Proportion



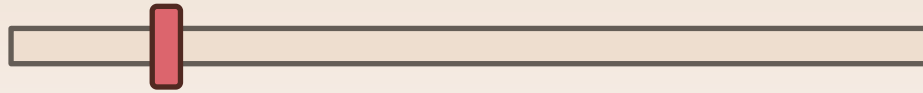
Caspi et al., 2020, JAMA Network Open



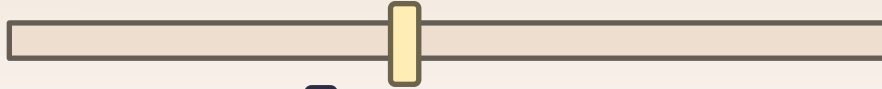
“Mental Health” reflects a dynamic interplay of thoughts, experiences, feelings, and behaviors



Our “baselines,” range, and movement on these poles arise from the interplay of our **fixed genes** & our **dynamic environments**



Positive Emotional Valence



Physiological Arousal

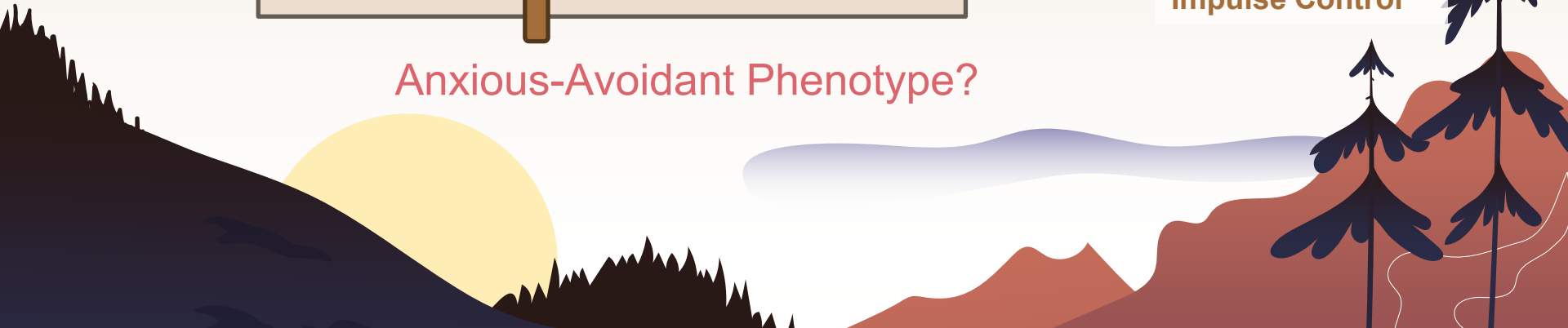


Stimulus Sensitivity



Impulse Control

Anxious-Avoidant Phenotype?



HIGH LEVEL
OF STRESS

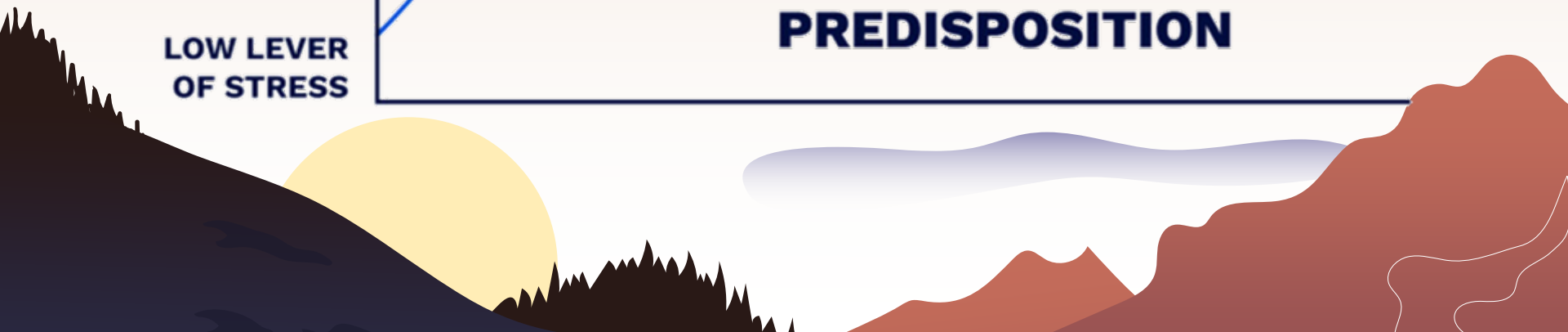
STRESS


Impaired function
/ distress

NATURAL
VULNERABILITY
THRESHOLD

LOW LEVEL
OF STRESS

PREDISPOSITION

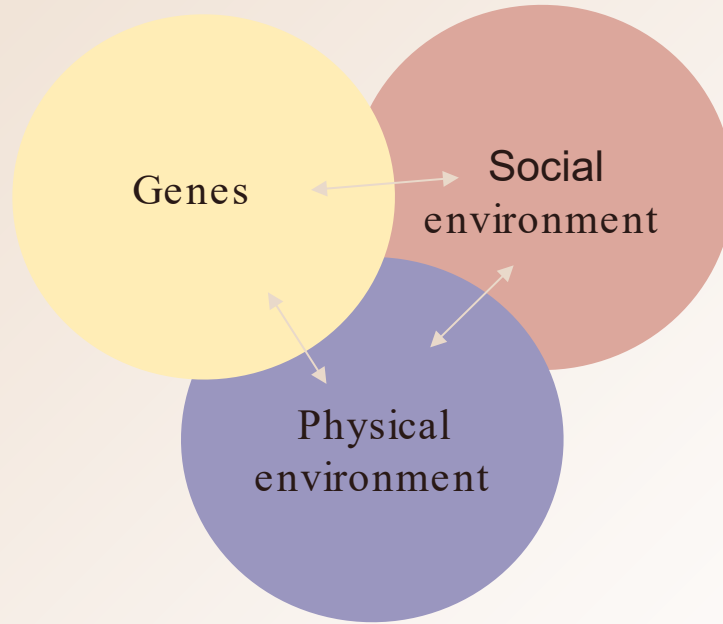




02

Contextualizing the
Air pollution-Mental
Health interplay

Dynamic
interplay
of stress &
resilience



Social environment

Siblings

Parents

Peers

Grandparents

Teachers

Neighbors

Social institutions

Economic institutions

Cultural institutions



Physical environment

Noise

Heat

Weather

UV light

Microbes

Flora

Fauna

Air Toxicants

Air particles

Water toxicants

Green spaces

Blue spaces

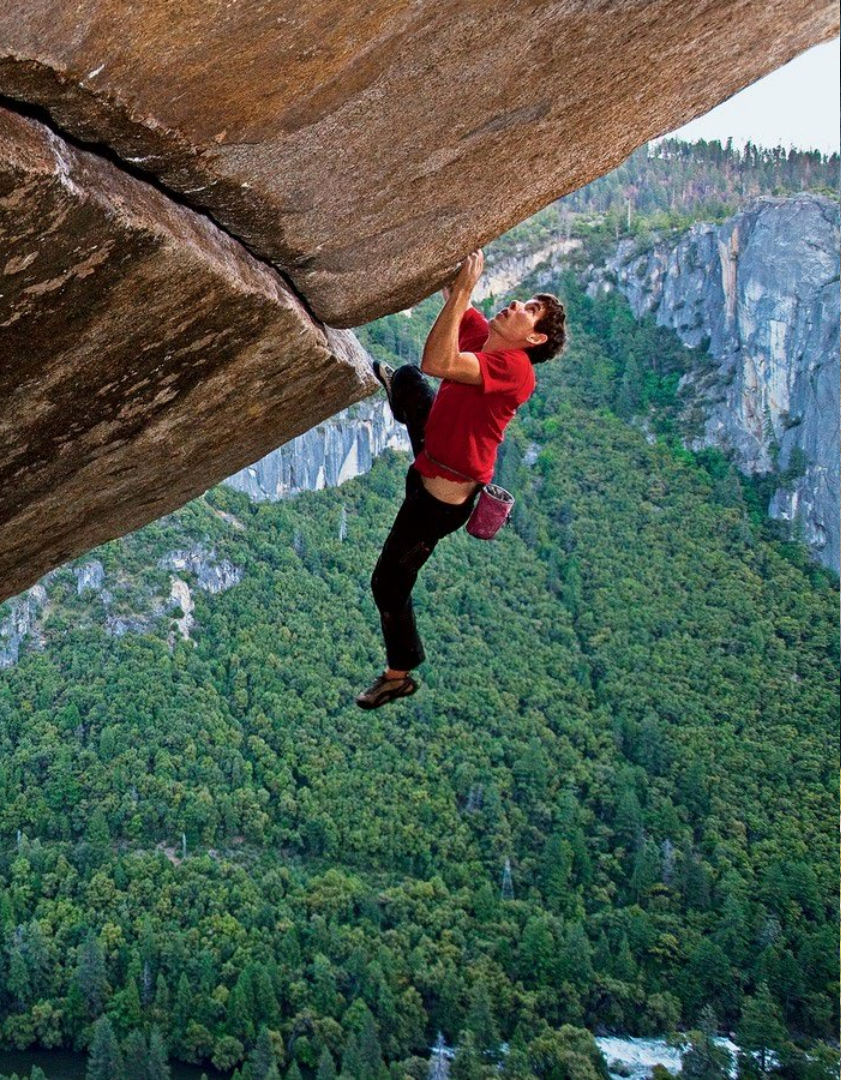
Highways

Rec centers

Shops

Narcotic outlets

Gambling venues



Healthy Location Index in Aotearoa New Zealand



Healthy Location Index

1-1

Goods-Bads

1 - best access; 3 - worst access

Environmental goods

99%

#469 out of 52891

Environmental bads

89%

#5900 out of 52891

Greenspace

99%

#1 out of 52891

Alcohol outlets

79%

#10841 out of 52891

Bluespace

81%

#9532 out of 52891

Gaming venues

89%

#5449 out of 52891

Physical activity

70%

#15729 out of 52891

Fast foods

78%

#11302 out of 52891

Fruit and vegetable

87%

#6854 out of 52891

Takeaways

62%

#19838 out of 52891

Supermarkets

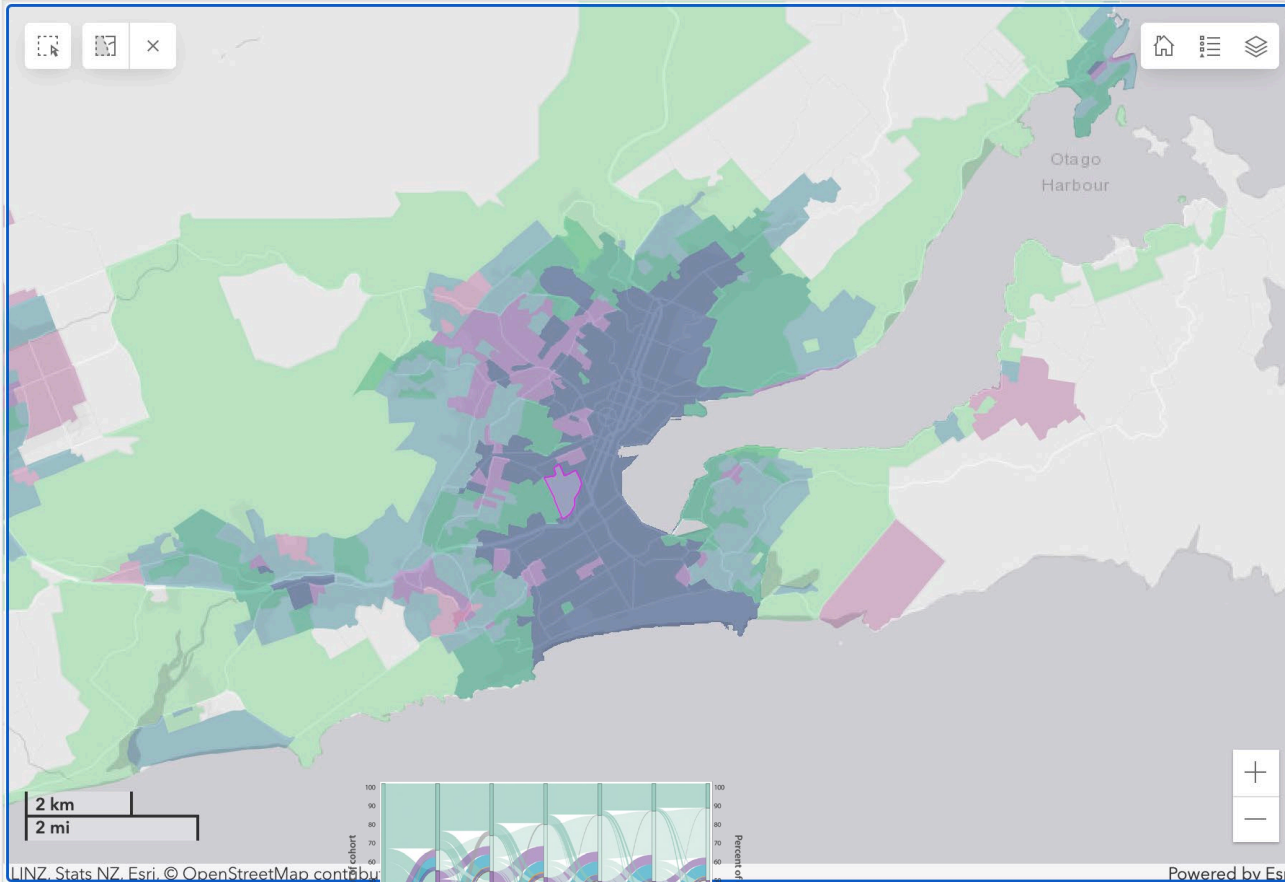
76%

#12380 out of 52891

Dairies

92%

#3902 out of 52891



Healthy Location Index

Relationship

Access to environmental bads

Access to environmental goods

others

High access to goods

Low access to both

High access to bads

Click on the to view other layers

New Zealand –based Dunedin Cohort

Healthy Location Index

1-1

Goods-Bads

1 - best access; 3 - worst access

Environmental goods

99%

#469 out of 52891

Environmental bads

89%

#5900 out of 52891

Greenspace

99%

#1 out of 52891

Alcohol outlets

79%

#10841 out of 52891

Bluespace

81%

#9532 out of 52891

Gaming venues

89%

#5449 out of 52891

Physical activity

70%

#15729 out of 52891

Fast foods

78%

#11302 out of 52891

Fruit and vegetable

87%

#6854 out of 52891

Takeaways

62%

#19838 out of 52891

Supermarkets

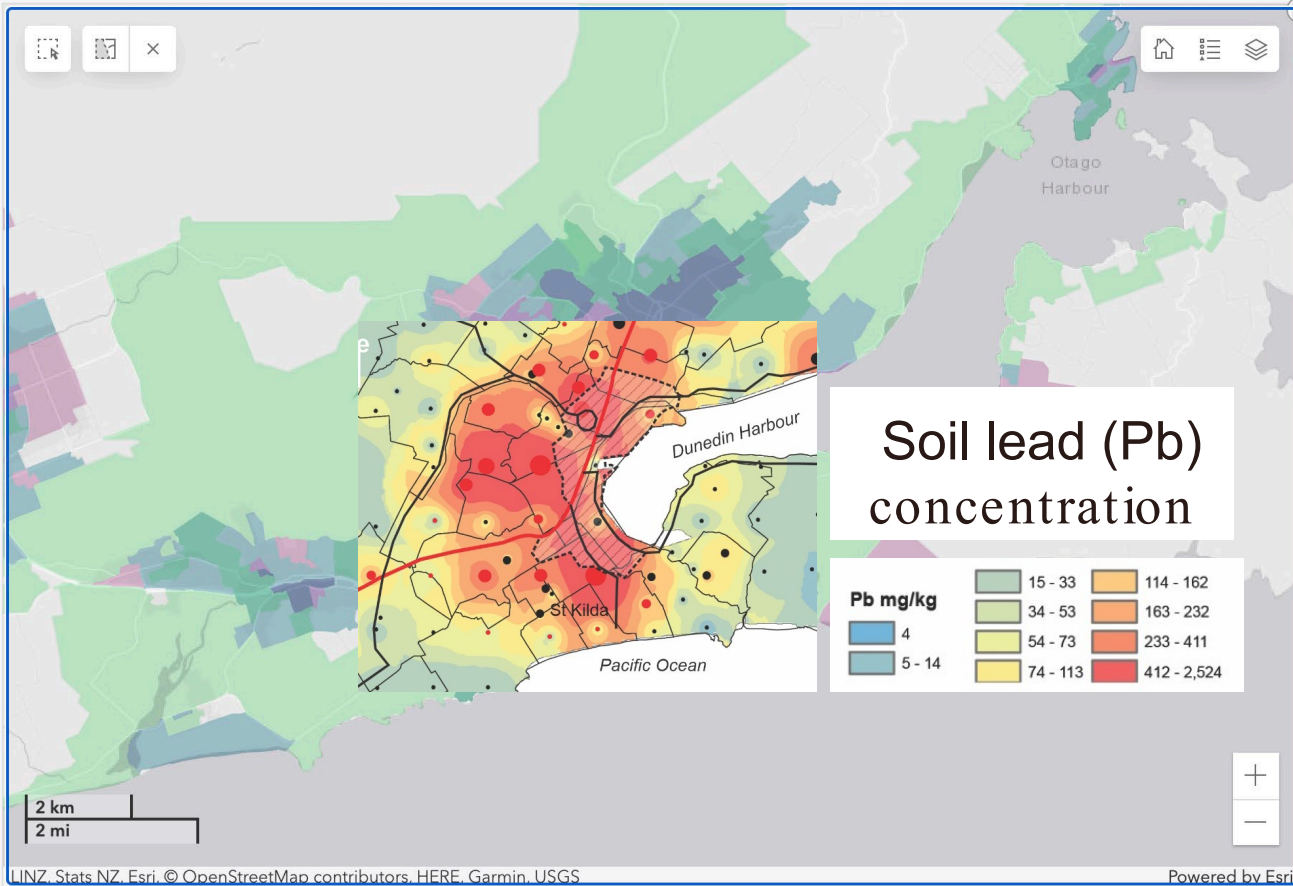
76%

#12380 out of 52891

Dairies

92%

#3902 out of 52891



Healthy Location Index

Relationship

Access to environmental bads

Access to environmental goods

others

High access to goods

Low access to both

High access to bads

Click on the  to view other layers

Healthy Location Index

1-1

Goods-Bads

1 - best access; 3 - worst access

Environmental goods

99%

#469 out of 52891

Environmental bads

89%

#5900 out of 52891

Greenspace

99%

#1 out of 52891

Alcohol outlets

79%

#10841 out of 52891

Bluespace

81%

#9532 out of 52891

Gaming venues

89%

#5449 out of 52891

Physical activity

70%

#15729 out of 52891

Fast foods

78%

#11302 out of 52891

Fruit and vegetable

87%

#6854 out of 52891

Takeaways

62%

#19838 out of 52891

Supermarkets

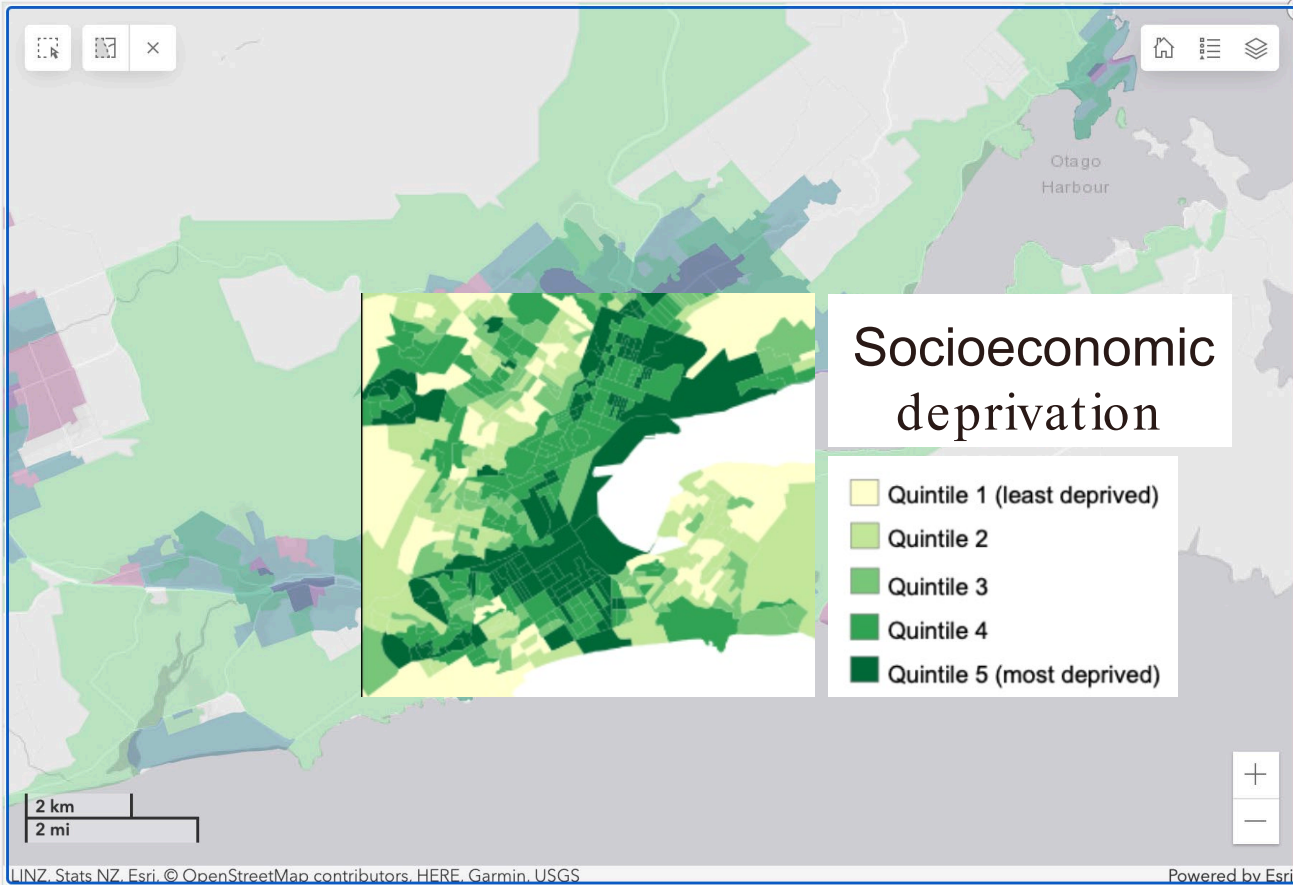
76%

#12380 out of 52891

Dairies

92%

#3902 out of 52891



Healthy Location Index

Relationship

Access to environmental bads

Access to environmental goods

others

High access to goods

Low access to both

High access to bads

Click on the  to view other layers

I n t e r n a l e n v i r o n m e n t

Microbes

Hormones

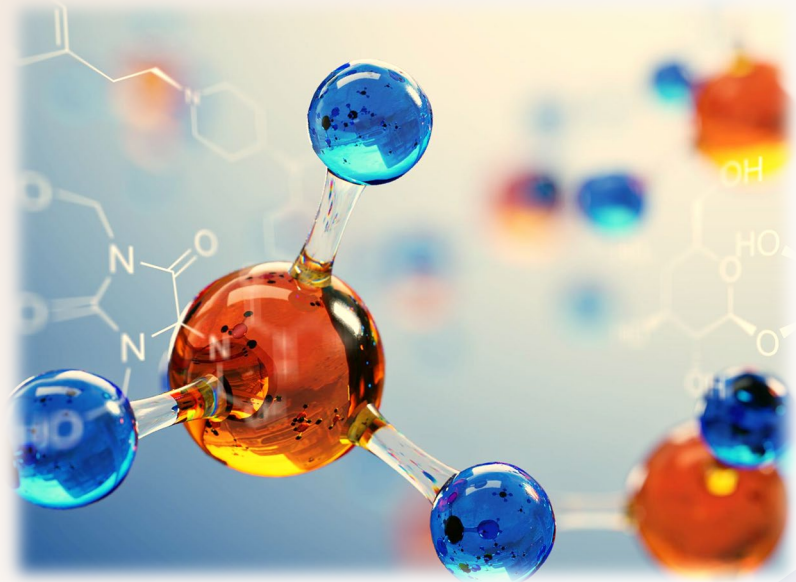
Nutrition

Toxicants

Medications

Metabolites

Epigenome



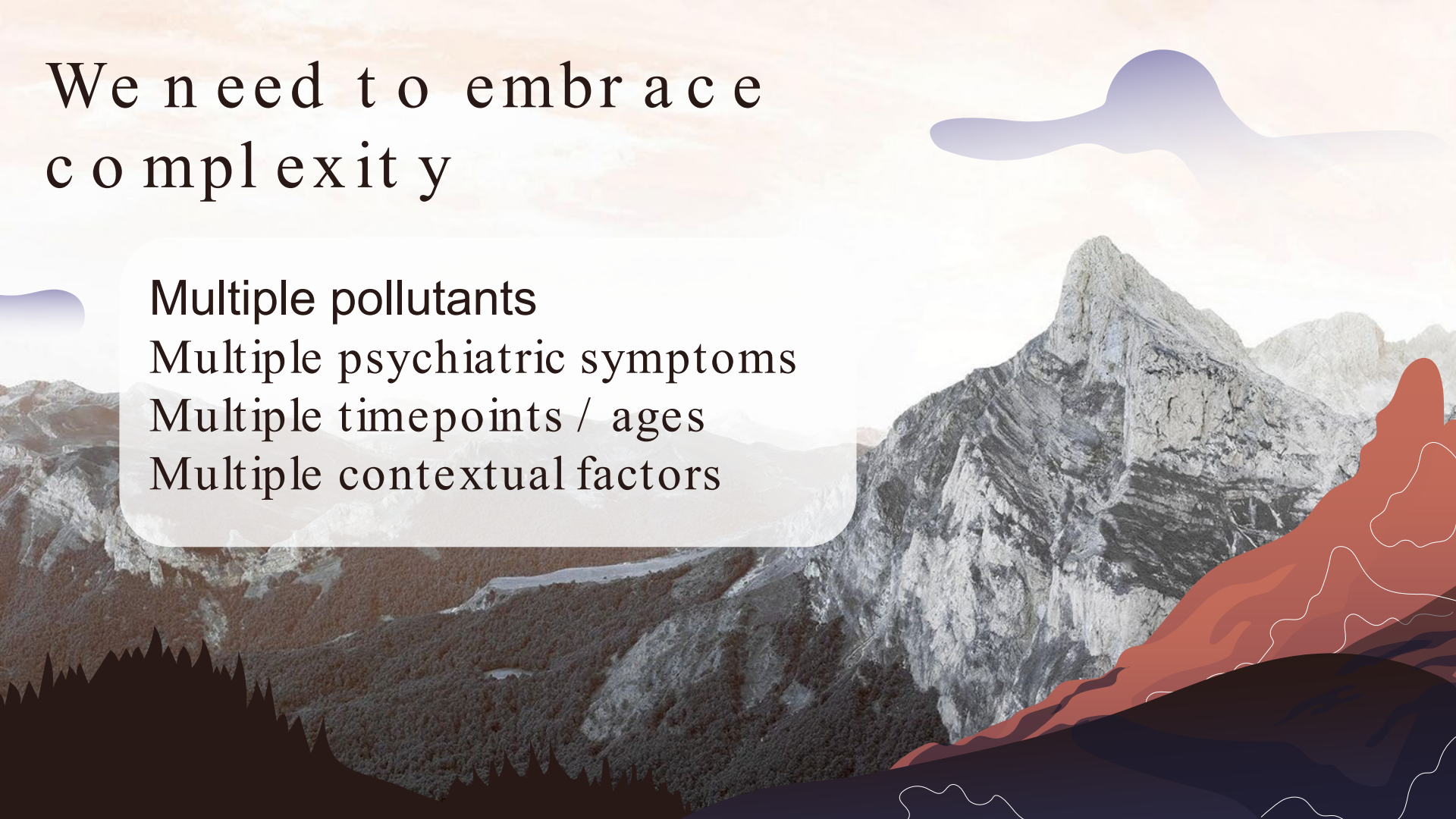
We need to embrace complexity

Multiple pollutants

Multiple psychiatric symptoms

Multiple timepoints / ages

Multiple contextual factors



E-RiSK

Environmental Risk
Longitudinal Twin Study

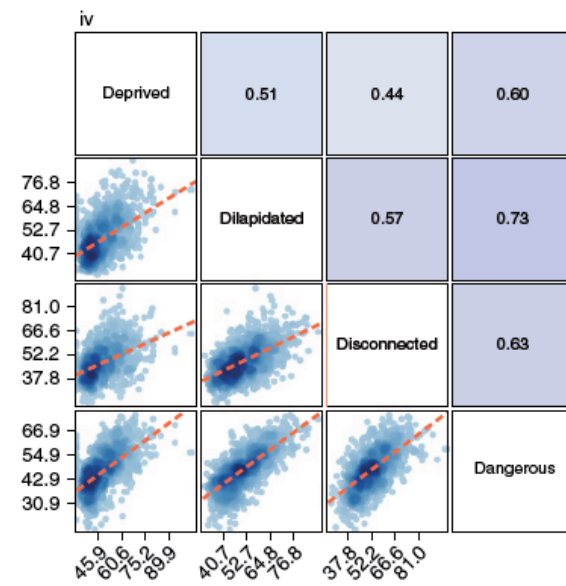
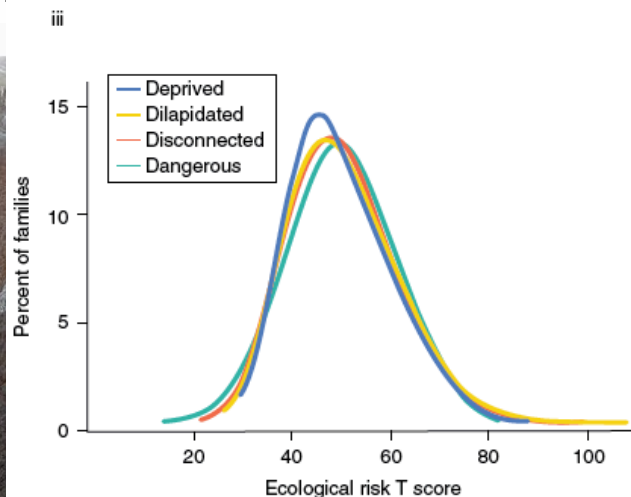
- 2,232 twin children
- Born 1994-1995
- In England and Wales
- Followed to age 18 (93% retention)



E-RiSK

Environmental Risk
Longitudinal Twin Study

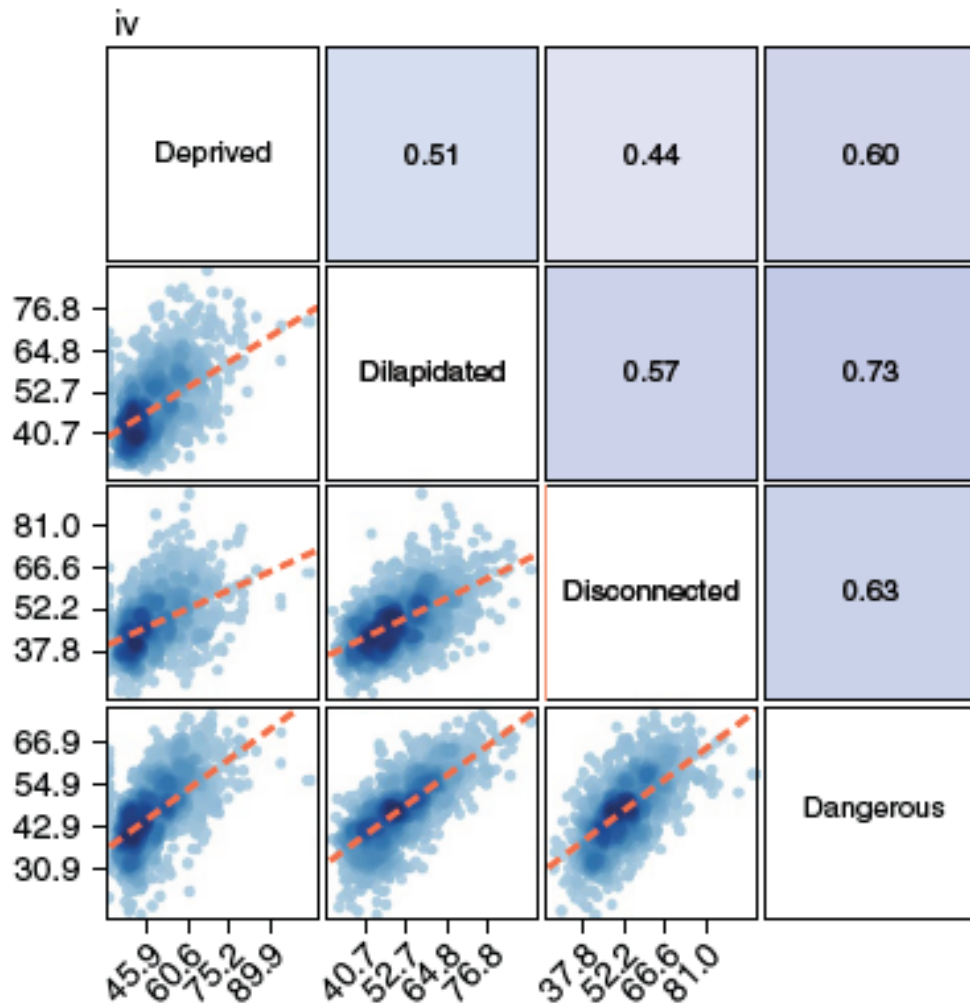
- 2,232 twin children
- Born 1994-1995
- In England and Wales
- Followed to age 18 (93% retention)



E-RiSK

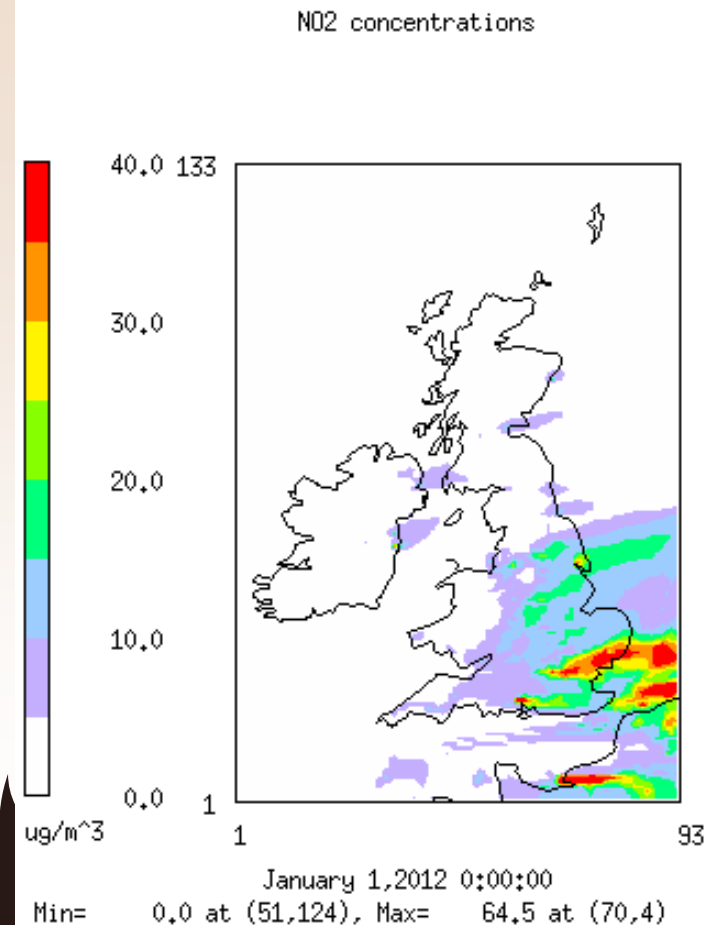
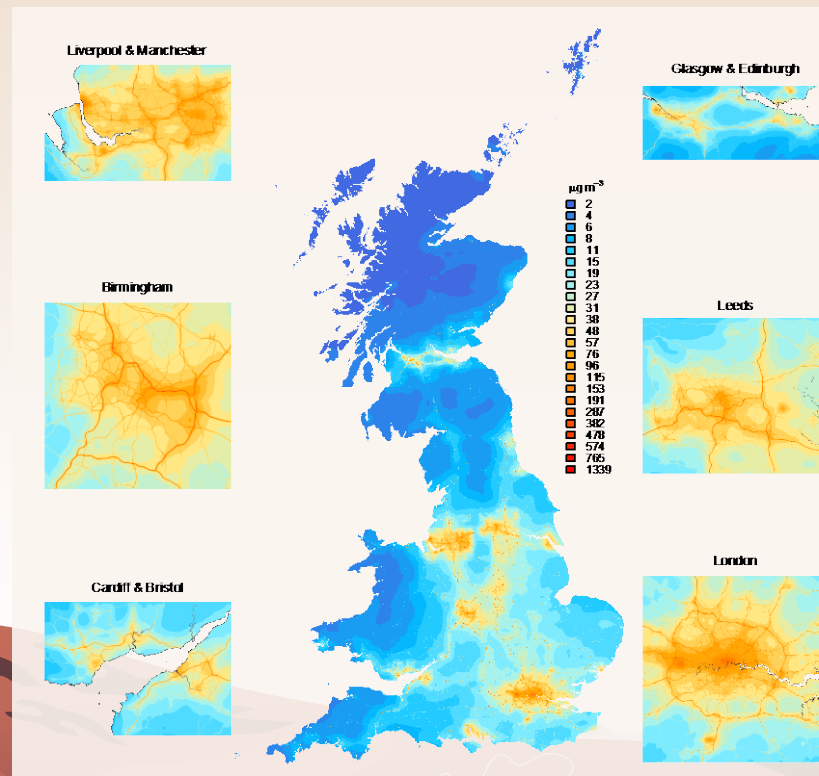
Environmental Risk
Longitudinal Twin Study

- 2,232 twin children
- Born 1994-1995
- In England and Wales
- Followed to age 18 (93% retention)

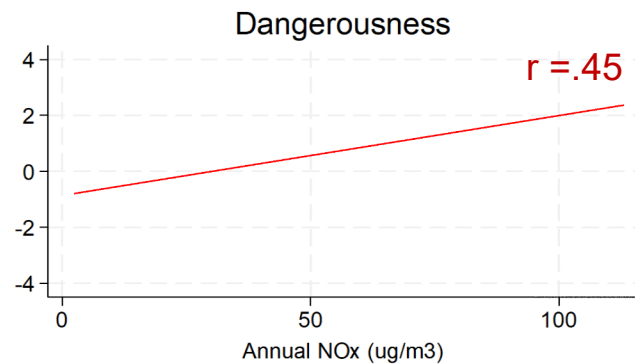
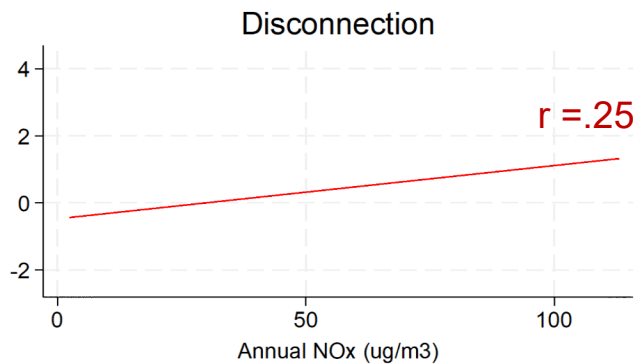
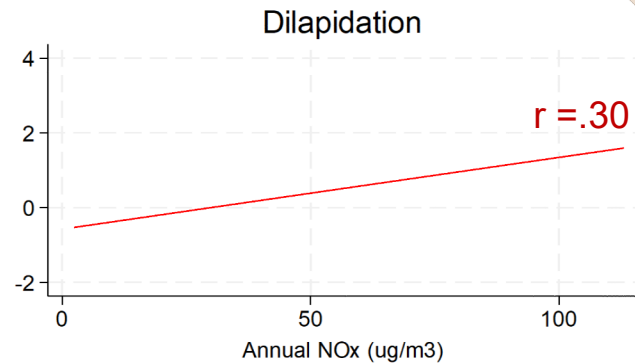
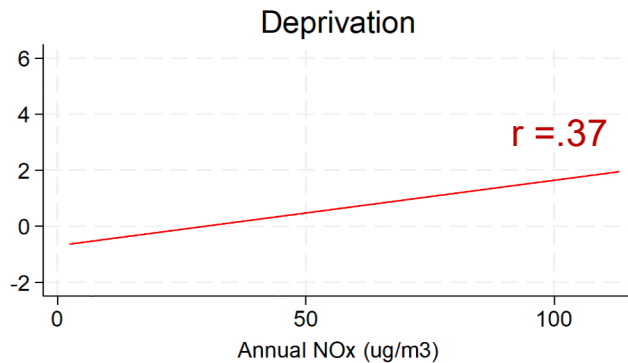


Assessed NOx and PM2.5

At 20x20m resolution down to home address

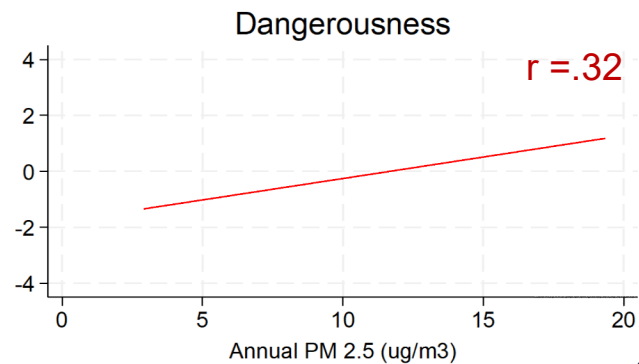
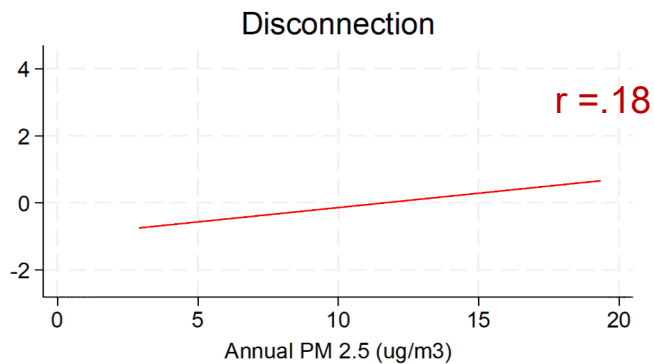
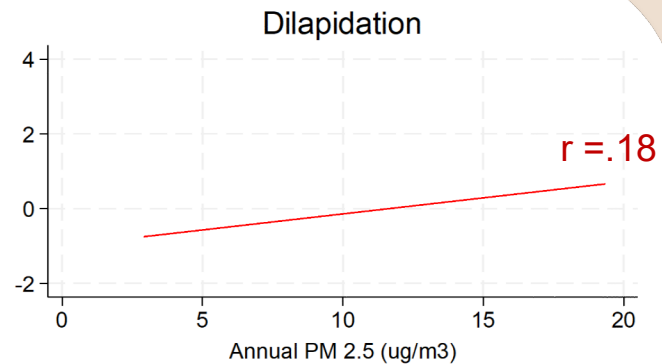
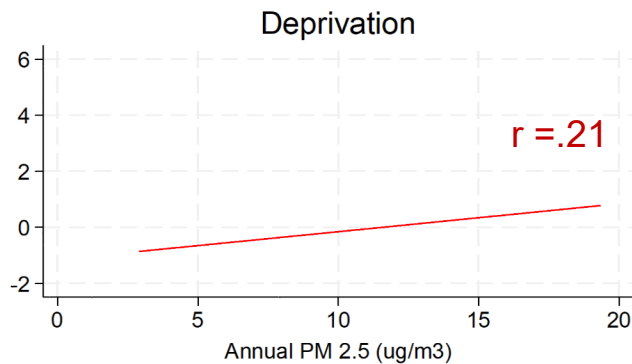


Significant air
pollution -
neighborhood
condition overlap

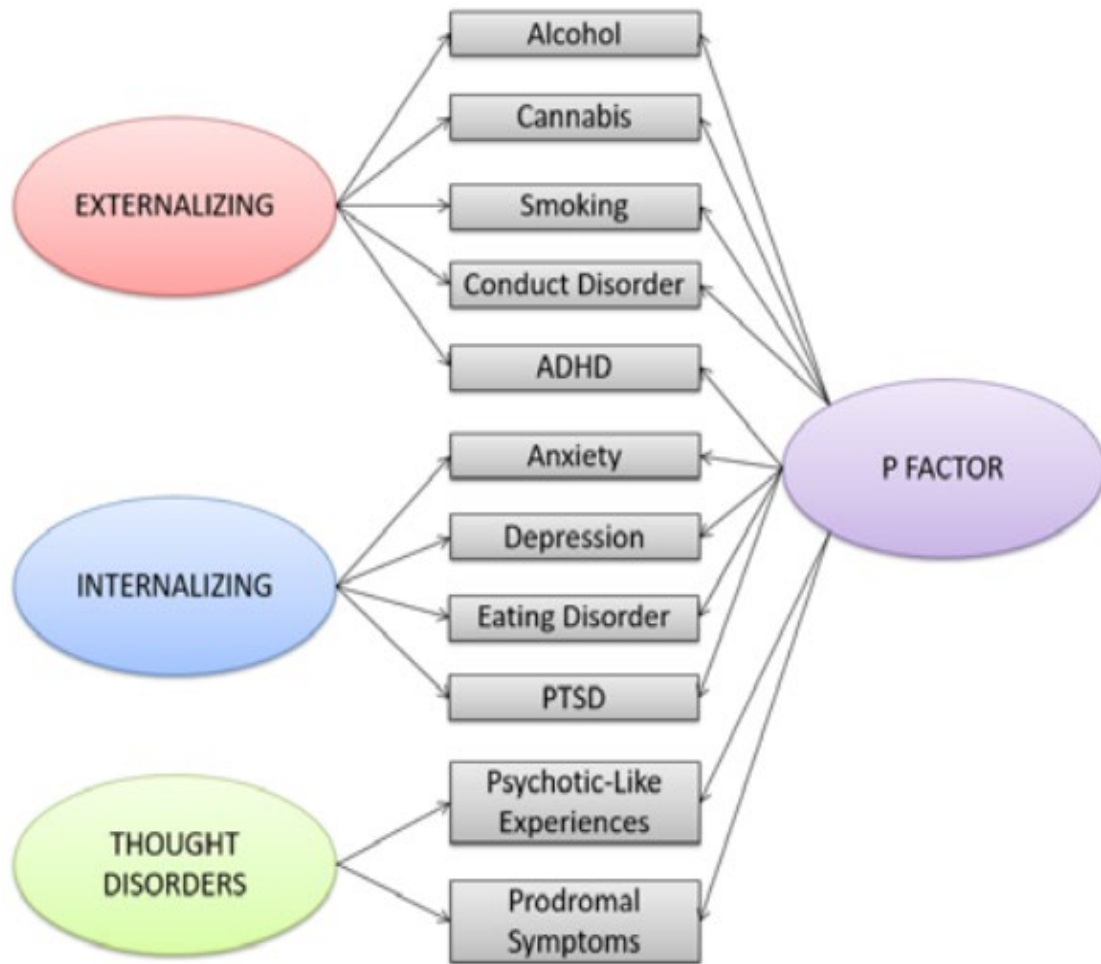


NO_x

Significant air
pollution -
neighborhood
condition overlap

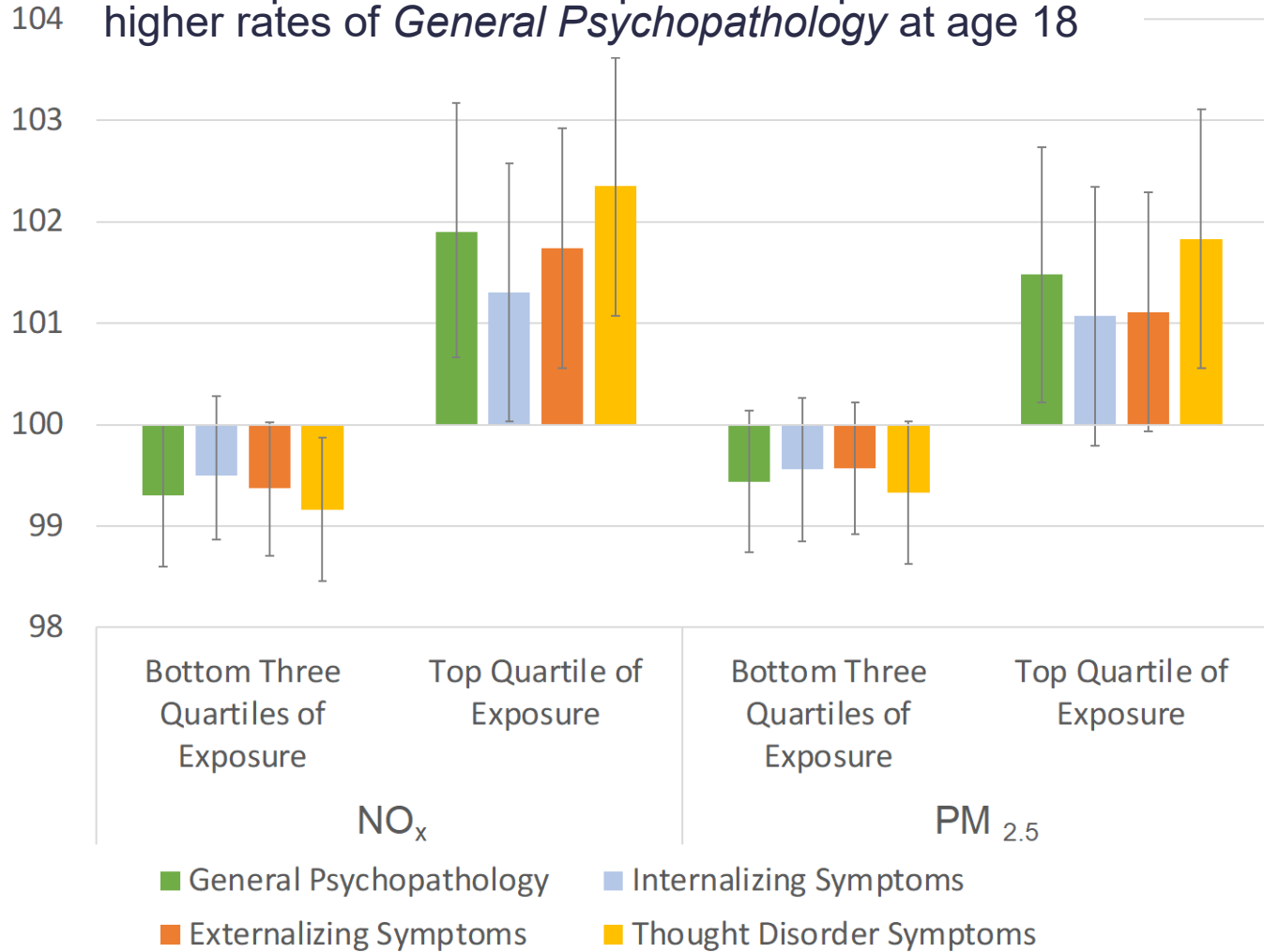


PM_{2.5}



Youth exposed to more air pollution experienced higher rates of *General Psychopathology* at age 18

Psychopathology Factor Scores



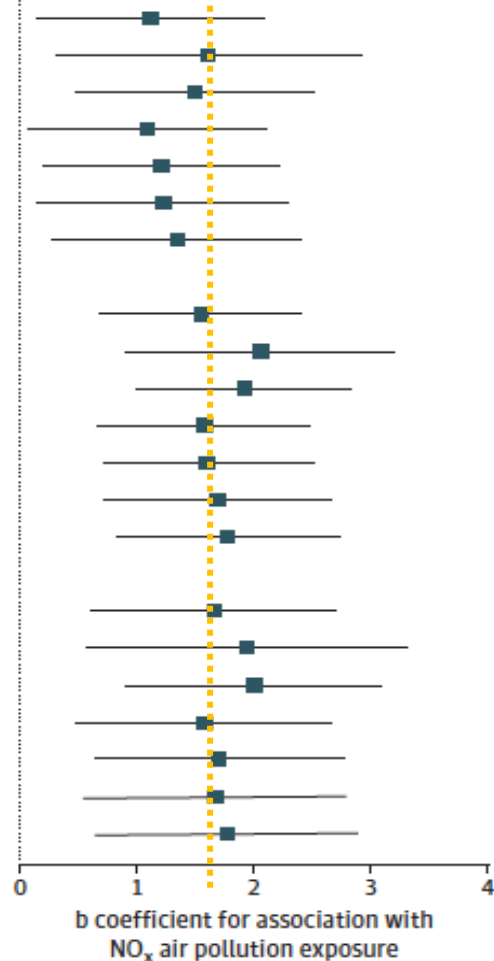
Reuben et al.,
2021, JAMA
Network Open

Internalizing

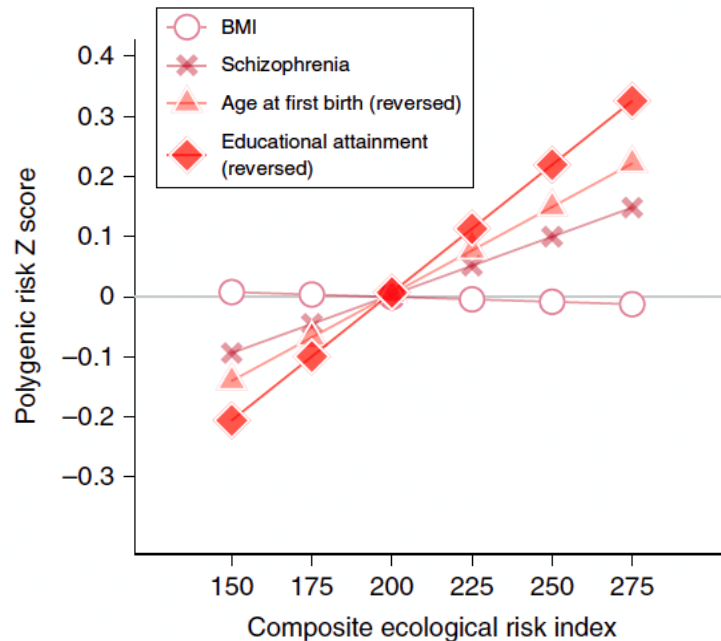
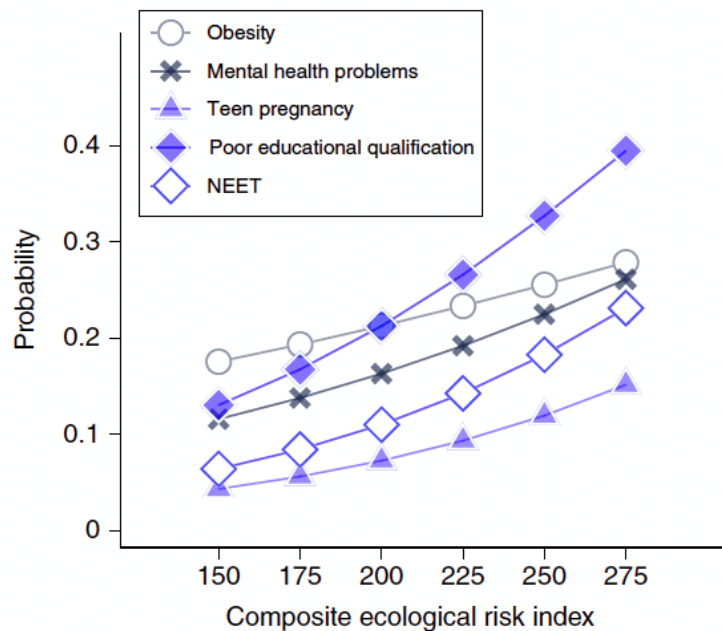
Externalizing

Thought disorder

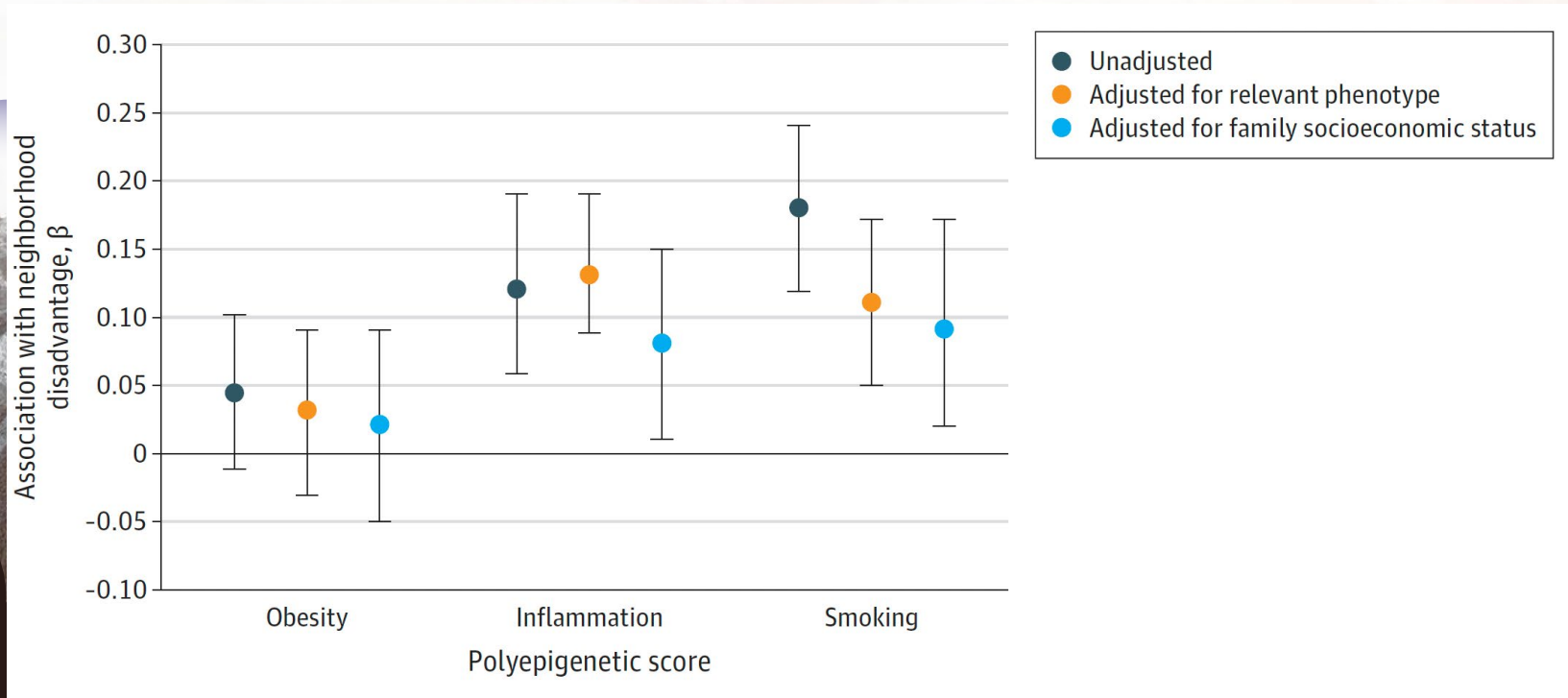
| Model | b (95% CI) |
|-----------------------------------------|------------------|
| Internalizing | |
| Stage 1 (original) fully adjusted model | 1.20 (0.22-0.22) |
| Adjusted for urbanicity | 1.70 (0.38-3.03) |
| Adjusted for socioeconomic deprivation | 1.59 (0.56-2.62) |
| Adjusted for physical dilapidation | 1.18 (0.15-2.20) |
| Adjusted for social disconnection | 1.31 (0.30-2.31) |
| Adjusted for dangerousness | 1.32 (0.24-2.41) |
| Adjusted for overall ecological risk | 1.44 (0.37-2.51) |
| Externalizing | |
| Stage 1 (original) fully adjusted model | 1.58 (0.69-2.48) |
| Adjusted for urbanicity | 2.09 (0.92-3.27) |
| Adjusted for socioeconomic deprivation | 1.96 (1.02-2.90) |
| Adjusted for physical dilapidation | 1.61 (0.68-2.53) |
| Adjusted for social disconnection | 1.64 (0.73-2.55) |
| Adjusted for dangerousness | 1.73 (0.73-2.72) |
| Adjusted for overall ecological risk | 1.82 (0.85-2.79) |
| Thought disorder | |
| Stage 1 (original) fully adjusted model | 1.66 (0.61-2.71) |
| Adjusted for urbanicity | 1.94 (0.58-3.31) |
| Adjusted for socioeconomic deprivation | 2.00 (0.90-3.09) |
| Adjusted for physical dilapidation | 1.58 (0.49-2.67) |
| Adjusted for social disconnection | 1.70 (0.63-2.77) |
| Adjusted for dangerousness | 1.67 (0.53-2.80) |
| Adjusted for overall ecological risk | 1.78 (0.65-2.90) |



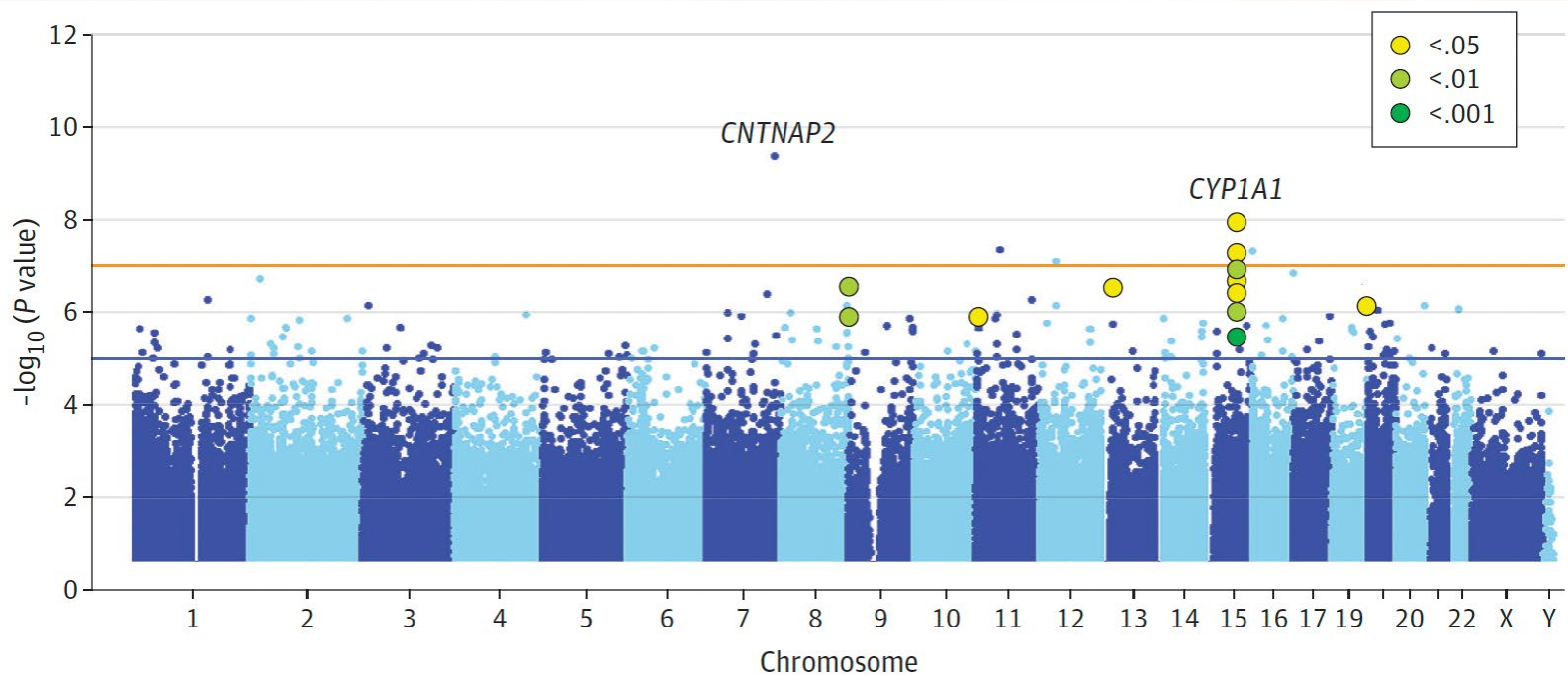
We need to embrace complexity



We need to embrace complexity



We need to embrace complexity



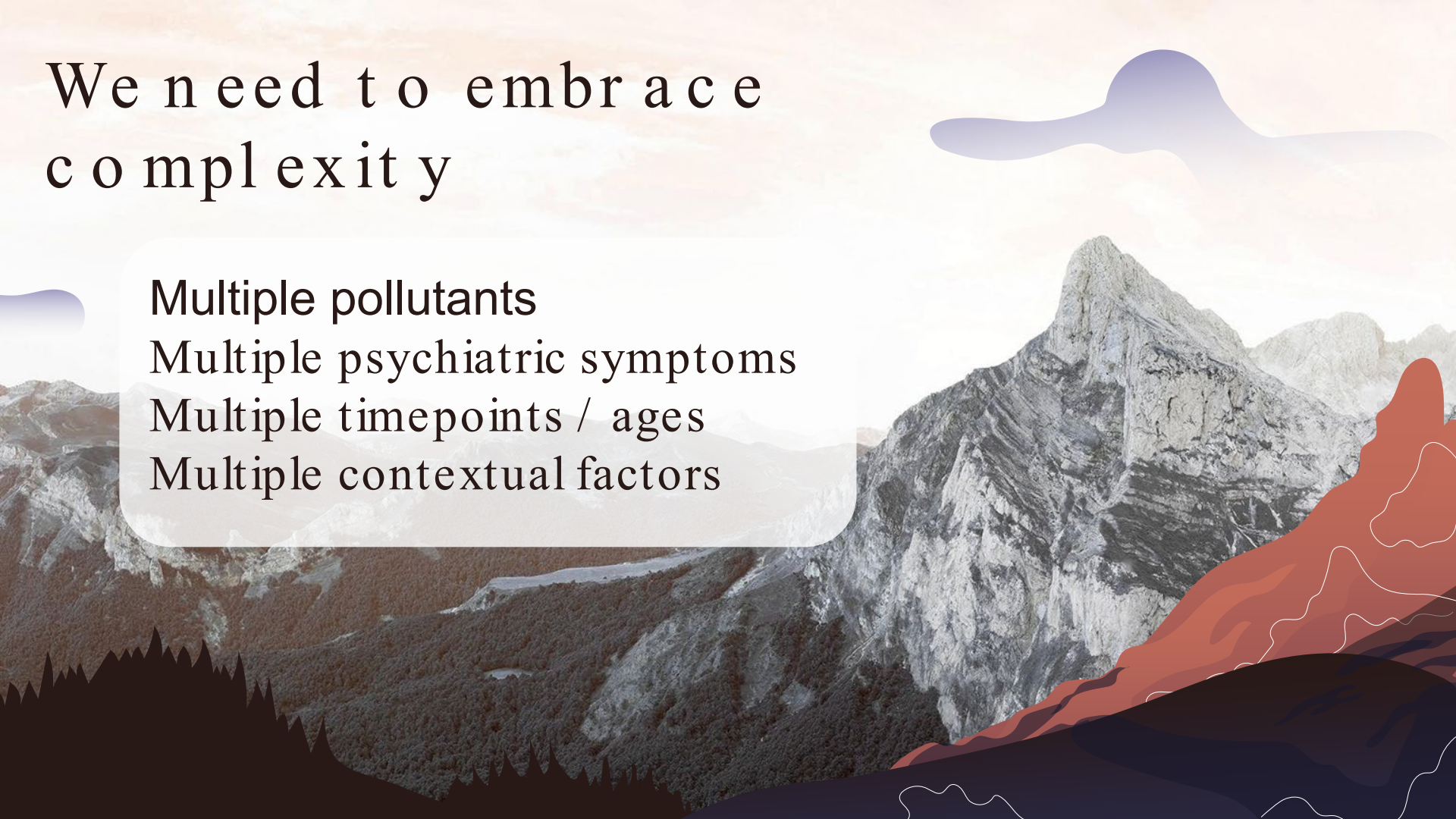
We need to embrace complexity

Multiple pollutants

Multiple psychiatric symptoms

Multiple timepoints / ages

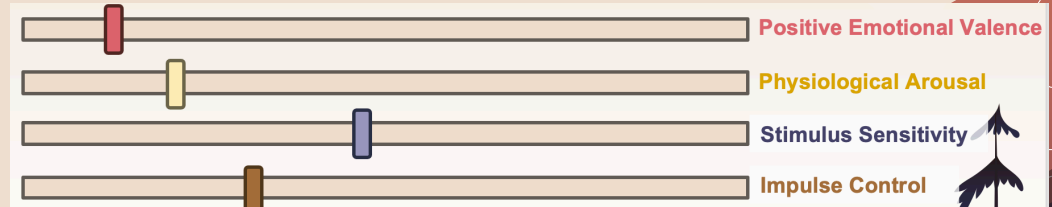
Multiple contextual factors



Why is air pollution robustly associated with global elevation in psychiatric symptoms?

A disordered brain?

- Weaker thought control
- Weaker impulse inhibition
- Weaker emotion regulation
- Etc.





Funders:



Co-authors and collaborators:

- Helen Fisher
- Terrie Moffitt
- Avshalom Caspi
- Joanne Newbury
- Moana Theodore
- Karen Sugden
- Jonathan Broadbent
- Renate Houts
- Ioannis Bakolis
- Sandhya Ramrakha
- Matthew Hobbs
- Daniel Belsky
- Jonathan Schaefer

Thank you

Aaron.Reuben@virginia.edu

www.aaronreuben.com

CREDITS: This presentation template was created by **Slidesgo**, including icons by **Flaticon** and infographics & images by **Freepik**