Microbiological Safety and Environmental Efficacy of Disposable Bedside Cool-Mist Humidifiers

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Background
The humidification of dry air, especially in the winter, may be soothing to chapped nasal and bronchial mucous membranes. However, humidifiers have long been associated with human illness. “Monsieur Pigeon,” a respiratory condition now pronounced after exposure to the causative workplace system lost in the 1950s, was described some 37 years ago. Numerous reports since then have implicated humidifiers in allergic syndromes and transmission of pathogens.

Hospital bedside room humidifiers are difficult to sterilize and provide a sanctuary for waterborne organisms. They can harbor pathogens such as Acinetobacter, Pseudomonas, and Burkholderia species. Humidifiers can aerosolize bacteria, and have been linked to nosocomial outbreaks. The presence of multidrug-resistant organisms may likewise contaminate their environment (including humidifier) with potentially pathogenic organisms.

Methods
We filled Cool Mist humidifiers (Kaz 4100) with sterile water and placed them in an empty patient room. Each humidifier was run for 5 days. Daily humidity and temperature readings were obtained from a sensor on the humidifier by day of sampling. Overall, there was a significant difference between summer and fall/winter humidity and temperature readings (p<0.001), but duration of exposure had no effect on either temperature or humidity. When controlling for season, the distance from the humidifier to the bed was the only variable that remained significant (p=0.006). In multivariable analysis, a higher number of colonies grew from reservoir cultures and settle plates in summer.

Results
We found a significant difference between humidifier and control experiments in both room humidity (38% and 25%, respectively, p<0.001) and temperature (75.2°F and 73.9°F, respectively, p<0.001). There were also significant differences between summer and fall/winter humidity and temperature readings (p<0.001), but duration of exposure had no effect on either temperature or humidity. When controlling for season, the humidity effect on temperature disappeared, but the effect on humidity remained significant (p=0.006). In multivariable analysis, a higher number of colonies grew from reservoir cultures and settle plates in summer than in fall/winter (p<0.002). Contamination appeared as early as day 1, increased with experiment day (p<0.001), and accelerated after day 3. Settle plate colony count diminished with increasing distance from the humidifier (p<0.001). Further controlling for temperature and humidity did not affect these results. Organisms that grew included skin flora and molds.

Conclusions
Bedside patient humidifiers had a modest effect on room humidity, but became contaminated with bacteria and mold over time despite the use of sterile water and only once daily rinsing. This risk is only partially mitigated by replacing humidifiers after three days.

The bacteria identified were common environmental molds as well as skin flora (see table) that most likely came from the investigators. It seems likely that patients who are colonized with multidrug-resistant organisms may likewise contaminate their environment (including humidifier) with potentially pathogenic organisms.

The aerosolization of these pathogens in humidifier vapor may pose an inhalation risk, especially to immunosuppressed patients, or patients susceptible to lung infections. Interestingly, our study showed an increased positivity of setlled plates during the summer, however, it is not possible to determine whether this observation was due to the humidifier.

Based on the results of our study, we would recommend against the use of bedside humidifiers in hospitals, particularly those that serve immunosuppressed patients. Humidification of oxygen lines could be used as an alternative measure to improve patient comfort.

Organisms grown on settling plates

Data from humidifier rooms, by season

<table>
<thead>
<tr>
<th>Organisms grown on settling plates</th>
<th>Summer</th>
<th>Fall/Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance [m] from humidifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

P = 0.001 by distance
P < 0.001 between seasons

Figure 1: The number of colonies isolated by distance from the humidifier. Distance “0” is the humidifier reservoir itself. There was a significant difference between summer and fall/winter colony numbers overall and by distance.

Figure 2: The number of organism colonies isolated from the humidifier by day of sampling. Overall, there was a significant difference in contamination as time elapsed during both summer (p<0.01) and fall/winter (p=0.037).

Organism growth from humidifier cultures

Data from humidifier run

<table>
<thead>
<tr>
<th>Organism growth from humidifier cultures</th>
<th>Summer</th>
<th>Fall/Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of colonies</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

P < 0.01

Figure 3: The number of organism colonies isolated per day from the reservoir only. The differences over time were significant overall (p=0.002), contributed by day 5 (p<0.01), but there was no overall seasonal difference (p=0.21).

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References