Health Impacts and Effectiveness of HEPA filters and Newer Air Purification Technologies
Background and Introduction

This session is focused on:

Health Impacts of Air Quality on

• Respiratory Asthma and Allergies
• Hospitals

Health Impacts of PECO - Comprehensive Air Purification Technology
Background and Introduction

- In USA alone
  - 10-40% suffer from respiratory allergies
  - 8% suffer from asthma
- Internationally, allergy and asthma is rising at an alarming pace
- Air Quality is a primary reason
- Hospital Acquired Infections (HAI) are a major concern even though Hospitals meet all the standards
Background and Introduction

Questions:

- Are HEPA filters enough to purify air to alleviate health concerns?
- How does PECO, a comprehensive air cleaning technology, help improve air quality in Hospitals?
- How does PECO help asthma and allergy sufferers?
- Should Hospitals adopt comprehensive air cleaning technologies like PECO?
- Is there a need to change/adopt tougher air quality standards in hospitals?
What is in our air

Particulate Matter, allergen particles

Microorganisms That Make us Sick

Harmful Gases (VOCs)
Indoor air has more pollutants

Bacteria
- E.Coli
- Tuberculosis
- S. Aureus

Viruses
- SARS
- H1N1
- Influenza
- Ebola

Mold
- Black Mold
- Aspergillus
- Anthrax

VOCs
- VOCs
- Hydrocarbons
- Carcinogens

Allergens
- Dust Mites
- Pollen
Airways and allergen sizes

Diagram A: Airways and regions
- Nasopharyngeal region
- Trachea
- Primary bronchi
- Secondary bronchi
- Terminal bronchioles
- Respiratory bronchioles
- Alveoli

Diagram B: Allergen sizes
- Coarse particles
- Pollen
- Fungal spores
- Mite feces, animal dander, rodent urine aerosols
- Bacteria
- Tobacco smoke
- Viruses
- Ultrafine particles

Legend:
- PM 10
- PM 2.5

Environment:
- Work environment
- Indoor/outdoor environment
Do air filters decrease asthma symptoms and improve sleep function?

Marginal benefit based on the literature review
Need for a Comprehensive Air Purification Technology that captures and destroys pollutants

Photo-Electrochemical Oxidation (PECO)
Photoelectrochemical Air Disinfection (PECO)

A comprehensive air purification technology that oxidizes and destroys microbes, VOCs and converts them into harmless products

Available as Molekule

BEFORE MOLEKULE
Black mold captured on the surface of the Molekule filter before being broken down

DESTRUCTION
Black mold in the process of being oxidized (broken down).

ELIMINATION
Black mold is completely oxidized and eliminated.
Destruction of VOCs

Time (minutes)

Percentage Balance

PECO  HEPA  Carbon
Destruction of Mold
Destruction of Ozone

Ozone degradation

- Ozone concentration (ppm)
- Time (min)

PECO initiated

C_i = 2 ppm
C_i = 4 ppm
Molekule Pilot Study for Allergy & Asthma Sufferers

• March 2015 to April 2017
• Adult patients only
• Volunteers had nasal and ocular allergy symptoms and also some had asthma
• Users were instructed to run device for 12 hrs per day at least and at night (close to bed if possible)
Pilot Study Details

• TNSS and TOSS reported every week
  • TNSS - total nasal symptom score
    • (nasal congestion, runny nose, itchy nose, sneezing)
    • Scale of 0-3 (none, mild, moderate or severe)
  • TOSS - total ocular symptom score
    • (eye itching, eye running, eye redness)
    • Scale of 0-3 (none, mild, moderate or severe)

• Sleep difficulty reported every week
  • Scale of 0-3 (none, mild, moderate or severe)

• Asthma symptoms (baseline and 4 weeks)
  • Puffs of inhaler, sleep quality, control of asthma and interference with daily activities
Pilot Study Details

- TNSS maximum score = 12
- TOSS maximum score = 9
- Sleep maximum score = 3
- Asthma maximum score = 4
- TNSS plus TOSS maximum score = 12
- Greater than 8 classified as active respiratory allergy subjects
## Pilot Study Demographics

### Table 1. Participants Characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>27 (55.1)</td>
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<tr>
<td>Male</td>
<td>22 (44.9)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>Mean (range)</td>
<td>40 (18–77)</td>
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<tr>
<td><strong>Race</strong></td>
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<tr>
<td>Asian or Pacific Islander</td>
<td>6 (12.2)</td>
</tr>
<tr>
<td>Black or African American</td>
<td>1 (2.0)</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>5 (10.2)</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>36 (73.5)</td>
</tr>
<tr>
<td>Middle Eastern</td>
<td>1 (2.0)</td>
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<tr>
<td><strong>Active Allergy Symptoms</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>38 (77.5)</td>
</tr>
<tr>
<td>No</td>
<td>11 (22.5)</td>
</tr>
<tr>
<td><strong>Asthma</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>18 (36.7)</td>
</tr>
<tr>
<td>No</td>
<td>31 (63.2)</td>
</tr>
<tr>
<td><strong>Medication–Allergies &amp; Asthma</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37 (75.5)</td>
</tr>
<tr>
<td>No</td>
<td>12 (24.5)</td>
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</table>
Improvement in mean Total Symptoms Score of 22 Allergy Sufferers

![Bar chart showing improvement in total symptoms score over weeks. Baseline is significantly higher than subsequent weeks.]

Improvement in baseline from mean total symptom score including - nasal congestion, nasal itchiness, runny nose, sneezing, eye itchiness, eye redness, and eye secretions for 22 allergy sufferers over a 28 day trial period.
Improvement in Asthma Score

Change in Mean Asthma Scores Over 4 Weeks

- Total score based on 15 Asthma Sufferers
- *Note: 4 point Asthma score based on:
  - use of inhaler
  - sleep quality
  - interference with activities
  - well controlled asthma.*
Pilot Study Results
Asthma and Medication Use

- **Asthma Sufferers: n=16**
  - Score at baseline 2.06
  - Score at 4 weeks 0.75 \( (p=.006) \)

- **Medication Use (at 4 weeks)**
  - 68% reported a decrease in use of their allergy or asthma medications
Pilot Study Conclusion

• IAQ affects our health – allergies, asthma ---

• Molekule PECO technology improved respiratory allergy symptoms
  • after just 1 week
  • greater sustained improvements at 4 weeks

• Molekule PECO also improved
  • asthma symptoms,
  • medication use and
  • sleep quality from allergies
Air Quality and Health Impacts in Hospitals

Background and Introduction

• Hospitals in USA provide the best healthcare for patients

• Hospitals follow infection control protocols - doctors, nurses, hospital staff follow stringent infection control requirements

• Hospitals follow all air cleaning standards

• Yet, there is no denying that Hospital Acquired Infection (HAI) is a reality

• Questions:

  ➢ Is there a need to tighten the air cleaning standards

  ➢ Is there a need to adopt comprehensive advanced air purification and disinfection technologies

• Mercy Health is proactively looking for answers for both of these questions by conducting IRB approved study
Four core service areas

- 7 hospitals
- 85+ primary and specialty care locations
- 15+ hospice, home health, medical equipment pharmacies
- 1 insurance company (wholly owned and operated)
<table>
<thead>
<tr>
<th>Category</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Hospitals</td>
<td>7</td>
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<tr>
<td>Clinical sites</td>
<td>85</td>
</tr>
<tr>
<td>Communities served</td>
<td>55</td>
</tr>
<tr>
<td>Counties served</td>
<td>15 (WI/IL)</td>
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<tr>
<td>Total patient visits</td>
<td>2.4 Million</td>
</tr>
<tr>
<td>Employee/Partners</td>
<td>8,000+</td>
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<tr>
<td>W2 Employed Physicians</td>
<td>750+</td>
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<td>Revenue</td>
<td>$3 Billion</td>
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JAVON BEA HOSPITAL AND PHYSICIAN CLINIC- RIVERSIDE

Mercyhealth
A passion for making lives better.

IAQA
2019 IAQA Annual Meeting
HYBRID OR
Air Quality Measurement and Impacts of PECO Technology

Protocol for Air Quality Monitoring

AHU80 Sampling
• Pre-filter: Two pleats were swabbed per sample
• Final filter: One pleat was swabbed per sample

MH1 Swabbing Sampling
• Pre-filter: Four pleats were swabbed per sample
• PECO-filter: Four pleats were swabbed per sample

MH1 Extraction Sampling
• Pre-filter: Removed from unit and placed within fresh Ziploc bag
• PECO-filter: Removed from unit, cut using sterile tin snips and placed within fresh Ziploc bag

Sample analysis at EMSL Analytical, Inc., Houston, TX
Results of Air Monitoring Potentially Pathogenic Microorganisms

• HVAC Pre-filter and final filter reduce microbes in air but not completely.
• PECO pre-filter inlet shows more microbes than the HVAC final filter outlet, indicating that additional microbes are introduced by personnel, visitors etc.
• PECO destroys microbes from air in the room completely.
Results of Air Monitoring
Bacterial microorganisms

- HVAC Pre-filter and final filter reduce bacteria in air but not completely
- PECO pre-filter inlet shows more bacteria than the HVAC final filter outlet, indicating that additional bacteria are introduced by personnel, visitors etc.
- PECO destroys bacteria from air in the room completely
Results of Air Monitoring Fungal microorganisms

- HVAC Pre-filter and final filter reduce fungal microbes but not completely
- No additional fungal microbes are introduced by personnel, visitors etc.
- PECO destroys fungal microbes from air in the room completely
Conclusions from Hospital Air monitoring

• Potentially pathogenic microbes are passing through the HVAC system’s pre- and final-filters

• MH1 pre-filters are trapping more potentially pathogenic microbes than are seen on the HVAC system final-filters, suggesting secondary sources of microbes (Patients, visitors etc.)

• PECO removes microbes from air completely
# Impact of PECO on Patients
(Preliminary Results)

## Pre- and Post- Intervention Results for all patients

- Length of stay in PICU reduced by ~ 42%
- # of days of nebulizer and nasal cannula O$_2$ used, and total length of stay all reduced

<table>
<thead>
<tr>
<th>Pre-post Intervention</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
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</thead>
<tbody>
<tr>
<td>LOS in PICU (days)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pre-intervention</td>
<td>366</td>
<td>0.67</td>
<td>2.975</td>
<td>0.15</td>
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<tr>
<td>Post intervention</td>
<td>172</td>
<td>0.39</td>
<td>1.062</td>
<td>0.08</td>
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<tr>
<td>LOS Total (days)</td>
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<td></td>
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<tr>
<td>Pre-intervention</td>
<td>366</td>
<td>3.21</td>
<td>3.055</td>
<td>0.16</td>
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<tr>
<td>Post intervention</td>
<td>172</td>
<td>2.92</td>
<td>1.665</td>
<td>0.12</td>
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<tr>
<td>How many days of nebulizer use?</td>
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<td></td>
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<td></td>
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<tr>
<td>Pre-intervention</td>
<td>254</td>
<td>2.93</td>
<td>1.931</td>
<td>0.12</td>
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<tr>
<td>Post intervention</td>
<td>119</td>
<td>2.61</td>
<td>1.452</td>
<td>0.13</td>
</tr>
<tr>
<td>Number of days nasal cannula O$_2$ used</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-intervention</td>
<td>154</td>
<td>2.62</td>
<td>1.663</td>
<td>0.13</td>
</tr>
<tr>
<td>Post intervention</td>
<td>68</td>
<td>2.59</td>
<td>1.547</td>
<td>0.18</td>
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</table>
Impact of PECO on **Asthma** Patients
(Preliminary Results)

Pre- and Post- Intervention Results for **asthma** patients only

- Length of stay in PICU reduced by ~ 37%
- # of days of nebulizer used reduced by ~ half day
Summary and Conclusions

• Molekule PECO technology reduced respiratory allergy symptoms and medication use and improved sleep quality

• Molekule PECO disinfected air in the patient rooms in IRB approved Hospital pilot study

• Air passing through HVAC systems in the Hospital contains pathogenic microorganisms

• Molecule PECO reduced length of stay in PICU and use of nebulizer in hospital

• We recommend more stringent standards for air cleaning in hospitals
Bibliography

1. Molekule results presented at American College of Asthma Allergy and Immunology meeting October 26-30, 2017, Boston, MA


Questions?