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to prevent cognitive disorders
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The impact of air pollution on brain health, mental health and wellbeing

- *What do we know?*
- *What do we need to still understand?*
- *What are the policy and practice implications?*

Headline News!

Small increases in air pollution linked to rise in depression, finds study

Exclusive: Cutting pollution levels may help to reduce rates of mental health problems, say scientists

Air pollution particles in young brains linked to Alzheimer's damage

Exclusive: if discovery is confirmed it will have global implications as 90% of people breathe dirty air

The New York Times

Air Pollution May Damage the Brain

Tiny air pollutants may cause changes in brain structure that resemble those of Alzheimer's disease.

Urgent action needed to understand links between air pollution and mental health

ENVIRONMENT | GLOBAL HEALTH | MEDICAL SCIENCES | MENTAL HEALTH | RESEARCH

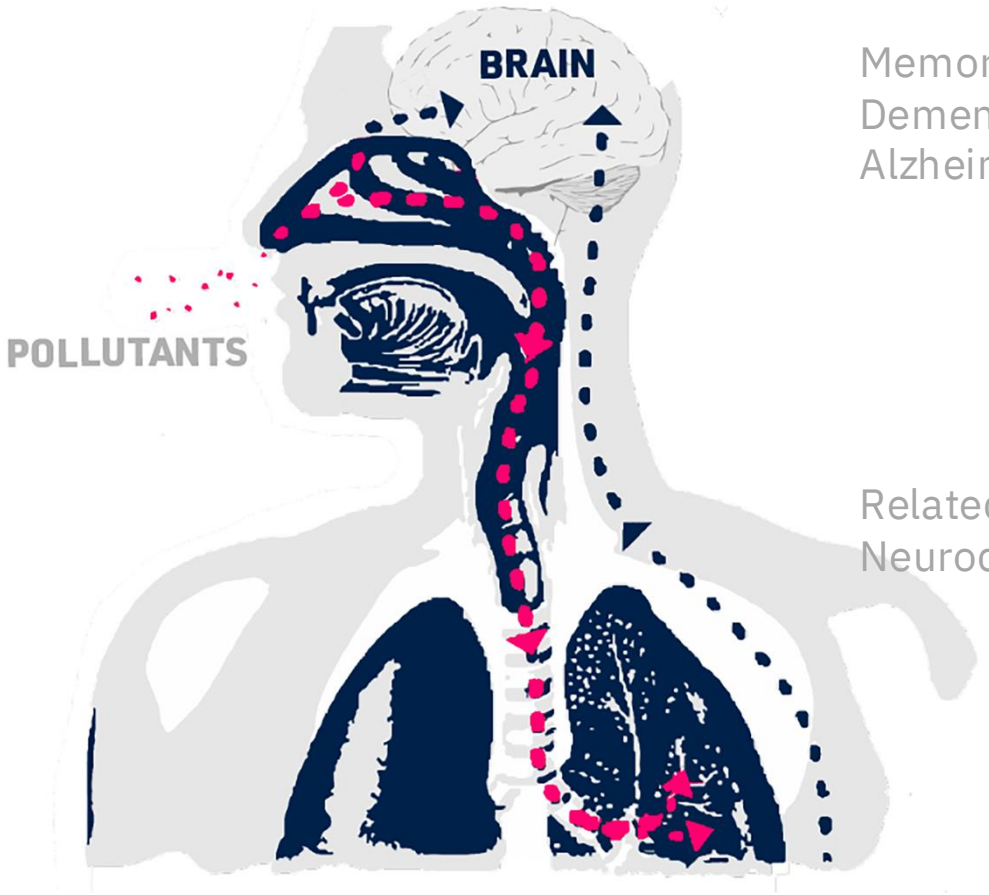
Leading scientists are calling for urgent global action to better understand the links between air pollution and mental health.

How dementia could be linked to air pollution in early life

Scottish researchers find childhood pollution a likely factor, but association with mid-life air quality less clear

What do we know?

Birth • Infancy and Early Years • Childhood and Adolescence • Adulthood and Later Life



Memory Impairment
Dementia
Alzheimer's Disease

Depression
Learning Disabilities
ADHD

Related Cardiopulmonary
Neurodegenerative Disorders

What do we know?

Air Pollution and Cognitive Function

- Chronic exposure to air pollution is associated with reduced global cognition, particularly in visuo-spatial abilities and executive function.
- PM2.5, NO_2, and O_3 are the most frequently studied pollutants, with evidence pointing toward long-term exposure accelerating cognitive decline.

What do we know?

Cognitive Decline, Cognitive Frailty, and Dementia Risk

- Epidemiological evidence suggests a causal relationship between air pollution and cognitive decline/dementia.
- Air pollution contributes to increased dementia incidence, including Alzheimer's disease, vascular dementia, and mild cognitive impairment (MCI).
- There is a consistent associations between exposure to air pollution and white matter volume reduction, suggesting neurodegeneration and vascular damage.
- Strong evidence links PM2.5, NOx, and O_3 to increased dementia risk.
- Chronic exposure leads to faster cognitive decline and higher dementia incidence.

What do we know?

Neuroinflammation and Biomarkers

- Few studies exist on air pollution and neuroinflammation in humans, but available evidence suggests air pollution exposure leads to increased neuroinflammatory markers.
- Air pollution seems to increase neuroinflammation, accelerating neurodegeneration.
- Systemic inflammation worsens blood-brain barrier integrity, allowing pollutants to penetrate deeper into the brain.
- Chronic exposure to air pollutants may exacerbate neurodegenerative disease pathology, particularly through inflammation and oxidative stress.
- Air pollution disrupts cerebral blood flow, contributing to vascular dementia.
- White matter hyperintensities, microbleeds, and infarcts are associated with pollution exposure.

What do we know?

No Safe Threshold Exists for Air Pollution Exposure

- Even low levels of PM2.5 and NO_2 have measurable negative effects on cognition.

Dementia Progression is Faster in Polluted Environments

- Post-diagnosis, dementia patients decline more rapidly when exposed to air pollution.
- Air pollution worsens sleep disturbances, psychiatric symptoms, and neurovascular complications.
- Improved air quality, antioxidant-rich diets, and exercise may slow decline.

What do we know?

Place-Based Factors Exacerbate Cognitive Decline

- Neighbourhoods with higher pollution levels tend to have higher dementia prevalence, particularly in urban, industrial, and traffic-heavy areas.
- The built environment (lack of green space, high noise pollution, urban sprawl) amplifies stress and cognitive decline.
- Research on the exposome suggests that long-term environmental exposures, including air quality, shape neurodegenerative disease risk

Socioeconomic Inequality Increases Vulnerability to Pollution

- Lower-income individuals experience higher cumulative exposure to air pollution due to residential proximity to highways, factories, and industrial zones.
- Wealthier populations often live in areas with better air quality, leading to lower dementia risk.

What do we know?

Air Pollution Reduces the Cognitive Benefits of Green Spaces in Deprived Areas

- Green spaces can mitigate air pollution's effects, but their distribution is uneven, with fewer parks and trees in lower-income areas.
- Green spaces are protective for cognitive function, but only in areas with lower air pollution levels.

Air Pollution Contributes to the Unequal Dementia Burden in Minority Populations

- Historically oppressed populations face higher environmental burdens, including air pollution, poor housing, and lack of healthcare access.
- Structural inequality further amplify wellbeing and cognitive and mental health risks in these groups.

What do we know?

Dementia Progression Post Diagnosis is Faster in Polluted and Deprived Environments

- Post-diagnosis, individuals in low-income, high-pollution areas can experience more rapid cognitive decline.
- Air pollution worsens sleep, neurovascular complications, and psychiatric symptoms in dementia patients, making disease management harder.

What do we still need to understand?

Which Pollutants Pose the Greatest Risk?

- PM2.5 and NOx are most studied, but which chemical components (e.g., polycyclic aromatic hydrocarbons, volatile organic compounds) are most neurotoxic?
- What is the contribution of microplastics, heavy metals, and ultrafine particles to cognitive decline?

Clarifying Dose-Response Relationships

- Identifying the impact of different exposure thresholds for different pollutants.

What do we still need to understand?

Early and Lifetime Exposure, how do they do their damage?

- Does early-life exposure have lifelong cognitive consequences?
- Is cumulative exposure over decades the main driver of dementia risk?

What Role Does Genetic Susceptibility Play?

- Do individuals with APOE-e4 or other genetic variants face greater risks from pollution?
- Are there genetic protective factors against pollution-related neurodegeneration?

What do we still need to understand?

What are the Mechanisms by Which Air Pollution Impairs Cognition?

- Is the primary driver vascular injury, direct neurotoxicity, or chronic inflammation?
- How do pollutants interact with neurodegenerative diseases like Alzheimer's and Parkinson's?

How Does Multi-Generational Exposure to Air Pollution Influence Dementia Risk?

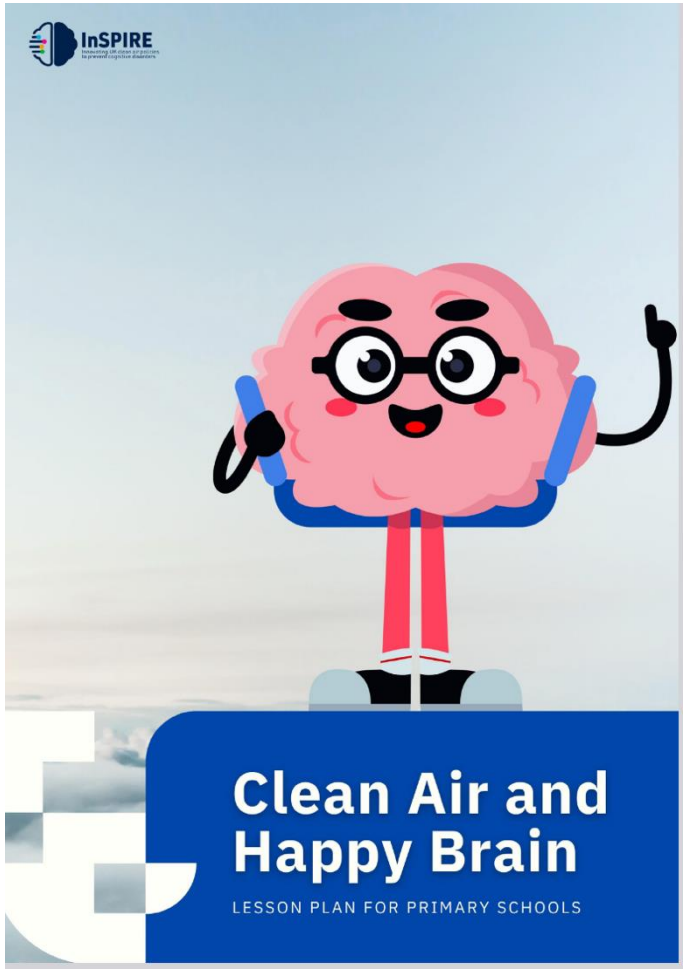
- Does living in a high-pollution area for multiple generations amplify cognitive decline across family lines?
- Are epigenetic changes caused by air pollution transmitted across generations?

What do we still need to understand?

How Can Urban Design Mitigate Cognitive Risks from Pollution?

- How can city planning and urban greenery be optimized to counteract air pollution’s neurotoxic effects?
- What policies could reduce environmental disparities in at-risk communities?

All of which takes us to policy and practice



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Review article

Mitigating the impact of air pollution on dementia and brain health: Setting the policy agenda

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What are the policy and practice implications?

Research and Funding

- **Increase targeted funding**: Establish dedicated research grants to study the impact of air pollution on brain health and mental health across the life course.
- **Support high-risk/high-reward research**: Fund studies that investigate long-term historical impacts of air pollution on cognitive decline and neurodegenerative diseases.
- **Expand epidemiological studies**: Develop longitudinal studies that track the impact of air pollution on cognitive health, mental health disorders, and neurodegenerative diseases.

What are the policy and practice implications?

Policy Integration and Awareness

- **Embed air pollution and brain health into existing public health strategies**: Integrate air quality considerations into policies related to dementia, mental health, climate change, etc.
- **Leverage co-health benefits**: Align air pollution mitigation strategies with policies on green urban planning, clean transport, and climate action to enhance brain health.
- **Raise public awareness**: Educate the public, healthcare providers, and policymakers on the links between air pollution, cognitive decline, and mental health.
- **Improve school-based policies**: Implement regulations to prevent exposure to air pollution in schools, such as reducing vehicle idling during drop-off and pick-up.

THESE ARE ALL EASY WINS!!!

What are the policy and practice implications?

Urban Planning and Environmental Regulations

- **Strengthen air quality standards**: Lower allowable air pollution limits below current thresholds, particularly for PM2.5 and NO2.
- **Improve indoor air quality**: Implement regulations requiring better ventilation, air purification, and pollutant-free building materials in schools, workplaces, and care homes.
- **Enhance urban green spaces**: Increase access to parks and vegetation in cities to improve air quality and support cognitive well-being.
- **Promote clean transport**: Expand investment in public transit, cycling infrastructure, and pedestrian-friendly urban design to reduce traffic-related air pollution.
- **Reduce residential exposure**: Implement policies requiring landlords to install heat pumps and improve indoor air quality to reduce exposure in vulnerable populations.

What are the policy and practice implications?

Community and Stakeholder Engagement

- **Encourage co-production and participatory policy development**: Involve citizens, advocacy groups, healthcare professionals, and researchers in policymaking to ensure air quality policies reflect diverse needs.
- **Address misinformation:** Counteract industry lobbying and misinformation about air pollution risks through transparent public communication.
- **Support vulnerable communities**: Implement targeted interventions in disadvantaged areas that experience higher levels of air pollution and health inequalities.

What are the policy and practice implications?

Life-Course and Targeted Interventions

- **Prioritize early-life interventions**: Improve air quality in schools, homes, and playgrounds to protect children's cognitive development.
- **Support older adults**: Reduce exposure in nursing homes and elderly care facilities, where residents are highly susceptible to air pollution’s neurodegenerative effects.
- **Implement dementia-specific air quality policies**: Study and address the post-diagnosis impact of air pollution on dementia progression to improve secondary and tertiary prevention strategies.

What are the policy and practice implications?

Policy Monitoring and Evaluation

- **Establish accountability mechanisms**: Regularly assess and update air pollution policies based on new scientific evidence.
- **Develop air pollution impact assessment tools**: Create standardized methods for evaluating the cognitive and mental health effects of air quality policies.
- **Incentivize compliance**: Provide financial or regulatory incentives for businesses and municipalities to implement clean air initiatives.

For more information, including our policy briefs, publications and monitoring websites, visit

https://www.inspireairbrain.org/