Environmental Exposures and Neurodegeneration: From Risk to Resilience

Burcin Ikiz, PhD

HEI Annual Conference
April 27, 2026

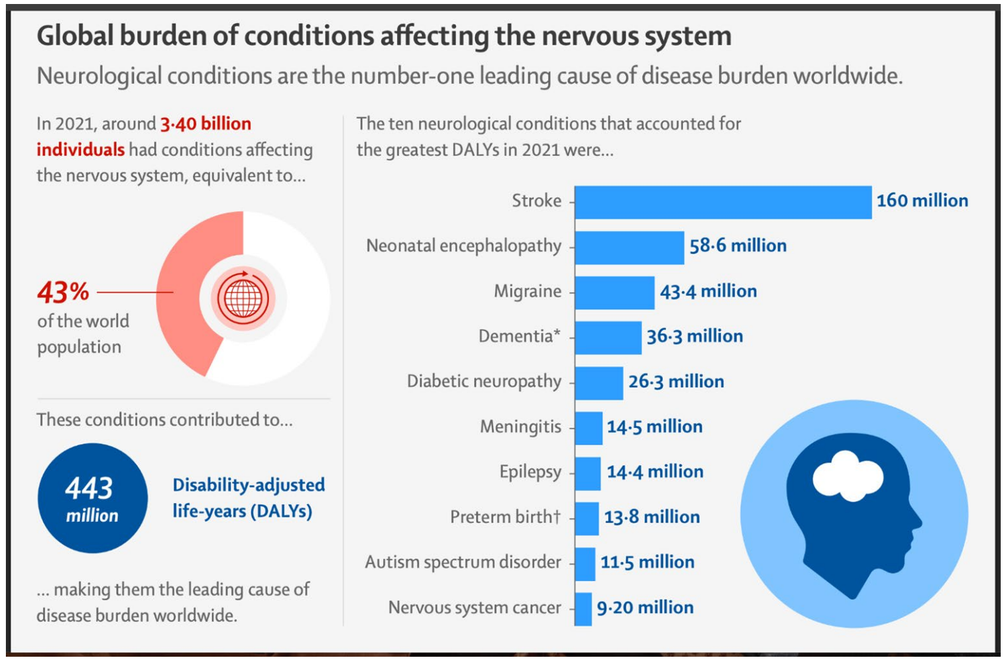
Neuro Climate
WORKING GROUP

Banyan Commons

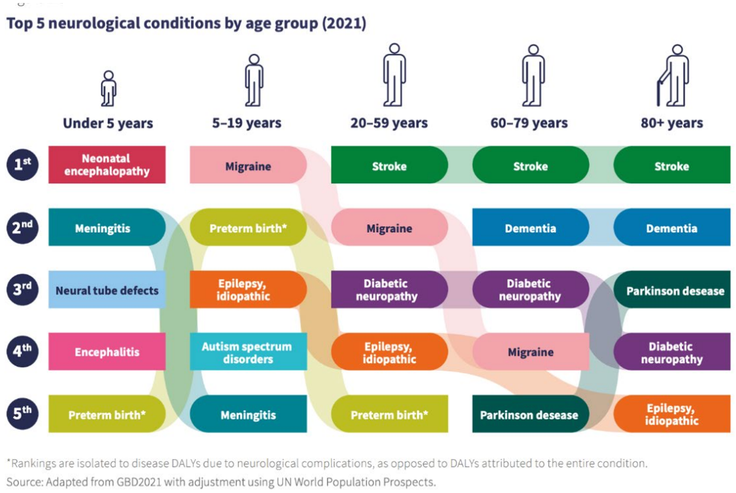
Stanford
University

GLOBAL CONSORTIUM
ON CLIMATE AND
HEALTH EDUCATION

Why do we care? The global burden of neurodegenerative diseases (NDs)



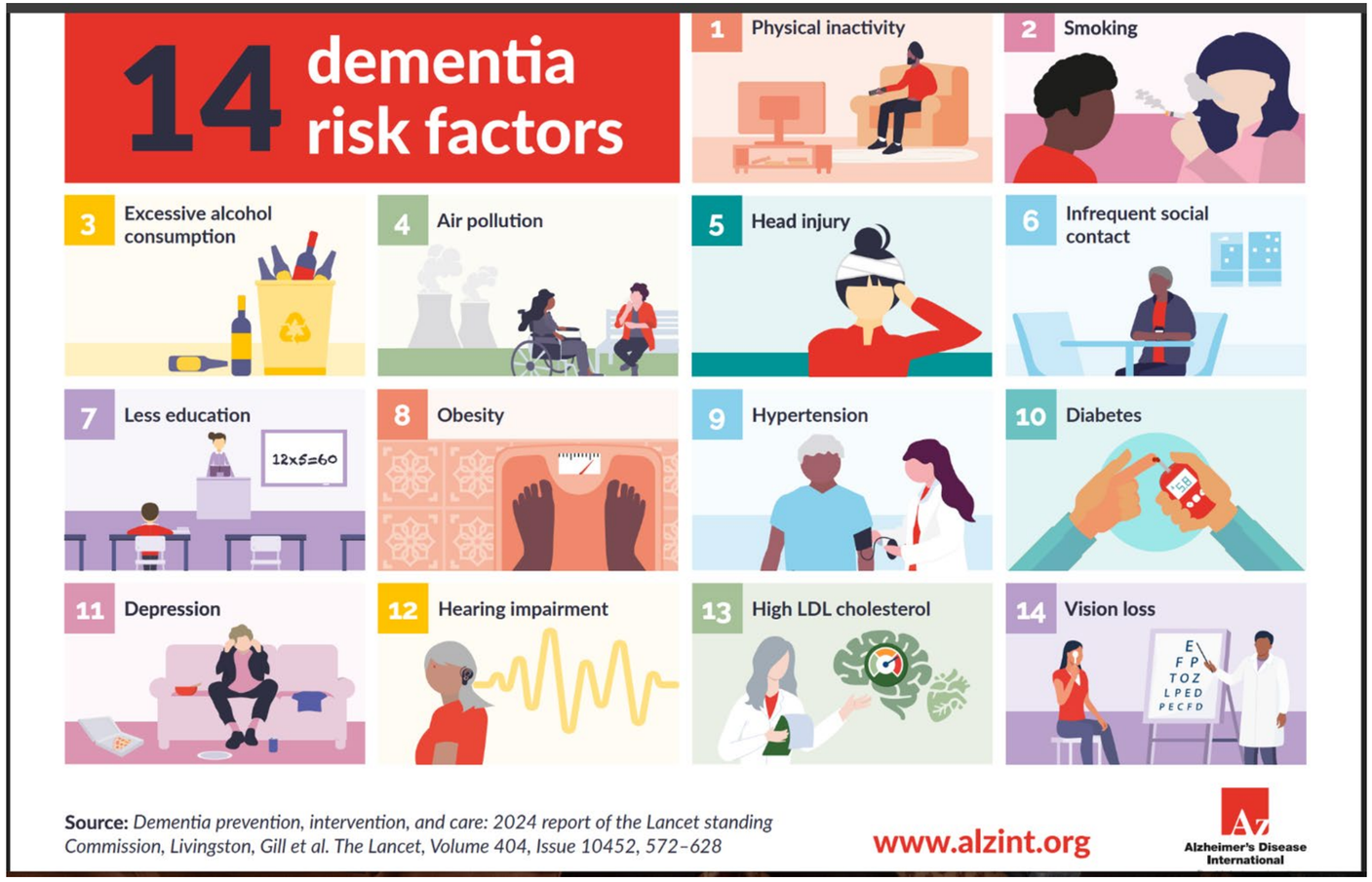
Steinmetz J et al., Global Burden of Neurological Diseases, The Lancet Neurology, 2024



WHO 2025 Global Status Report on Neurology

Neuro Climate
WORKING GROUP

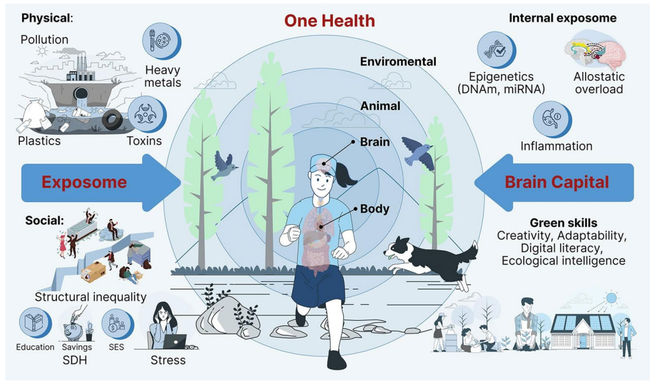
Beyond genetics: the modifiable risk factors of NDs



Up to ~45% of dementia risk is linked to modifiable factors

Neuro Climate
WORKING GROUP

Our brains' aging and ND risk are shaped by our environments



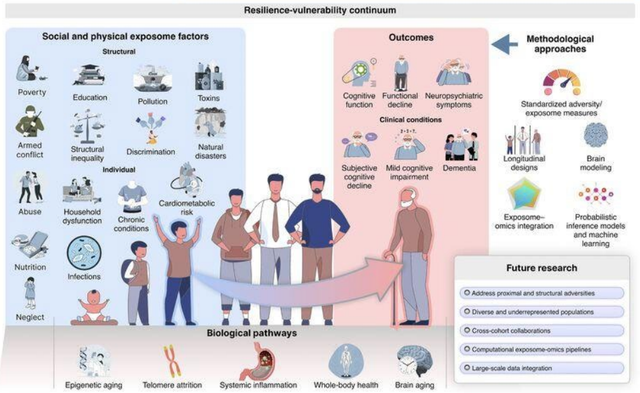
Ibanez et al., Neuron. 2024

REVIEW

CURRENT OPINION

Childhood adversities and the exposome in dementia risk and brain health

Sandra Baez[a,b], Yehia Nabil[c] and Agustin Ibanez[a,d,e,f,g]

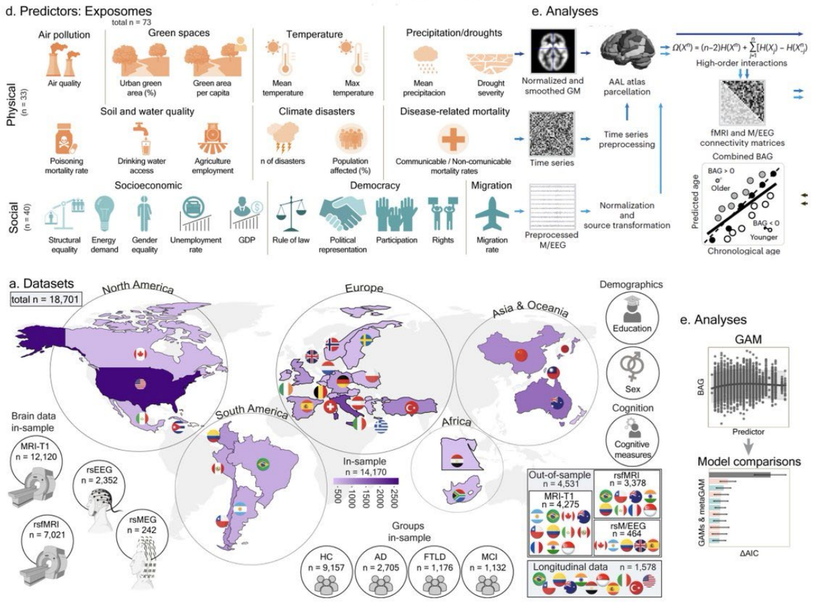


Baez et al., Curr Opin Psychi, 2026

nature medicine

Article

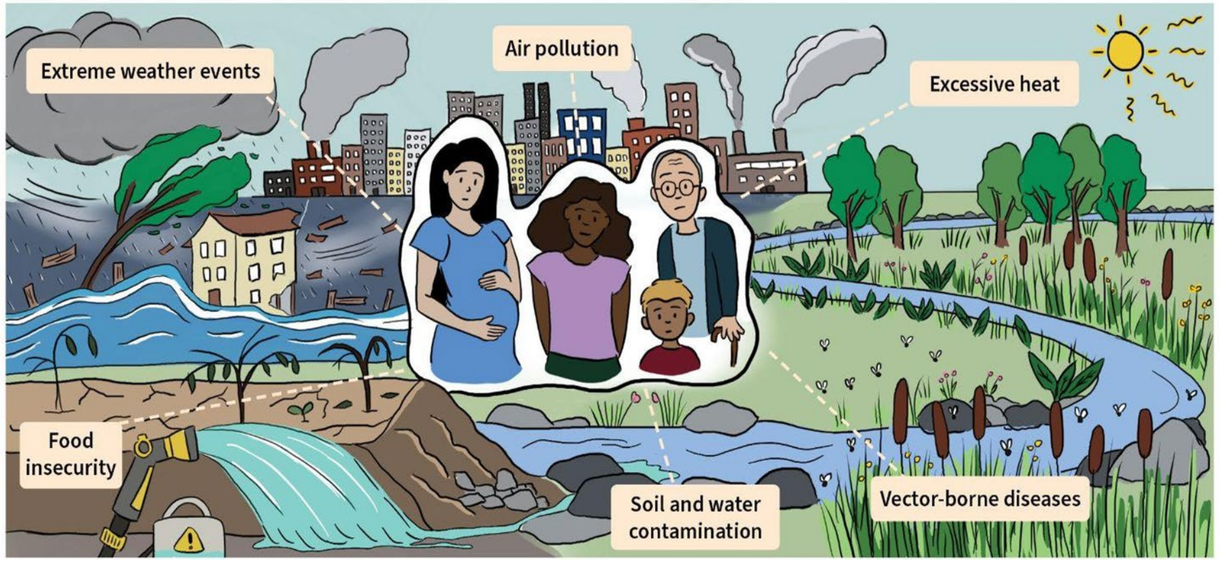
The exposome of brain aging across 34 countries



Legaz et al., Nature Medicine, 2026

Neuro Climate
WORKING GROUP

Environmental risk factors of ND



Associated brain diseases and effects

● Neurodevelopmental disorders ■ Neurodegenerative disorders ▲ Mental health disorder ⬟ Intergenerational effects ✦ Other neurological conditions

Factors	↓	Direct effects on brain health	Effects on cognition and behavior
Excessive heat	● ✦ ■ ▲	Changes in blood-brain barrier (BBB) permeability, making the brain more vulnerable to inflammation and toxins.	Impairments in memory and attention, increased risk in mental health symptoms, aggression, and impulsivity.
Extreme weather events	▲ ⬟	Brain volume alterations in the amygdala, hippocampus, and caudate.	Acute stress responses that can lead to depression, anxiety, and post-traumatic stress disorder.
Air pollution	● ■	Particulate matter from the air penetrates BBB leading to inflammation, oxidative stress, and neurodegeneration.	Symptoms of anxiety, depression and impaired cognitive functions.
Food insecurity	● ⬟	Lack of nutrients to the brain can impair growth and brain development.	Malnutrition can cause long-term cognitive effects during critical developmental periods and increase stress.
Soil and water contamination	■	Neurotoxins found in the environment accumulate to the top of the food chain (humans) and have neurodegenerative effects.	Lead to cognitive impairments, behavioural problems and developmental delays.
Vector-borne diseases	● ✦ ⬟ ▲ ■	Inflammation, neurodegeneration, and birth defects, such as microcephaly.	Increased risk of mental health disorders (e.g., individuals diagnosed with Lyme disease).

Neuro Climate WORKING GROUP

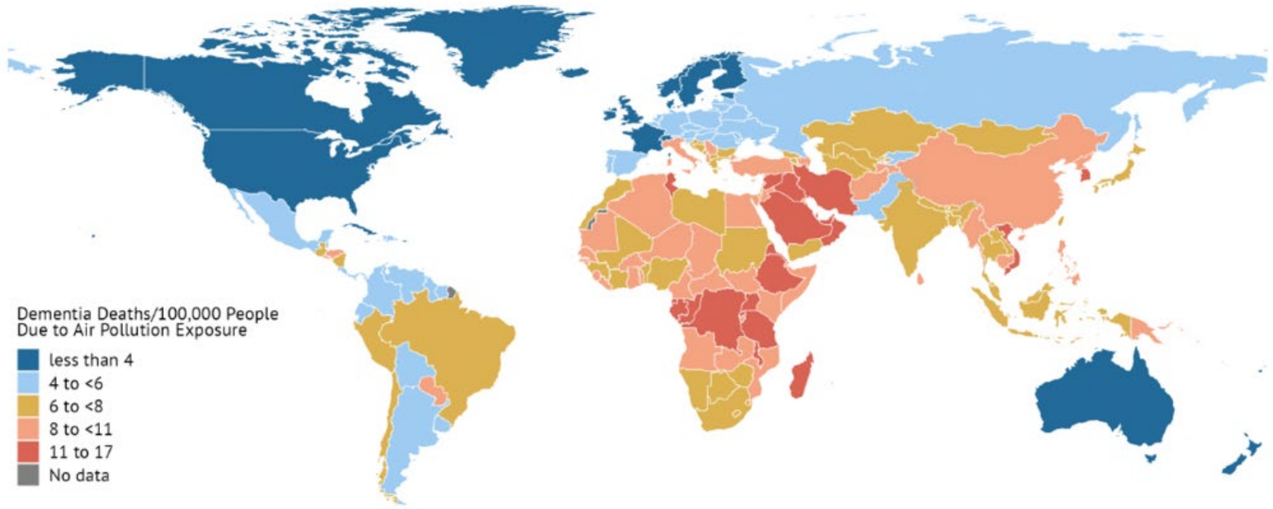
Neuro Climate Working Group State of Science Report 2026 (coming soon)

Air Pollution: A major modifiable risk factor of NDs

- Air pollution is now recognized as a major contributor to neurodegeneration, including Alzheimer's disease, vascular dementia, and mild cognitive impairment.
- In 2023, approximately 626,000 dementia deaths globally (≈29%) were attributable to air pollution, with the highest burdens in Africa and Asia.
- Even modest pollution-related increases in dementia risk have large societal impacts, given population-wide exposure, aging demographics, and caregiving burdens, especially for women.

Late adulthood

Increased risk for cerebrovascular diseases and dementia



In 2023, dementia attributable to air pollution resulted in 626,000 deaths and 11.6 million healthy years of life lost.

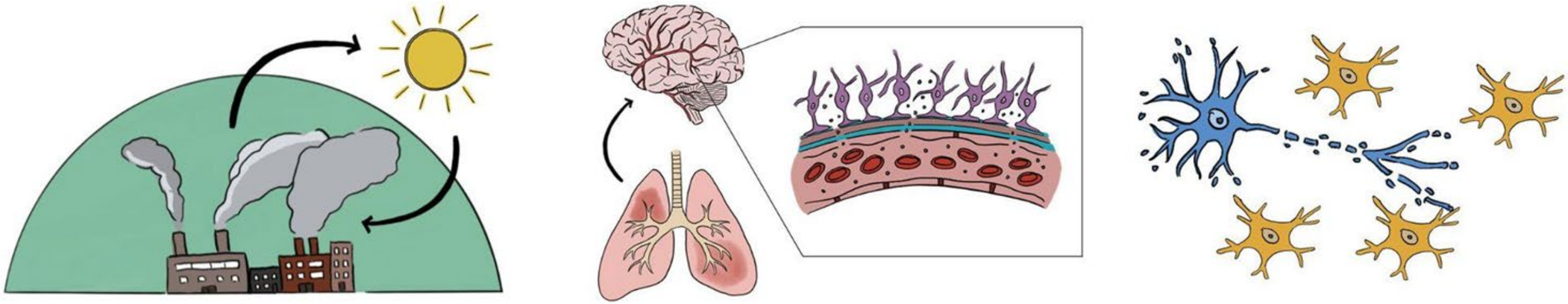
More than **1 in 4** dementia deaths

FIGURE 17: **Age-standardized rates of death due to dementia attributable to air pollution in 2023.**

Neuro Climate
WORKING GROUP

Mechanisms: how air pollution affects the ND risk

Some air pollution are greenhouse gases contributing to climate change, which in turn, can intensify air pollution. → Fine particles from air pollution can irritate the lungs causing systemic effects on the brain and penetrate the blood-brain barrier. → This can lead to inflammation and neurodegeneration.



Source: Neuro Climate Working Group

Systemic inflammation: Fine particles trigger inflammation and oxidative stress that damage brain cells
Direct brain exposure: Fine particles enter the bloodstream and reach the brain
Blood-brain barrier disruption: Pollution weakens the brain's protective barrier
Vascular effects: Increased heart diseases and stroke raise dementia risk

Neuro Climate
WORKING GROUP

Populations most at -risk

- **Older adults:** Higher risk of cognitive decline, dementia, and stroke.
- **People with pre-existing conditions:** Neurological, cardiovascular, or mental health disorders increase susceptibility.
- **Low-income and marginalized communities:** Higher exposure and fewer protective resources.

  Women: Greater caregiving burden and higher dementia prevalence in later life.

Neuro Climate
WORKING GROUP

Challenges & knowledge gaps

- Synergistic impacts are poorly understood
- Incomplete mechanistic understanding
- Limited causal inference
- Confounding factors
- Inadequate or imprecise air pollution exposure assessment
- Underdiagnosis and surveillance gaps
- Equity gaps
- Low policy integration
- Fragmented systems

Restoring environments, restoring minds

Neuro Climate
WORKING GROUP

Better air quality, better brain health

PLOS MEDICINE

RESEARCH ARTICLE

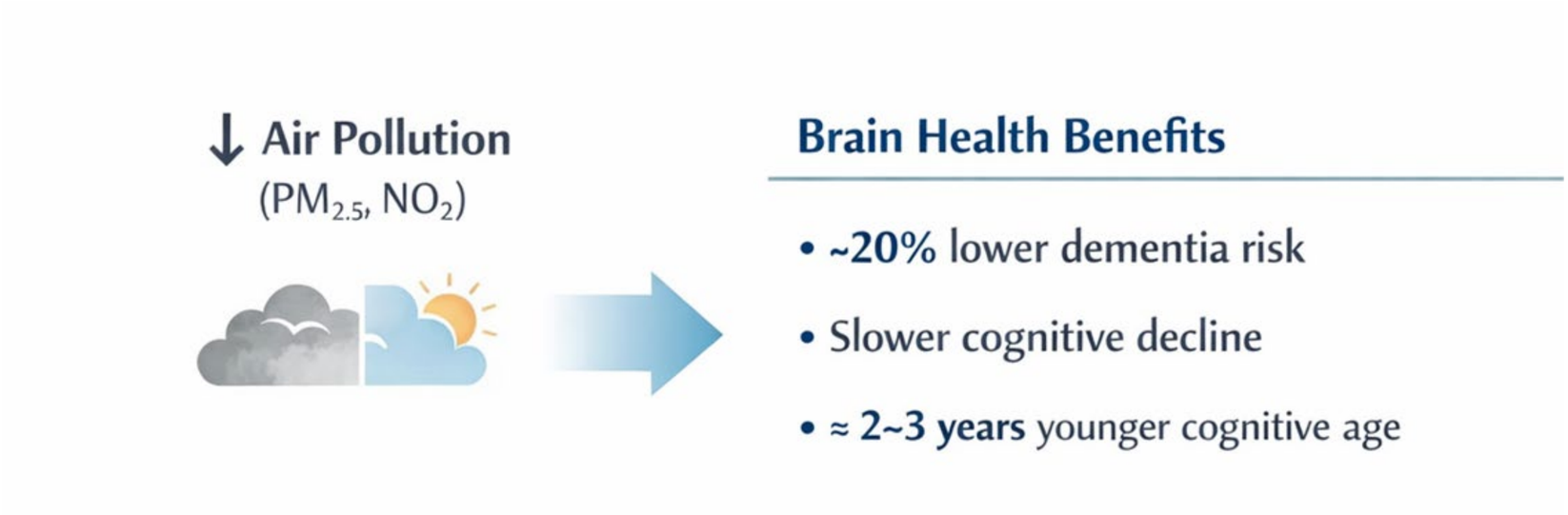
Air quality improvement and cognitive decline in community-dwelling older women in the United States: A longitudinal cohort study

Diana Younan[1☯*], Xinhui Wang[2☯], Joshua Millstein[1], Andrew J. Petkus[2], Daniel P. Beavers[3], Mark A. Espeland[3], Helena C. Chui[2], Susan M. Resnick[4], Margaret Gatz[5], Joel D. Kaufman[6], Gregory A. Wellenius[7], Eric A. Whitsel[8], JoAnn E. Manson[9], Stephen R. Rapp[10], Jiu-Chiuan Chen[1,2]

1 Department of Population and Public Health Sciences, University of Southern California, Los Angeles,

Association of improved air quality with lower dementia risk in older women

Xinhui Wang[a,1], Diana Younan[b,2,1], Joshua Millstein[b], Andrew J. Petkus[a], Erika Garcia[b], Daniel P. Beavers[c], Mark A. Espeland[c], Helena C. Chui[a], Susan M. Resnick[d], Margaret Gatz[e], Joel D. Kaufman[f,g,h], Gregory A. Wellenius[i], Eric A. Whitsel[j,k], JoAnn E. Manson[l], Stephen R. Rapp[m,n], and Jiu-Chiuan Chen[a,b,2]



Brain health co -benefits of climate and clean air policies

Urban Nature

Clean Infrastructure

Social Connection

Brain -focused Design

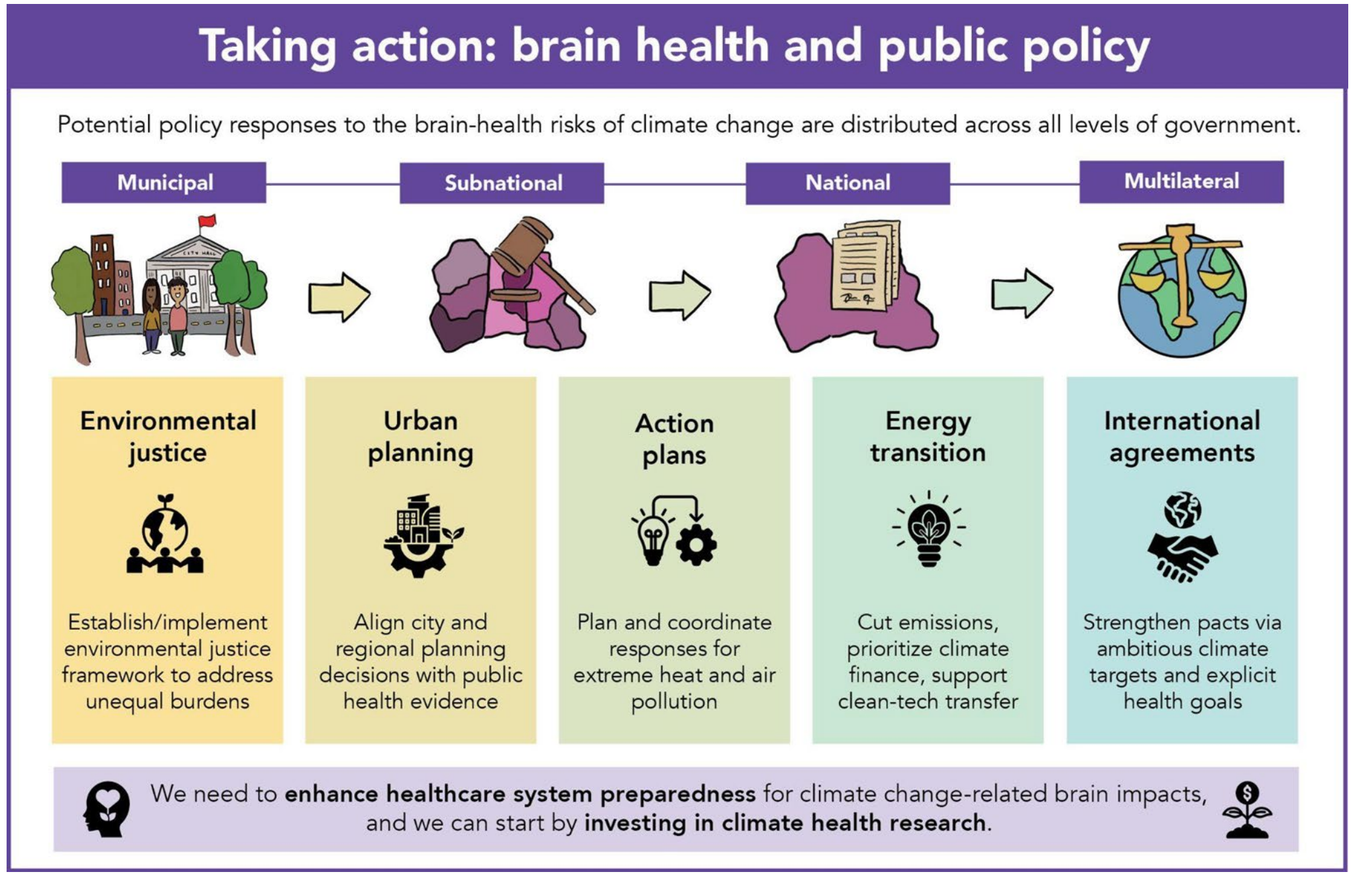
Cleaner energy → cleaner air → healthier brains

Heat mitigation → better sleep, learning, productivity

Resilient infrastructure → reduced trauma and stress

Safer environment → more outdoor activity and community interaction

Policy-relevant solutions



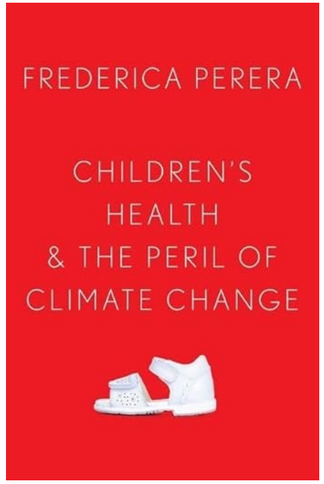
NCWG State-of-Science Report, Climate Change and Brain Health: From Evidence to Action (coming soon)

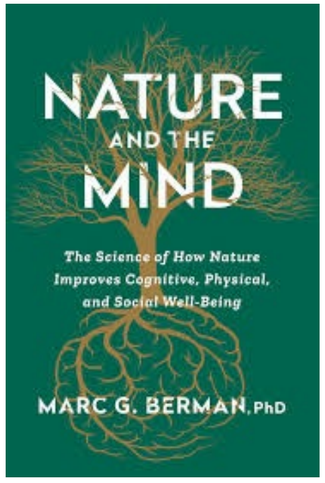
- Clean energy transitions
- Heat standards for housing and workplaces
- Urban cooling and green infrastructure
- Health-inclusive climate and energy policy
- Data and metrics that include brain health outcomes

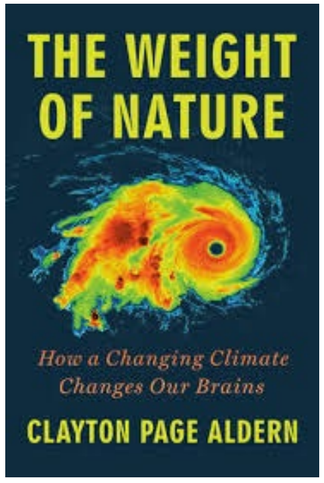
Neuro Climate
WORKING GROUP

Wanna learn more?

neuroclimate.org







Neuro Climate
WORKING GROUP

Thank you!

Interested in the intersection of climate change and brain health? Join our Neuro Climate Working Group.

Wanna connect?
Please email me at burcin@stanford.edu

Neuro Climate
WORKING GROUP