Speech Intelligibility of Elastomeric Respirators in Healthcare Settings

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Hospitals are noisy environments

- University of Chicago study: Average noise levels in patient rooms: 50-80 dB(A)
- World Health Organization (WHO) recommends hospital noise levels should not exceed 40 dB(A) at night and for patient rooms no more than 35 dB(A) during the day and 30 dB(A) at night
- Speech Intelligibility (SI) during respirator wear report decrements in performance with ambient noise levels as low as 40 dB(A)
- Hospital noise levels have steadily increased since the 1960’s during the day and night
- Why? Modern hospitals are busier, more complex and contain a vast amount of technology and medical monitoring devices emitting sounds
Factors Contributing to Speech Intelligibility

1. Background Noise Levels
2. Signal to Noise Ratio (SNR)
3. Space Design
4. Construction Materials
5. Facial PPE Usage
Advantages and Key Issues with Elastomeric Respirators

**Advantages**
- Reusable
- Fit is maintained after repeated use
- Durable with respect to disinfection
- Reusability = cost savings

**Key Issues**
- Diminished Speech Intelligibility compared to Surgical Masks and N95s
- Standard disinfection process
- Storage space between employee work shifts
- Annual Fit Testing is required
Elastomeric Properties Contributing to Speech Intelligibility

- Material Properties – Sound transmission is attenuated through rubber/synthetic materials
- Material Clarity – Lack of material transparency takes away visual stimuli especially important to hearing impaired populations, children, etc.
- Speech Clarity – Pressure on the nasal alae may alter speech and reduce speech intelligibility
- Mandible Movement – Restricted Mandible range of motion due to straps and/or user concerns for compromising proper fit may contribute to altered syntax and reduced intelligibility
- Acoustic Amplification - When speaking while wearing a respirator, sound is perceived louder to the user
- Surface area of filter(s) – Sound wave diffraction alters sound transmission properties
Speech Intelligibility of Protective Facemasks and Air-Purifying Respirators

Speech Transmission Index (STI) Scale

<table>
<thead>
<tr>
<th>STI Value</th>
<th>Quality according to IEC 60268-16</th>
<th>Intelligibility of Syllables in %</th>
<th>Intelligibility of Words in %</th>
<th>Intelligibility of Sentences in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.3</td>
<td>bad</td>
<td>0 - 34</td>
<td>0 - 67</td>
<td>0 - 89</td>
</tr>
<tr>
<td>0.3 - 0.45</td>
<td>poor</td>
<td>34 - 48</td>
<td>67 - 78</td>
<td>89 - 92</td>
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<tr>
<td>0.45 - 0.6</td>
<td>fair</td>
<td>48 - 67</td>
<td>78 - 87</td>
<td>92 - 95</td>
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<tr>
<td>0.6 - 0.75</td>
<td>good</td>
<td>67 - 90</td>
<td>87 - 94</td>
<td>95 - 96</td>
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<tr>
<td>0.75 - 1</td>
<td>excellent</td>
<td>90 - 96</td>
<td>94 - 96</td>
<td>96 - 100</td>
</tr>
</tbody>
</table>
Speech Intelligibility of Protective Facemasks and Air-Purifying Respirators

**Methods**

- Two Protective Facemasks (PF), N95 and Elastomeric (EAPR) models
- Hemi-Anechoic Chamber
- Modified NFPA 1981 Supplementary Voice Communications System Performance Test (3 samples per model x 5 STI measurements per sample)
- STI measurements using pink noise levels of 52.5 – 72.5 dB(A) in 5.0 dB(A) increments
- 5 measurements x 5 background ranges x 3 samples = 75 STI measurements per model
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**Key Results**

- Significant differences in SI between PF, N95 and EAPR
- EAPR models had the most significant impact on SI, differing from the baseline by 42% (Scott Xcel) and 45% (North 5500)
- At 2 kHz and 4 kHz, the sound pressure level of both EAPRs was nearly equal to the background noise level, masking the STI signal in these key frequency ranges and degrading speech intelligibility
Future Work

- Investigate further elastomeric issues (stockpiling, disinfection, impact on operations and patient care, etc.)
- Work with manufacturers and stakeholders to develop novel materials and designs while retaining and/or improving protection
- Develop multifactorial approaches to increasing SI in different hospital settings
- Investigate SI for Powered Air-Purifying Respirators (PAPR) in healthcare settings
Contact Information and Disclaimer

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Disclaimer: The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.”