Does Indoor Air Filtration Improve Health?

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A rotating team of residents and field technicians assisted with data collection in Shanghai, undergraduate students in the Bergin lab assembled, tested, and prepared equipment for the field, and staff/students at Duke and the University of Wisconsin.

We also acknowledge the participants in both Beijing and Shanghai for inviting us into their homes and for their cooperation throughout the project.
Rationale for the Project

- High levels of ambient pollution in China
- Individuals spend the majority of their time indoors
- Specific pollutants in the indoor environment in China have not been rigorously quantified (e.g., VOCs, O$_3$, components of PM)
- If effective, purifiers may allow individuals to improve their indoor environment, with potential benefits for health
Project Objectives

A. To quantify air pollutants in homes in urban China
B. To assess the feasibility of measuring pollutants using low-cost sampling equipment
C. To determine if air purifiers reduce pollutants a) indoors b) for personal exposure
D. To evaluate the impact of air purification on the respiratory health of asthmatic children
**Project Overview**

**Study design:** randomized, double-blind crossover trial

Visit 1: 1\textsuperscript{st} intervention washout
Visit 2: washout
Visit 3: 2\textsuperscript{nd} intervention
Visit 4: 2\textsuperscript{nd} intervention

**Air purifier:**
Used in bedroom

- Pre-filter
- HEPA filter
- Activated carbon filter

*Removed during sham filtration*
Sampling Overview: Calibration

- Co-location of real-time sensors with reference monitors pre- and post - in-home sampling
PM2.5 and Ozone Concentrations in Beijing (Outdoor/Indoor/Personal Exposure)
Beijing: Real-time PM$_{2.5}$ Indoor/Outdoor Ratios

- Indoor/outdoor PM$_{2.5}$ ratios as averaged by hour of the day during true and sham filtration

Avg: 0.74

Avg: 0.17
Due to personnel and instrumentation, this crossover study design was implemented in four batches.
Shanghai: Filter-based PM$_{2.5}$

48-hour integrated base station and outdoor home sampling concentrations of PM$_{2.5}$ for 42 homes
Wild Fire Influence on Air Pollution (PM$_{2.5}$) and Related Tweets

![Graph showing the influence of wild fires on air pollution and related tweets.]
PM$_{2.5}$ Reductions by Household
PM$_{2.5}$ Reductions by Household for Personal Exposure
## Health Indicators

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Method</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airway inflammation</td>
<td>Fractional Exhaled Nitric Oxide (FeNO)</td>
<td>NIOX machine, Airway inflammation</td>
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<tr>
<td>Symptom</td>
<td>C-ACT questionnaire</td>
<td>Self-reported questionnaire, Overall, exercise, cough, wake up at night, daytime symptom, wheeze</td>
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<tr>
<td>Airway Mechanics</td>
<td>Spirometry</td>
<td>Best results of 3 exhalations, FEV₁, FVC, FEV₁/FVC: lung obstruction</td>
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<tr>
<td></td>
<td>Impulse Oscillometry</td>
<td>Normal breathing sound wave, Sensitive detection of early changes of small airway function</td>
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<tr>
<td></td>
<td>Peak Expiratory Flow (PEF)</td>
<td>Self-administrated daily, Maximum speed of expiration, indicates airway obstruction</td>
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</table>
Shanghai: Health Effects - Results

Two-weeks of indoor air filtration:

- Decreased respiratory inflammation
  \[ \downarrow \text{FeNO by 23\%} \]
- Improved the small airway mechanics
  \[ \downarrow \text{Z}_5 \text{ by 14.7\%} \]
  \[ \downarrow \text{R}_5 \text{ by 22.4\%} \]
  \[ \downarrow \text{R}_5 - \text{R}_{20} \text{ by 40.6\%} \]

Cui et al. *Unpublished*
Small airways are of pathophysiological significance for asthma

- The major site of airflow limitation and airway inflammation
- Early changes of lung function

Summary

• Under proper conditions indoor filtration can substantially reduce indoor concentrations
• Personal exposure reductions are less apparent for indoor filtration due to varied activity and related exposures
• There are health benefits to indoor filtration for asthmatic children, but it is not a clear slam dunk