

Indoor & Outdoor Air Pollution Exposure on Brain Health Across Lifespan: A Literature Review

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Background

Air pollution is a global environmental threat linked not only to cardiovascular and respiratory diseases but also to mental and cognitive health. Pollutants such as fine and ultrafine particles, NO₂, CO₂, and VOCs can enter the bloodstream and disrupt the brain through neuroinflammation, oxidative stress, and blood-brain barrier damage. Children, older adults, and marginalized communities face greater vulnerability due to higher exposure, chronic stress, and limited mitigation access. Poor ventilation in indoor settings also impairs cognitive performance. Recognizing mental health as a pollution-related outcome expands opportunities for surveillance, policy reform, and equity-focused interventions.

Research Question

How does exposure to indoor and outdoor air pollution influence mental health and cognitive outcomes, and which populations demonstrate the highest vulnerability?

Learning Objectives

- Analyze peer-reviewed literature** and existing public health data to evaluate the neurological and mental health impacts of air pollution, with specific attention to factors such as particulate matter and trace metals.
- Apply spatial analysis methods** and pre-existing community data to assess patterns of air pollution exposure in Cleveland neighborhoods, specifically those near industrial corridors.
- Synthesize conclusions from literature, data analysis, and community input** to formulate evidence-based policy and program recommendations for the Cleveland Department of Public Health.

Methods

A narrative literature review was conducted to synthesize current evidence on the relationship between air pollution exposure and mental health outcomes across lifespan. **Databases:** PubMed, ScienceDirect, Nature, *Environmental Health Perspectives* **Search terms:** air pollution, particulate matter, indoor air quality, mental health, anxiety, depression, cognition, neuroinflammation, children, vulnerable populations **Time frame:** Studies published 2013–2025 **Inclusion:** Human studies on air pollution and mental or cognitive outcomes **Exclusion:** Physical-health-only studies, animal-only work without translational relevance **Analysis:**

- Grouped by population and exposure type: short-term pediatric effects, indoor air quality and cognition, long-term ambient pollution and psychiatric outcomes
- Extracted data on pollutant type, exposure duration, mental health endpoints, mechanisms, and vulnerability modifiers

Key Findings

Short-Term Exposure

- PM (1, 2.5, 10) and temperature variability linked to increased school absences and distress
- Female and urban youth show higher sensitivity to combined stressors
- Climate–air interactions can intensify acute mental health risks

Indoor Air Quality

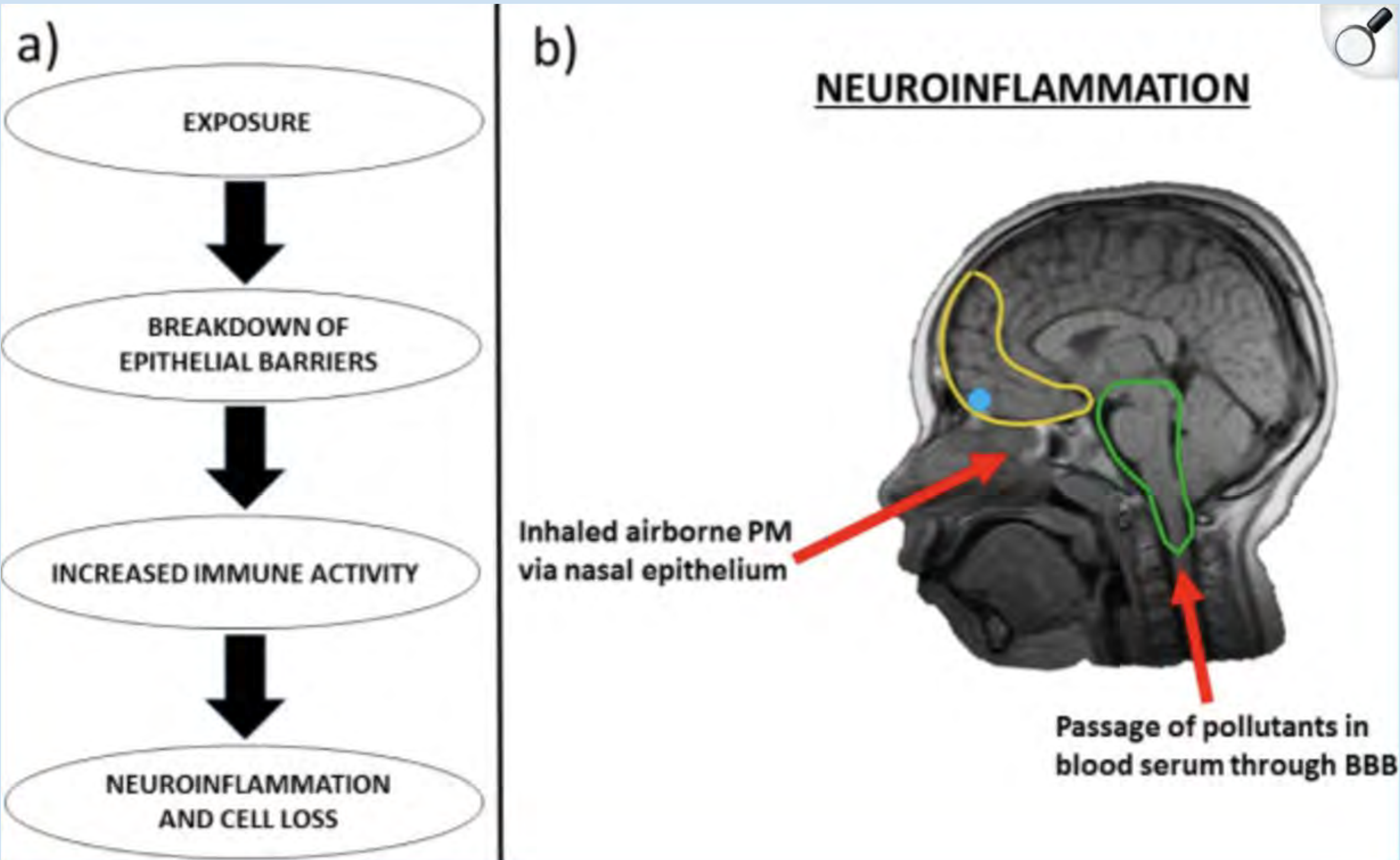
- Elevated CO₂ and VOCs impair higher-order cognitive performance
- Improved ventilation and lower emissions enhance workplace functioning
- Indoor air remains an underregulated mental health exposure domain

Long-Term Exposure

- Chronic PM_{2.5} and ultrafine particle exposure linked to depression, anxiety, and schizophrenia-spectrum disorders
- Effects persist after controlling for socioeconomic factors, suggesting cumulative neurological damage

Environmental Inequities

- ER visits for mental distress rise during pollution spikes in redlined neighborhoods
- Youth (0–18) experience the strongest susceptibility to PM_{2.5} and NO₂
- Findings reflect environmental injustice and unequal exposure burdens



Adapted from Brockmeyer & D'Angiulli (2016), *Frontiers in Neuroscience*.

Gaps & Future Directions

- Causality:** Most studies are observational; pollution effects not isolated from social stressors
- Exposure Assessment:** UFPs and indoor pollutants often lack individual-level monitoring
- Vulnerable Populations:** Children, adolescents, and marginalized groups underrepresented
- Mechanisms:** Need longitudinal, biomarker-based, and neuroimaging studies to confirm causal pathways

Future Work Should:

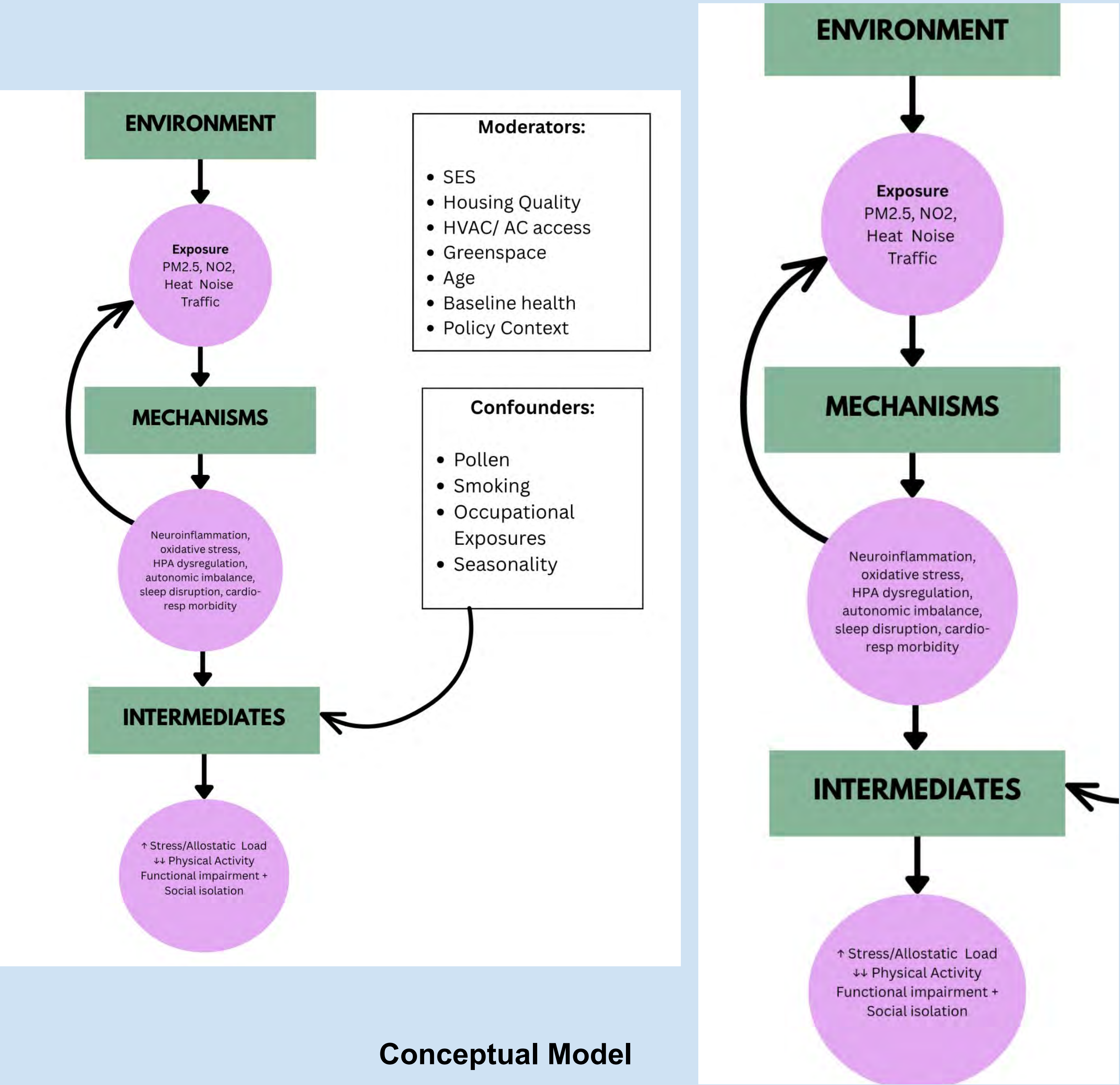
- Integrate indoor and outdoor exposure metrics across lifespan
- Use mobile sensors and modeling to improve exposure accuracy

Conclusion

Air pollution adversely affects mental, emotional, and cognitive health, driven by neuroinflammation, oxidative stress, and barrier disruption. Impacts are greatest among children, indoor workers, and structurally marginalized communities. Recognizing mental health as an air pollution outcome underscores the need for stronger air quality policies, school/workplace protections, and equity-driven public health interventions to reduce preventable neurological harm across the lifespan.

Acknowledgements & Citations

I would like to thank the Department of Air Quality, Christina Yoka and the Cleveland Department of Public Health for this opportunity.



Conceptual Model