Particulate Matter and Dementia

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HEALTH IMPACTS OF CLIMATE CHANGE

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…

3

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

4

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

5

Aim

Examine associations between:
- Dementia
- AND
  - Total PM2.5 exposure
  - Source-specific PM2.5 exposure

6

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)

7

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

8

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
  $$= (PM2.5_{Total}) \times (PM2.5_{Source\text{-}specific\ fraction})$$

9

Outcomes

- Primary: Incident dementia

- Secondary: Hazard ratio for incident dementia
  - How much the dementia risk changes with different levels and sources of emissions

10

Covariates

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

- Urbanicity of neighborhood

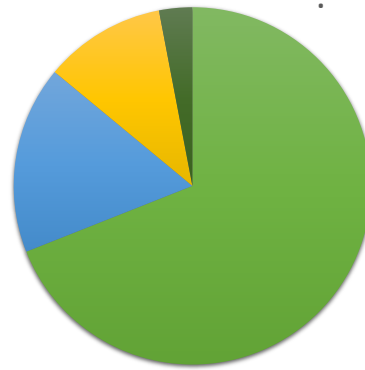- Socioeconomic status of neighborhood

11

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

12

Demographics

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

- Non-Hispanic White
- Non-Hispanic Black
- Hispanic
- Other Races (American Indian, Alaska Native, Asian, Pacific Islander)

13

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

14

Results
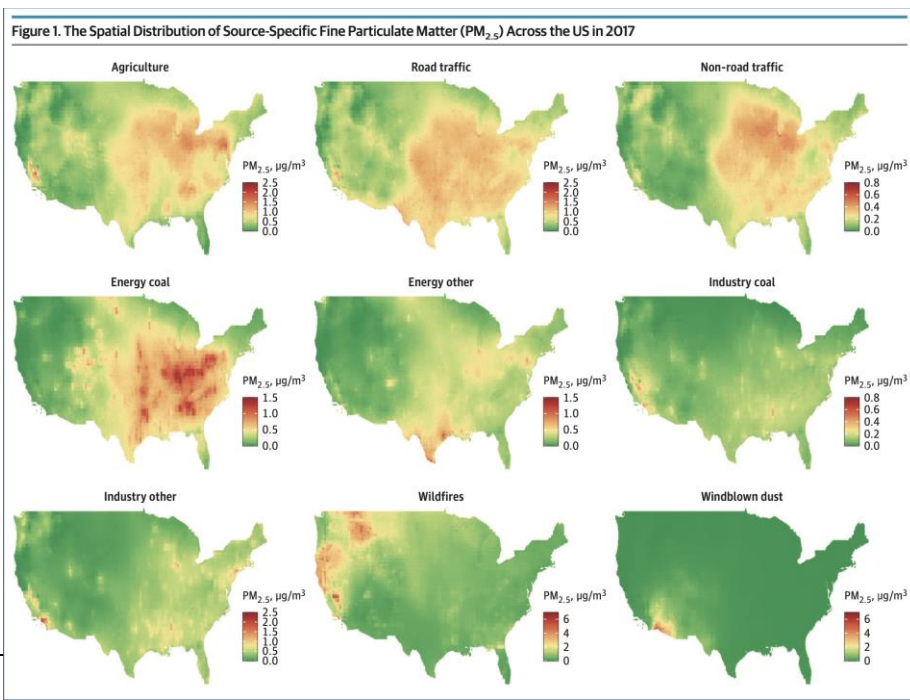
- Increased PM2.5 exposure → increased risk of dementia

  - Strongest associations:
    - Agriculture ─┐
    - Wildfires ───┤ Strongest association when controlled for all other sources and co-pollutants
    - Traffic
    - Coal Combustion

15

Figure 1. The Spatial Distribution of Source-Specific Fine Particulate Matter (PM$_{2.5}$) Across the US in 2017

Midwest: Agriculture, traffic, energy production

West: Wildfires

Southwest: Windblown dust

16

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

17

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

18

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.

19

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.

20

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

21

Discussion - Wildfires

- **It is not getting better**

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

22

Discussion

- **~188,000/year** attributable to PM2.5
  - Prevention = necessary

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

23

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

24

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

25

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

26

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

27

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

28

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29