



AIR INNOVATIONS



The HEPAiRx® System and Field Study

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Outline

- Background and Motivation
- The HEPAiRx[®] System
- The Field Study
- Future Work



Background and Motivation

- Asthma is a worldwide problem, with one death occurring every 20 seconds (WHO, 2005).
- Poor indoor air quality (IAQ) is linked to high incidence of asthma; therefore, improving indoor air quality may provide relief to sufferers of asthma
- However, studies evaluating the efficacy of HEPA filter air cleaners, for the most part, have shown no statistical difference in health measures (Wood et al, 1998; Ellen et al, 2002).
- Providing an HEPA filter air cleaner with a ventilator that allows high outdoor air exchange may improve the success of the intervention.

HEPAiRx[®] by Air Innovations

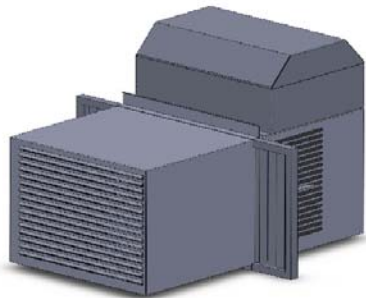
- Integrated Energy Recovery Ventilator (IERV) equipped with pre-filters, HEPA filter, and air heaters and coolers
- Provides approximately 3 air changes per hour of outside air and 9 air changes per hour of re-circulated air for a bedroom



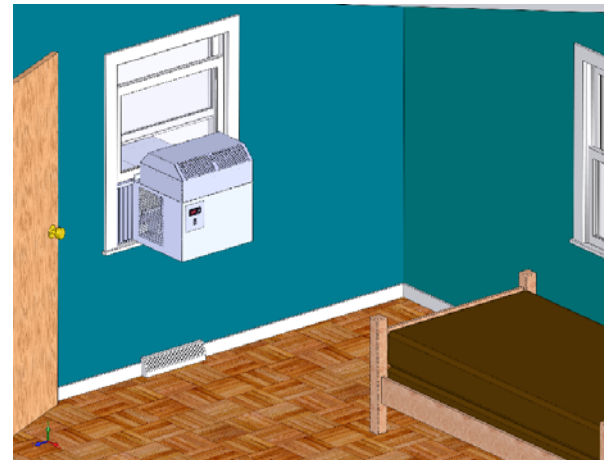
1st generation HEPAiRx unit shown in subject's bedroom

2nd Generation HEPAiRx[®]

- Mounted through wall or in window
- Filters out particulate matter including indoor aeroallergens
- Dilutes gases, including CO, CO₂, SO₂, NO₂, VOCs
- HEPAiRx takes over complete control from room, which is isolated from rest of house and central system
- IERV rated at 84% effectiveness



2nd gen HEPAiRx concept drawings





Objectives of the Field Study

- Evaluate the effectiveness of the HEPAiRx in improving indoor air quality
- Assess whether these improved air conditions will be effective in alleviating asthma symptoms



Methods

- 30 participants ages 5-16 years separated into two groups: A and B
- A group: HEPAiRx ON for 12 weeks, then unit OFF for 6 weeks
- B group: HEPAiRx OFF for 6 weeks, then unit ON for 12 weeks
- Health measurements conducted every 6th day before bed and upon awakening on the 7th day. A questionnaire about health and activities were completed every 6th day as well
- Indoor air quality: temperature, relative humidity, particulate matter (0.5-10 μ m size range), CO, CO₂ and total volatile organic compounds (TVOC) concentrations monitored in the bedrooms using AirAdvice IAQ multi-meters

Health Measures - EBC

○ Exhaled breath condensate (EBC)

- Contains many non-volatile substances and is likely to reflect the composition of the airway lining fluid
- Collected by RTube™ (Respiratory Research, Inc, VA)
- Nitrate analyzed as a biomarker using a nitrate reduction apparatus connected to a nitric oxide analyzer (NOA™280i)
- pH analyzed using Orion 525-A pH meter



Health Measures - PEF

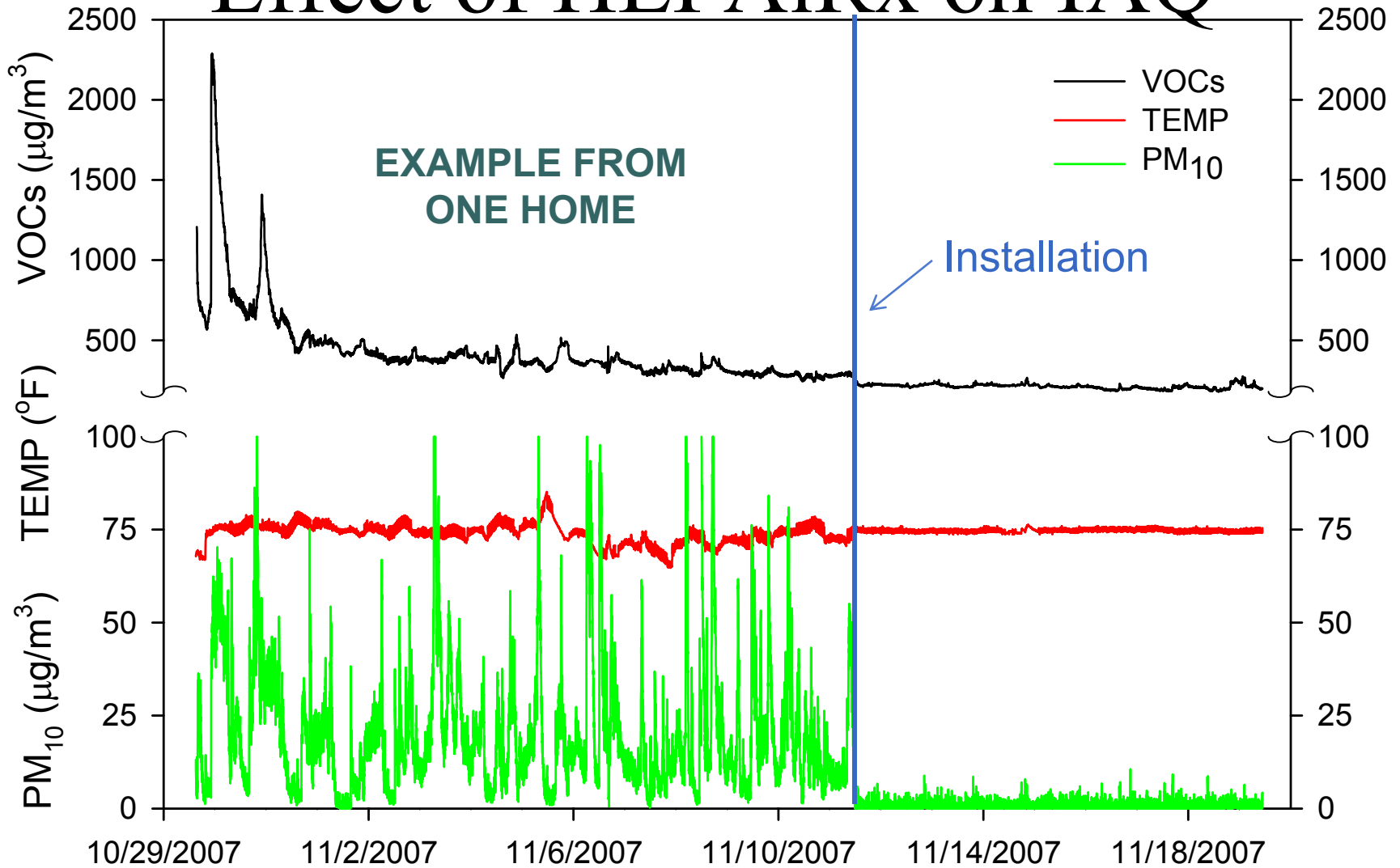
○ Peak Expiratory Flow (PEF)

- Low PEF related to obstructive lung disease, restricted lung expansion
- Peak flow meter (A.D.A.M. Inc.,)
- Based on literature recommendations, the PEF values were z-transformed while the EBC nitrate concentrations and pH values were not

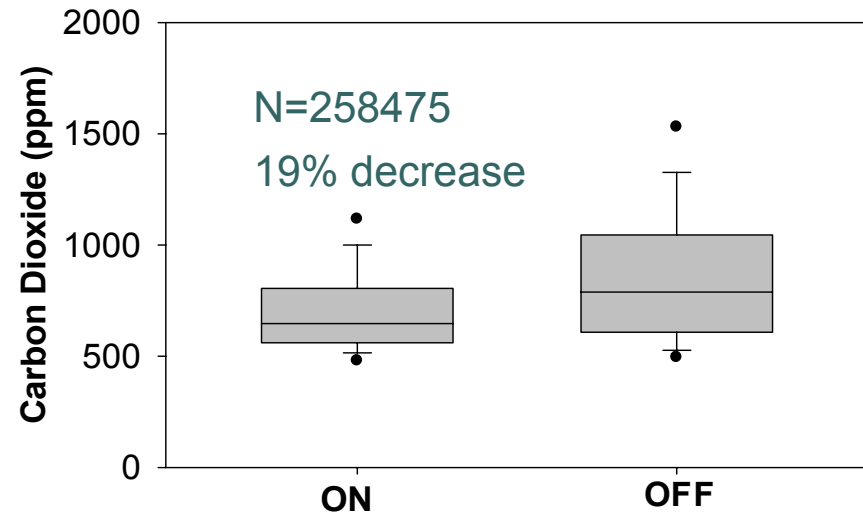
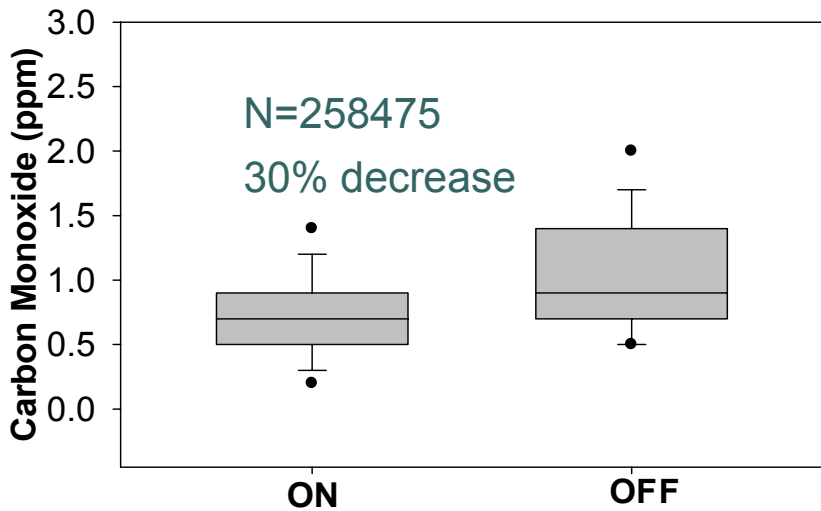
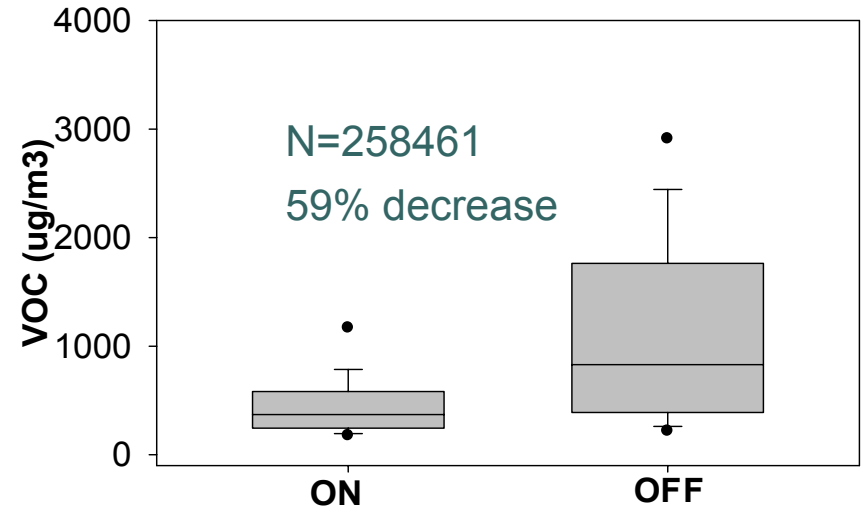
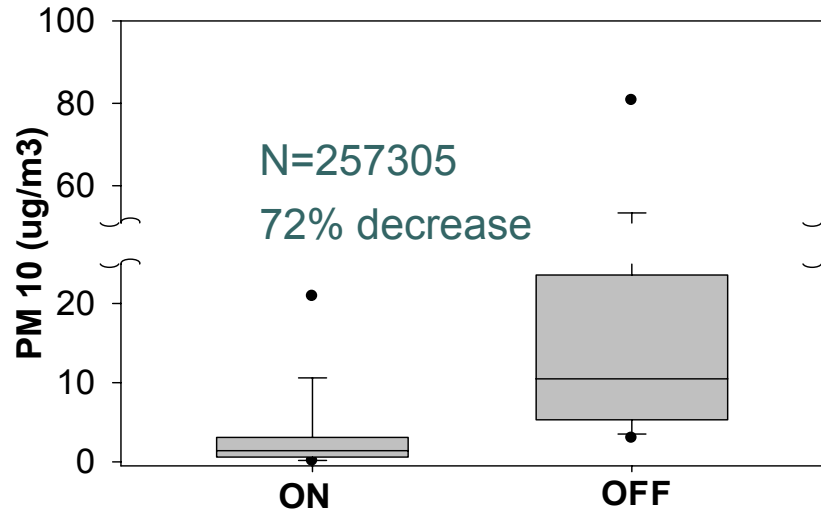
Peak flow meter



Effect of HEP AiRx on IAQ



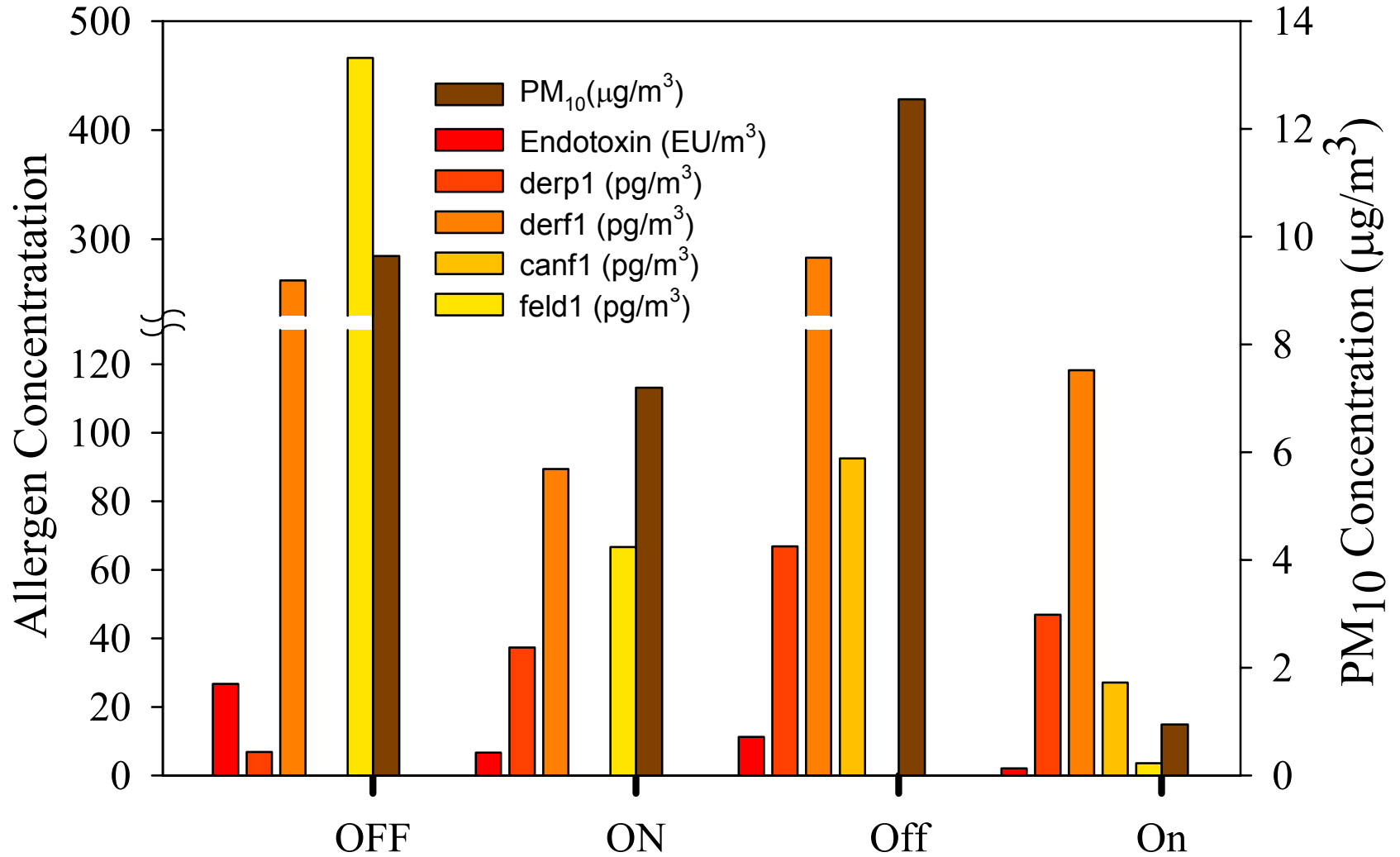
Summary IAQ with HEPAiRx On and Off



Q1=25th percentile, Q3=75th percentile

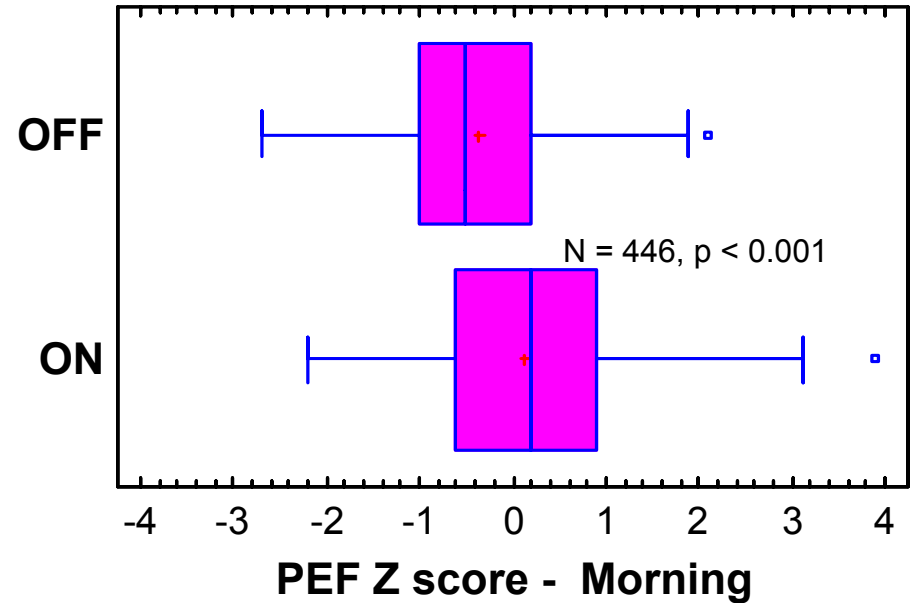
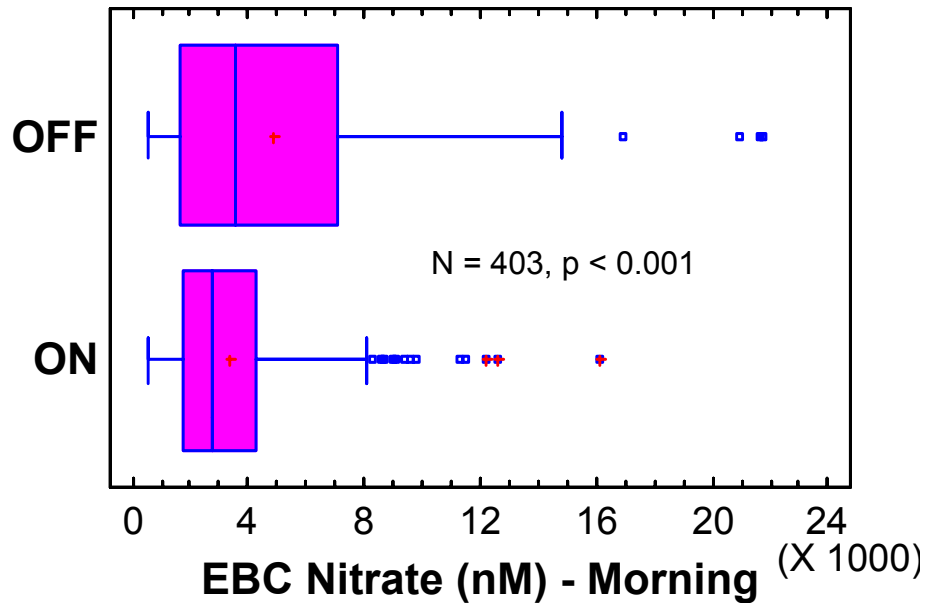
Lower Limit = $Q1 - 1.5(Q3 - Q1)$; Upper Limit = $Q3 + 1.5(Q3 - Q1)$

Aeroallergens in 2 Bedrooms



Morning EBC Nitrate and PEF

Groups A & B Combined

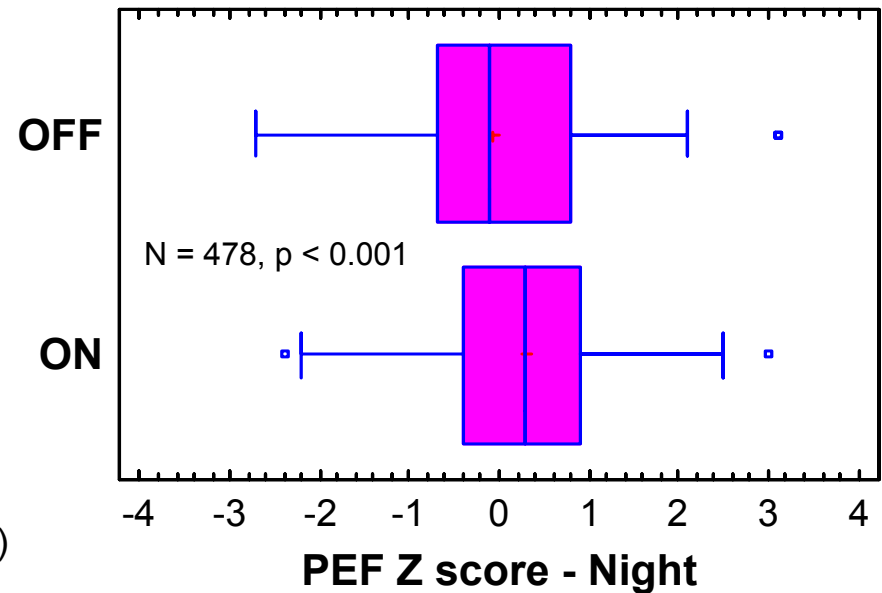
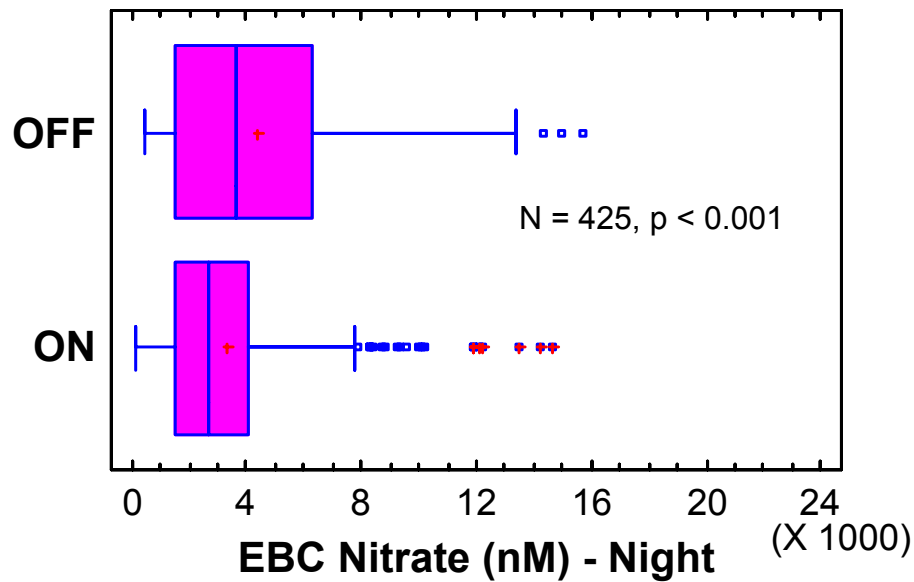


An F-test shows:

The mean of EBC Nitrate concentrations and PEF z scores collected from morning samples were significantly different depending on the operation of HEPAiRx.

Evening EBC Nitrate and PEF

Groups A & B Combined



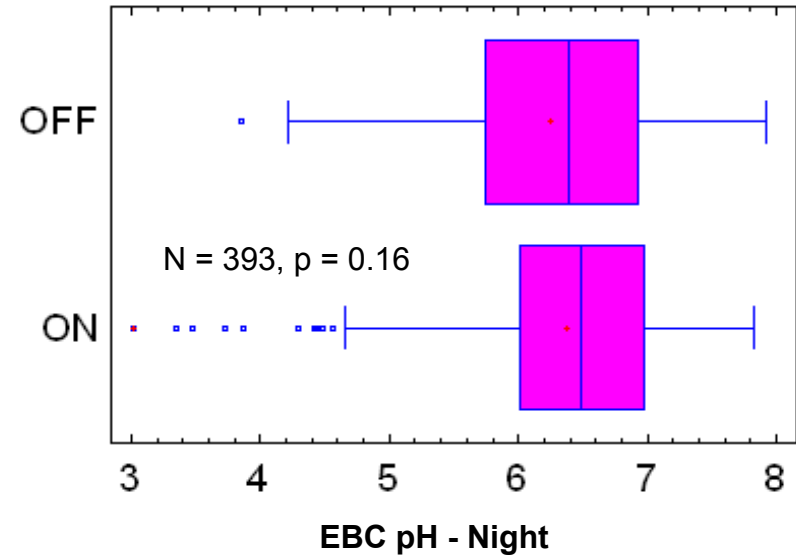
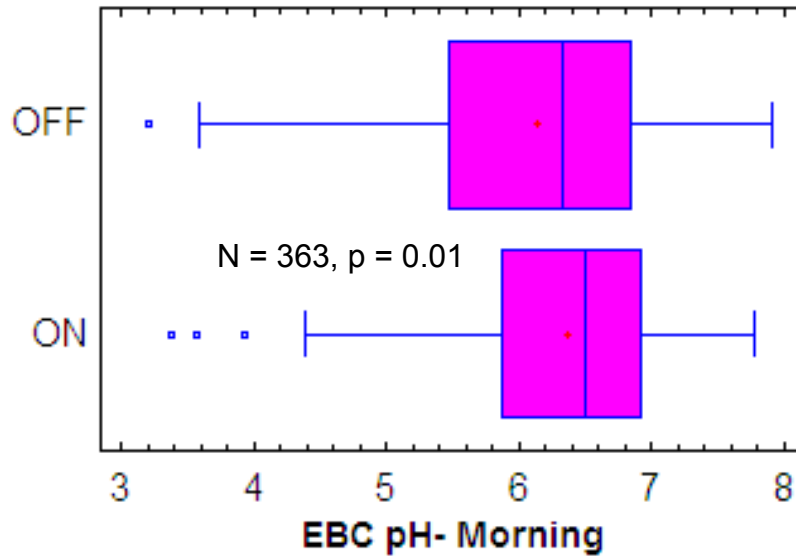
F test shows:

The mean of EBC Nitrate concentrations and PEF z scores collected from night samples were significantly different before and after the operation of HEPAiRx.

NOTE: Children spend day in other microenvironments; carryover effect is evident.

Morning and Evening EBC pH

Groups A & B Combined

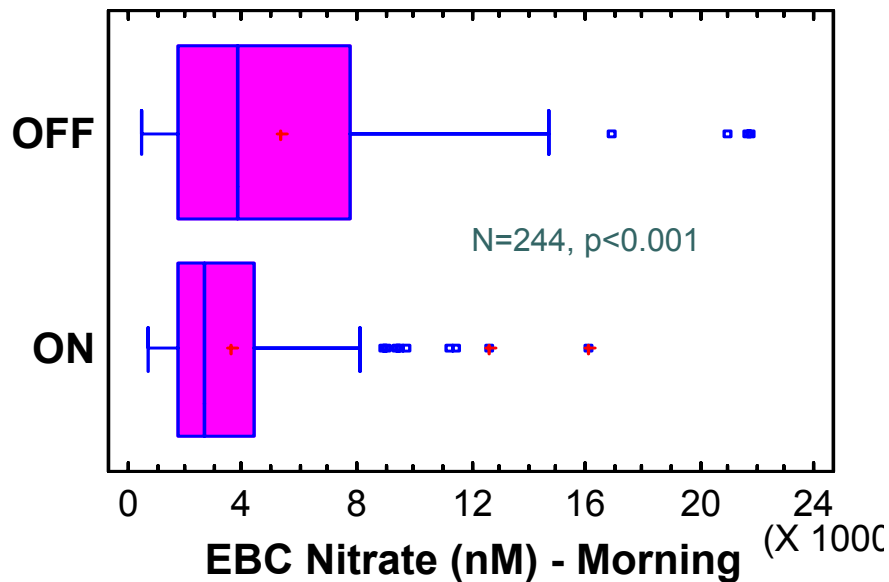


F test show:

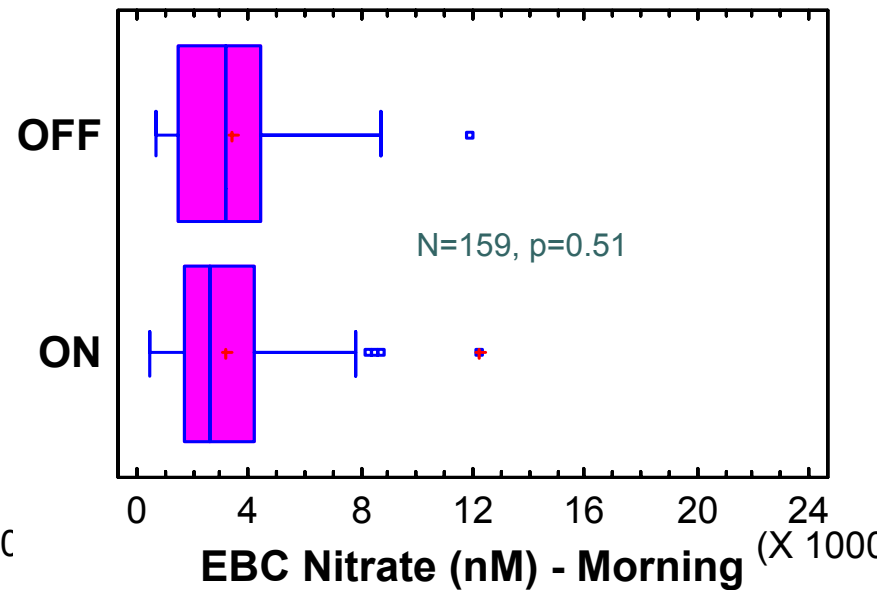
The mean values of EBC pH were significantly increased after the operation of HEPAiRx during the night.

Separate Group Analysis: EBC

Group B



Group A

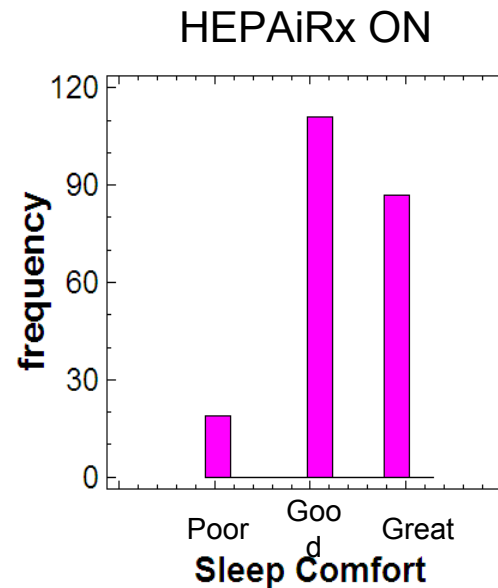
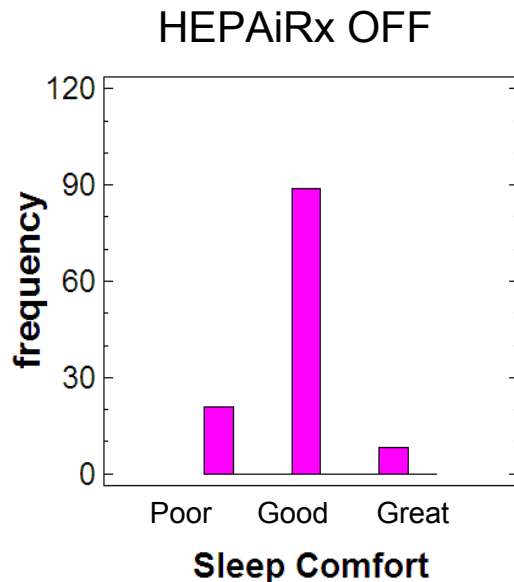


F test shows:

Group B participants responded a statistically significant change in EBC nitrate during before and after the operation of HEPAiRx

Reported Sleep Comfort

- Question: “How well did you sleep last night? Please select one: Poor, Good, Great”



P value of F test is **0.0015**, which shows sleep comfort was significantly improved with the operation of HEPAiRx.



Major Findings

- HEPAiRx proved to be effective for reducing particle, gas, and indoor allergen concentrations.
- Significantly lower EBC nitrate concentrations and higher EBC pH and PEF z scores indicate improvement of the asthma symptoms with the use of the HEPAiRx in the bedrooms of the asthmatic children
- A short-term, carryover effect is evident:
 - Night samples show improvement with HEPAiRx although participants spend daytime in other environments
 - Group A participants show improvement even weeks after the HEPAiRx was shut off.



Future Work

- Complete aeroallergen analysis
- Conduct mass balance modeling to predict IAQ different air cleaner/ventilator configurations
- Develop smaller, user-friendly HEPAiRx in a window or through-wall mounting configuration
- Conduct larger study to include urban environments and separate out various factors, including placebo effect



Acknowledgements

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