Indoor and Outdoor Air Pollutants, AQI Values, and Childhood Asthma

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Study Basis

Pediatrician & School Official Question:
Does keeping children indoors on high air pollutant days protect health?

• Utah Div. Of Air Quality issues heath advisories based on Air Quality Index (AQI) and coordinates with the Utah Dept. Of Health and school districts

• Very little peer-reviewed literature supporting the “Stay indoors on high air pollution days” recommendation
Relevance

- Increasing childhood asthma.
- Keeping children inside has health, behavioral, and social consequences.

### Asthma Prevalence* by Age

*United States: 1980–1996*

Source: National Health Interview Survey

* 12-month prevalence
Study Methods

• Indoor and Outdoor Air Quality Monitoring:
  – Particulate size distribution, mass and composition
  – Volatile Organic Compounds (VOCs) concentration and composition

• Clinical: Spirometery before and after recess and health questionnaire.
Study Site - Hawthorne Elementary School, SLC UT
Air Quality Index

- AQI is composed of:
  - Ground-level Ozone
  - Particle pollution
    - PM2.5, fine particulates
    - PM10, coarse particulates
  - Carbon monoxide
  - Sulfur dioxide
  - Nitrogen dioxide

- Highest value becomes the reported AQI
- Measurements recorded twice daily (morning/evening)
- Designed to be easy method to inform public of pollution levels
- AQI based on science, consensus and opinion
Air Quality Index Values

- No really serious air pollution episodes
PM 2.5 Vs. AQI

- Health recommendations:
  - Green – Good
  - Yellow – Moderate
  - Orange – Sensitive
  - Red – Unhealthy
  - Purple – Very Unhealthy
  - Maroon - Hazardous
Particulates

- Measured Indoors/Outdoors with:
  - GRIMM aerosol spectrometer model 1.108
    - Continuous measurements on 15 bins (0.3 - 20+ µm)
  - Tapered Element Oscillating Microbalance (TEOM)
    - EPA approved
    - Used for determining correction factor for Grimm PM 3
  - Speciation performed:
    - Indoor samples taken weekly for PM 10
    - Outdoor samples taken every 3 days for PM 2.5
    - Results averaged daily over study period
Particulate Results
Indoor and Outdoor Pollution

Outdoor Air
Avg. of 5 Least and Most Polluted days

Indoor Air
Avg. of 5 Least and Most Polluted days
Time Trend Data
0.3 to 0.4 Microns

Hawthorne Particulates
Hourly Averages (0.3 to 0.4 Microns in Size)
Time Trend Data
4 to 5 Microns

Hawthorne Particulates
Hourly Averages (4 to 5 Microns in Size)
Time Trend Data
10 to 15 Microns

Hawthorne Particulates
Hourly Averages (10 to 15 Microns in Size)
Low penetration of outdoor submicron particles indoors. Clear school-day peaks in 10µm PM are observed indoors.
Indoor Air – Time Average

- **0:00-1:00**: 0.3-0.4 µm
- **2:00-3:00**: 0.5-0.65 µm
- **4:00-5:00**: 0.80-1.0 µm
- **6:00-7:00**: 1.6-2.0 µm
- **8:00-9:00**: 3.0-4.0 µm
- **10:00-11:00**: 5.0-7.5 µm
- **12:00-13:00**: 10-15 µm
- **14:00-15:00**: 0.0
- **16:00-17:00**: 0.5-0.65 µm
- **18:00-19:00**: 0.80-1.0 µm
- **20:00-21:00**: 0.80-1.0 µm
- **22:00-23:00**: 0.3-0.4 µm

**Mass** (µg/m³)
Outdoor Air – Time Average

![3D plot of outdoor air mass (µg/m³) over time and particle size distribution (µm)]
Particulate Results
Study Average with Speciation

Estimated Mass (micrograms/m^3)

Particle Size in Microns

Outdoor PM 2.5

Indoor PM 10

- Ammonium
- Nitrate
- Elemental Carbon
- Organic Carbon
- Aluminum
- Iron
- Silicon
Particulate Results

TEOM vs. GRIMM

Indoor

\[ y = 0.59x - 0.172 \]

\[ R^2 = 0.51 \]

Outdoor

\[ y = 0.56x + 2.83 \]

\[ R^2 = 0.76 \]

- TEOM FDMS Mass (ug/m³)
- TEOM Mass (ug/m³)

- TEOM Outdoor Mass (micrograms/m³)
- Fitted values

- TEOM Indoor Mass (micrograms/m³)
- Fitted values
Particulate Summary

- Larger particles indoors; Smaller outdoors
- Outdoor submicron particulates penetrating indoors
- Study particulate average composition:
  - Outdoor PM 2.5 was primarily nitrate aerosols with organic carbon and ammonium
  - Indoor PM 10 was primarily organic aerosols with some elemental carbon
VOCs

• 3 vacuum canister sample pairs (indoor/outdoor)
  – 2 sample pairs taken during low AQI days (AQI <50)
  – 1 sample pair taken during elevated AQI day (AQI > 100)

• Analyzed using EPA method TO 17
  – 51 targeted + 30 tentatively identified compounds
Volatile Organic Chemicals

- VOCs appear to be from indoor sources
- No obvious relationship to outdoor pollution
Study Conclusions

Is Staying Indoors Protective?

• Yes:
  – Overall PM is less indoors than outdoors
  – Indoor school air is protective of submicron sized particles

• Indoor pollutant levels include higher levels of VOCs
  – Levels not hazardous, just higher than outdoors
  – Association of low level VOCs not well understood
    • Possible contributing factors to chronic effects such as asthma
Study Conclusions
Indoor Air Quality

• Indoor and outdoor environments differ
• Larger indoor particles generated by human activity
• Submicron particles are infiltrating indoors, but at considerably lower concentrations
• VOCs generally present in higher concentrations indoors than outdoors
Acknowledgements

Financial Support
• Primary Children's Medical Center Foundation
• NIEHS K25 ES11281

• RR Larson, PhD
• EM Wood, MD
• HS Kim, PhD
• John Veranth, PhD
• N Frei, MD
• K Buchi, MD
• G Warwick, MS
• S Packham, PhD
• K Perry, PhD
• G Smith
• R Dalley
• B Allen
• L Chuy

• In kind support
  – State of Utah Department of Environmental Quality, Air Quality Division
  – Salt Lake School District
  – Desert Research Institute
  – DataChem Laboratories
  – Rocky Mountain Center for Occupational and Environmental Health