Influence of Face Shields on Aerosol Exposure Reduction

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Introduction

- There has been an increased focus on personal protective equipment (PPE), specifically face masks and face shields, due to the recent COVID-19 crisis.
- Aerosols, especially sizes below 5 µm, can be hazardous to human health.
- May cause infectious disease, acute toxic effects, allergies and cancer.
- A pilot study was conducted to gain understanding on the efficiency of face shields to prevent aerosols from entering into the breathing zone.

Methods

- **Experiment Setup**: Three different designs of face shields (referred to as A, B, and C) were tested using a breathing mannequin system set to breathing minute volumes of 6 and 20 lpm.
- Sampling was conducted in an ultra-low speed wind tunnel with a spatially uniform distribution of aerosols.
- Two different sizes of ISO test dust (fine and ultra-fine) were used as challenge aerosols in separate tests.
- **Samplers**: A sampling inlet tube, threaded through the mannequin and out of the nostril, was attached to a GRIMM 1.109 Portable Laser Aerosol Spectrometer, which measured particle concentration and size (31 size bins from 0.25-32 µm) in the breathing zone.
- A second GRIMM was located upstream of the mannequin to measure background particle concentrations.
- Control sampling was conducted to compare the location of both samplers. During the control testing, a face shield was not placed on the mannequin. The breathing zone GRIMM and reference GRIMM results were compared to calculate a correction factor that was applied to all efficiency calculations.
- **Statistical Analysis**: Overall efficiency (0.25-32 µm) was calculated by comparing the concentrations measured by the breathing zone GRIMM to the reference GRIMM. Multi-factor ANOVAs with interaction effects were used to compare the efficiency of each face shield for each size bin of the smallest particle sizes (0.25-6.50 µm).

Results

<table>
<thead>
<tr>
<th>Face Shield</th>
<th>Breathing Rate (lpm)</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>93%</td>
</tr>
<tr>
<td>A</td>
<td>20</td>
<td>94%</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>56%</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>48%</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>75%</td>
</tr>
<tr>
<td>C</td>
<td>20</td>
<td>51%</td>
</tr>
</tbody>
</table>

Figure 1. Main Effects Plot of the Interaction Between Face Shields and Particle Size (0.25-6.50 µm)

- Each face shield was able to significantly reduce aerosol concentrations in the breathing zone of the mannequin with both breathing rates (p-value < 0.0001).
- Face shield A had the highest efficiency for overall particles 0.25-32 µm (93-94%).
- Face shield B and C were affected by breathing rate.
- Interaction effects between:
  - Face shield and breathing rate (p-value < 0.0001)
  - Face shield and individual particle size bins 0.25-6.50 µm (p-value < 0.0001)
  - Face shield, breathing rate, and individual particle size bins 0.25-6.50 µm (p-value < 0.0001)
- Particle size bins 0.25-6.50 µm and breathing rate interaction was not significant (p-value = 0.678)

Discussion

- **Strengths of the study** include using well-controlled environment, standard aerosols, and simultaneous particle measurement.
- **Limitations** of the study include the lack of rotation of the mannequin to account for human movement and sampling was exclusively simulating nose breathing.

Conclusion

- Each face shield showed some ability to prevent airborne particles from entering into the breathing zone, with higher efficiency for larger particles.
- Face shield A had the highest efficiency, notably using a design that has a closer fit and wraps further around the face.
- Results from this pilot study demonstrate that additional research is needed to further understand the protective nature of face shield designs and fit, especially against particle sizes below 0.25 µm. Additional research including mannequin rotation may also be beneficial to understand the efficiency of face shields.

Acknowledgements

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References