COVID-19: How Much Protection do Face Coverings Offer?

Liqiao Li, Muchuan Niu, and Yifang Zhu
Department of Environmental Health Sciences,
Fielding School of Public Health
University of California, Los Angeles

The Inaugural APRU Crisis Management Webinar, September 29th, 2020
Background

- Respiratory droplets produced by coughing within a close range of about 1.8 m (6 ft) is one of the main routes of human to human transmission of SARS-CoV-2 virus during the COVID-19 pandemic (CDC, 2020; Acter et al. 2020)

- Virus-laden particles were found less than 5 µm in the air (Liu et al. 2020); remain viable and suspended in the air for hours (Morawska 2006; van Doremalen et al. 2020)

- Many previous studies focus on the inward filtration efficiency of different face coverings (Konda et al 2020; Lindsley et al 2014; Steinle et al 2018; van der Sande et al 2008; Zhou et al 2018)

- Knowledge gap:
  - Effectiveness of using different face coverings to mitigate the outward transport of respiratory droplets in an indoor environment has not been fully understood
Objective
- To evaluate the effectiveness of different face coverings to mitigate coughing particles at 0.3, 0.9, and 1.8 m (i.e., 1, 3, and 6 ft) away from the coughing source

Hypothesis
- Particle concentrations decrease with distance from the coughing source
- Different face coverings provide a wide range of efficacy to mitigate particles generated by human coughing
Tested Face Coverings

#1 No face covering
#3 Cotton mask (2-ply, 100% cotton)
#5 Flannel mask (50/50 cotton & polyester)
#7 Surgical mask
#9 N95 respirator

#2 Face shield only
#4 Face shield + cotton mask
#6 Face shield + Flannel mask
#8 Face shield + Surgical mask
#10 KN95 mask
- At 0.3 m, cough particles increased then decreased to a near-background level within 2-3 s.
- At 0.9 and 1.8 m, particle levels were 47% and 10%, respectively, of what was measured at 0.3 m.
- Peak flow rate in this study: ~20 L/min << reported in a clinical study (i.e., ~200 L/min) (Salam et al. 2004).
## Results - Particle reduction rates using various face coverings

<table>
<thead>
<tr>
<th>Face Covering Conditions</th>
<th>Background-subtracted PNC at 0.3 m, #/cm³ (Mean ± SE)</th>
<th>Particle Reduction Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 No face covering</td>
<td>43 ± 7</td>
<td>/</td>
</tr>
<tr>
<td>#2 Face shield only</td>
<td>42 ± 10</td>
<td>4%</td>
</tr>
<tr>
<td>#3 Cotton mask</td>
<td>7 ± 3</td>
<td>83%</td>
</tr>
<tr>
<td>#4 Face shield + Cotton mask</td>
<td>6 ± 2</td>
<td>85%</td>
</tr>
<tr>
<td>#5 Flannel mask</td>
<td>12 ± 5</td>
<td>72%</td>
</tr>
<tr>
<td>#6 Face shield + Flannel mask</td>
<td>4 ± 1</td>
<td>91%</td>
</tr>
<tr>
<td>#7 Surgical mask</td>
<td>3 ± 2</td>
<td>94%</td>
</tr>
<tr>
<td>#8 Face shield + Surgical mask</td>
<td>3 ± 1</td>
<td>94%</td>
</tr>
<tr>
<td>#9 N95 respirator</td>
<td>2 ± 3</td>
<td>95%</td>
</tr>
<tr>
<td>#10 KN95 mask</td>
<td>2 ± 1</td>
<td>94%</td>
</tr>
</tbody>
</table>

Particle reduction rate (%) = \( \left( 1 - \frac{\text{PNC with face covering}}{\text{PNC without face covering}} \right) \times 100\% \)

- How effective a face covering can reduce the particles generated from coughing
**Results** – Background-subtracted PNC at three locations

*p ≤ 0.05, **p ≤ 0.01, *** p ≤ 0.001; Error bars show the standard error of the mean.*
Results – Particle size distributions at 0.3, 0.9, and 1.8 m

Please note different scale on Y-axis.
Conclusions

- Most cough particles were found ≤ 2.5 µm in the indoor environment.

- For outward protection: N95 respirator, KN95 mask, and surgical mask > cloth masks/cloth masks + face shield > face shield only

- N95 respirator, KN95 mask, and surgical mask offered excellent protection and substantially reduced the cough droplets within 1.8 m.

- Despite a wide range of efficacy, all face coverings (except for shield only) can serve as a simple barrier to help reduce the concentration of cough-generated particles and likely decrease the spread of COVID-19.
Take Home Message

Wear Your Mask!
Acknowledgement

- This study was partially supported by philanthropy and the Administrative Vice Chancellor’s office at UCLA.

- The authors sincerely thank Dr. Shane Que Hee for providing the hot wire anemometer and the volunteer who participated in the experiments.
Reference


Morawska L 2006. Droplet fate in indoor environments, or can we prevent the spread of infection? Indoor Air. 16 335-347.


