Particulate Matter and Dementia

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Article

Comparison of Particulate Air Pollution From Different Emission Sources and Incident Dementia in the US

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Why is this relevant?

• Little current knowledge on different emission sources and dementia risk

• Aging population
  • World Health Organization:
    • 2030: 1 in 6 will be > 60
    • 2050: number of people > 80 will triple → 426 million
  • Increasing cases of dementia

• Compounded by:
  • Worsening pollution, global warming, wildfires...

What is Particulate Matter?

• Aka PM

• Particles from different emission sources

• PM10 ≤ 10 microns
  • 10 microns or less → able to be inhaled

• PM2.5 ≤ 2.5 microns
PM2.5

• From sources in environment
  • Traffic emissions, agriculture, fires, etc.

• Risk factor for dementia
  • Livingston et al. and US Environmental Protection Agency
  • Mechanism: a few options
    • Enter CNS via blood brain barrier or olfactory bulb
    • Neuroinflammation
    • Oxidative stress secondary to lung irritation

Aim

Examine associations between:

• Dementia
• AND
  • Total PM2.5 exposure
  • Source-specific PM2.5 exposure
Study Design

• Participants from Health and Retirement study cohort
  • Longitudinal, nationally-representative study on aging at University of Michigan
    • Began 1992, Surveys participants every other year

• Inclusion criteria:
  • > 50 y.o.
  • 2 interviews between 1998-2016
  • No dementia at 1st interview

• Exclusion criteria:
  • Missing information (exposures, outcomes, key covariates)

Assessing Total PM2.5

• Used home addresses to estimate exposure:
  • Data from environmental agencies
  • Estimations from nearby transport, land cover/use, population density, emission types, vegetation
Assessing Source-Specific PM2.5

• 9 emission sources:
  • Agriculture
  • Wildfires
  • Wind-blown dust
  • Traffic – road and non-road
  • Coal combustion – energy and industry
  • Other energy and industry

• Source-specific PM2.5 concentration

\[ \text{PM2.5}_{\text{Total}} \times \text{PM2.5}_{\text{Source-specific fraction}} \]

Outcomes

• Primary: Incident dementia

• Secondary: Hazard ratio for incident dementia

  • How much the dementia risk changes with different levels and sources of emissions
Covariates

• Personal characteristics
  • Race and ethnicity
  • Education level
  • Wealth

• Urbanicity of neighborhood

• Socioeconomic status of neighborhood

Dementia Assessment

• Participant able/willing to participate:
  • Word recall – immediate and delayed
  • Serial 7s subtraction
  • Counting backwards

• Participant unable/unwilling to participate:
  → Conversation with proxy regarding:
  • Participant’s memory
  • Cognitive impairment
  • ADL limitations
Demographics

- N = 27,857
- Avg age = 61
- Majority female (56.5%)

Results

**N = 27,857 → 15% diagnosed with dementia over avg. follow-up of 10 years**

- Dementia diagnosis more likely in:
  - Non-White
  - Lower educational level
  - Lower wealth
  - More PM2.5 level at home address
Results

- Increased PM2.5 exposure → increased risk of dementia

- Strongest associations:
  - Agriculture
  - Wildfires
  - Traffic
  - Coal Combustion

Midwest: Agriculture, traffic, energy production
West: Wildfires
Southwest: Windblown dust
Results – PM2.5 Exposure

• Increased exposure in:
  • Increased age
  • Non-Hispanic Black
  • Lower education level
  • Lower wealth

• EXCEPT: PM2.5 from wildfires and windblown dust
  • Wildfires and windblown dust impact people regardless of their characteristics

Results – Hazard Ratios

• Range: 1.0 - 1.17
  • Windblown dust = 1.0
  • Agriculture = 1.17

• Adjusting for all other pollutants:
  • Statistically significant HR:
    • Agriculture and Wildfire

• Estimation using HR
  • 188,000 new cases of dementia/year
    • Attributable to PM2.5 total exposure
Discussion - Agriculture

• Largest hazard ratio – 1.17

• Large source of ammonia → 30% of total PM2.5 in US

• Association between exposure to herbicides and neurotoxic pesticides and dementia
  • Aloiziou et al.

Discussion – Agriculture + Wildfires

• Individuals in rural areas
  • ↑ exposure to agriculture and wildfires

• Could explain disparities in rural-urban dementia risk
  • Dementia significantly more present in rural areas
    • Weden et al.
Discussion - Wildfires

• 25% of total PM2.5 in US
  • >50% in Western US
• Release of toxic components
  • Uncontrolled burning → Not just smoke from burning trees
    • Homes, gas stations, etc.
• Burning starts in different spots
  • BUT long-range smoke goes to the same “downwind” locations
  • Many cities >30 days/year affected by smoke

Discussion - Wildfires

• It is not getting better

• ↑Global warming → ↑ temperatures
  • → ↑ wildfire frequency and severity
  • → earlier snow melt in Spring → ↑length of fire season
Discussion

• ~$188,000/\text{year}$ attributable to PM2.5
  • Prevention = necessary

• Reducing PM2.5 through any means possible
  • Small scale: Personal air purifiers
  • Large scale: New emission regulations

Previous Studies

Consistent findings:

• Wilker et al. - Harvard TH Chan School of Public Health, April 2023
  • Similar Hazard Ratio

• Ailshire and Walsemann, 2020
  • Similar increased risk of PM2.5 exposure in those with lower education levels
Previous Studies

Only one other study has examined specific emission sources:

- Oudin et al. - 2018

- 2 emission sources vs 9 in current study
  - Traffic and residential wood burning
  - ↑ exposure to both sources → ↑ hazard ratio of dementia
  - Similar results

Strengths

- First study to evaluate >2 specific emission sources
- Estimated PM2.5 exposure with exact home addresses
  - Compared to previous study using zip codes
- Nationally-representative cohort
- Population from urban and rural areas
Limitations

• Potential underestimation of dementia
  • Health survivor bias
    • Those with comorbidities associated with pollution and dementia = those most likely to be lost to follow-up

• There are other trends related to dementia that are not related to pollution

• Different birth years of participants
  • Pollution levels change over time
    • Solution: Grouped by birth years

Conclusion

• Increased particulate matter exposure
   → Increased dementia risk

• If pollution, global warming, wildfires, etc. continue to increase
   → Incidence of dementia will keep increasing

• Intervention on specific emission sources = key to healthy cognitive aging
  • Make the earth safe, keep our brains safe
References