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Concise Communication

Does a mobile dust-containment cart reduce the risk of healthcare-associated fungal infections during above-ceiling work?

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Abstract

Immunocompromised patients are at risk for infections due to above-ceiling activities in hospitals. Mobile dust-containment carts are available as environmental controls, but no published data support their efficacy. Using microbial air sampling and particle counts, we provide evidence of reduced risk of fungal exposure during open ceiling activities.

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From telesitters to point-of-care devices, technology is transforming healthcare. To function properly, the Internet of Medical Things (IoMT) requires extensive above-ceiling cable installations and router upgrades, especially in older medical facilities. Above-ceiling openings in intensive care units and procedural areas can potentially release fungal spores into the environment. It is well documented that construction, maintenance, and renovation projects place critically ill and immunocompromised patients at high risk for fungal infections and mortality.[1]

Constructing barriers for multiple above-ceiling access points is time-consuming and costly, leading healthcare facilities and contractors to use mobile dust-containment carts (MDCC) with integrated high-efficiency particle air (HEPA) filtration and vacuum systems (Fig. 1). Several companies market MDCCs for infection control purposes. However, no published studies on a cart's ability to reduce infection risk are available in the literature. Therefore, we studied the ability of MDCCs to prevent environmental contamination.

Methods

This study was conducted at a 923-bed academic medical center that requires the use of barriers for above-ceiling access in the highest risk areas based on an infection control risk assessment.[2] Overall, 3 MDCCs with HEPA filtration (Clean Work Booth, Jacksonville, FL) were used during above-ceiling activities in November–December 2019. In total, 48 fungal air samples and 96 particle counts were collected. Each selected above-ceiling activity had 4 samples collected: (1) before above-ceiling work began, (2) inside the MDCC during above-ceiling work, (3) outside the MDCC during above-ceiling work, and (4) in proximity to the MDCC's HEPA air exhaust during the above-ceiling work.

Fungal samples were collected using a microbial air sampler (SAS Super 180, Bioscience International, Rockville, MD) that passed 1,000 L of air over an inhibitory mold agar plate (Thermo Fisher Scientific, Lenexa, KS). Plates were incubated at room temperature for 7 days, and colony-forming units (CFU) were counted. A correction factor for a 401-hole impactor was applied.[3] Colonies were identified to the genus level. Molds that could not be identified from the primary agar plate were subcultured onto potato flake agar (Thermo Fisher Scientific), were incubated at 30°C for 14 days, and were identified or recorded as "mold not otherwise specified." Minimum and maximum particle count for each sampling position and location were recorded using an ultrafine particle counter (P-Trak 8525, TSI, Shoreview, MN).

Results from the 2 sampling methods were analyzed (GraphPad Software, San Diego, CA). A Pearson correlation analysis and 1-way analysis of variance (ANOVA) were used to examine the associations between fungal counts and particle counts. We applied the Bonferroni-Šídák correction for post hoc multiple comparisons to test the statistical significance of the 6 position combinations (before vs inside, before vs outside, etc).[4] P values $< .05$ were considered statistically significant. Mean CFU/m^3, mean particles/cm^3, and 95% confidence intervals were calculated using Microsoft Excel software (Microsoft, Redmond WA).

Results

Mean colony-forming units per cubic meter (CFU) and mean particle count per cubic meter (particle count) collected inside the MDCC (CFU, 11; particle count, 3,634) were statistically different ($P < .01$) from the control (CFU, 4; particle count, 1,471),

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Fig. 1. Typical mobile dust-containment cart (MDCC) used for above-ceiling access.

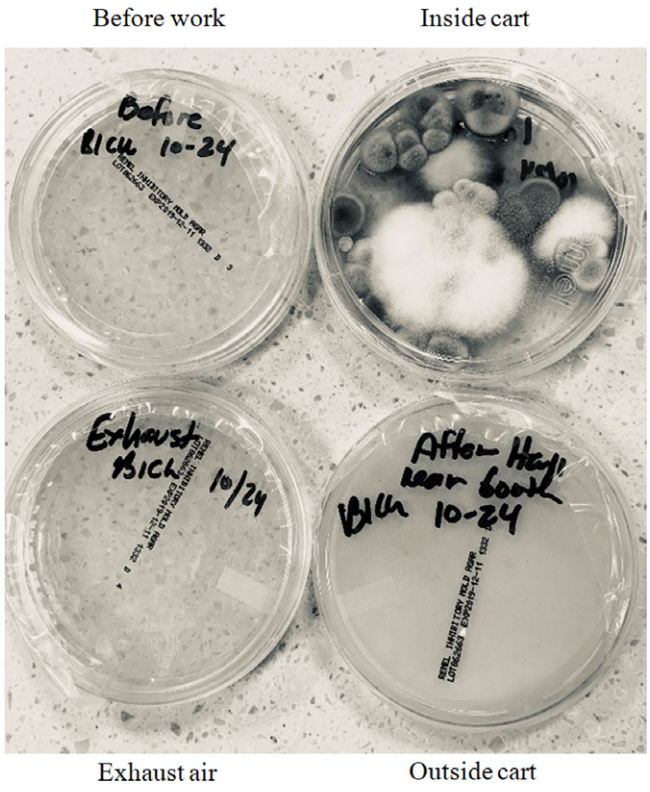

Fig. 3. Fungal growth (at day 7) from samples collected in and around a mobile dust-containment cart (MDCC) during above-ceiling work in a burn intensive care unit.

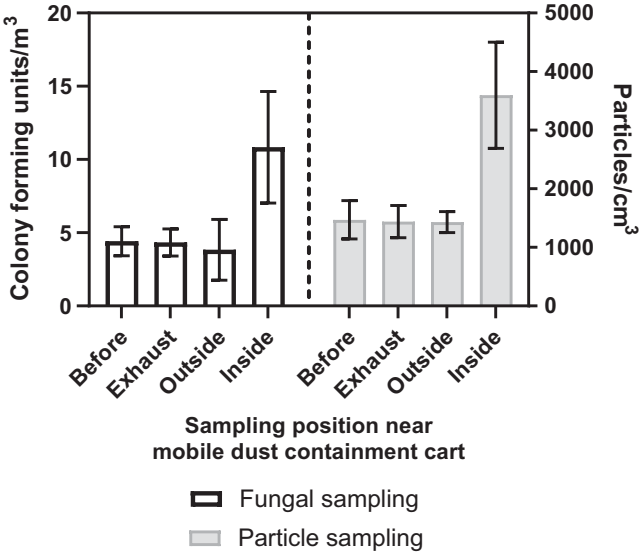

Fig. 2. Mean colony-forming units per cubic meter and particle counts per cubic meter by sampling position, with 95% confidence intervals.

outside (CFU, 4; particle count, 1,430) and HEPA exhaust (CFU, 4; particle count, 1,446). The control, outside samples, and HEPA exhaust samples were not statistically different from each other (Fig. 2). The correlation coefficient of CFUs and particle counts from all samples was +0.48. Fungal release from above-ceiling activity varied substantially (0–38 CFU/m^3) based on sampling location within the hospital and MDCC sampling position. Also, 11 distinct genera of mold were identified from sampling including medically important pathogenic genera: *Aspergillus*, *Rhizopus*, *Cladosporium*, and *Curvularia*.

Discussion

Indoor air quality in hospitals is an important factor in the control of healthcare-associated respiratory infections, especially in immunocompromised hosts.[5] Types and amount of fungi released from above-ceiling activity in healthcare facilities varies by location and cannot be predicted. *Aspergillus*, for instance, remains the most common construction-related pathogen; it can remain aerosolized for extended periods and travel long distances.[6] The MDCC significantly reduced the potential for aerosolization of pathogenic fungi, especially in above-ceiling spaces with high levels of fungi. The highest concentration of fungi we identified was collected inside the MDCC (38 CFU/m^3) compared to outside (1 CFU/m^3) and near the exhaust (0 CFU/m^3) (Fig. 3). Sampling occurred in the burn intensive care unit that housed patients at high risk for respiratory infections.

The correlation coefficient for CFU and particle count was +0.48, indicating a moderate relationship between fungal CFU and particle count, even though our ultrafine particle counter measures particles <1 μm and most molds are larger in the range of 2–20 μm. Previous researchers have detected a strong correlation between fungal counts and particle counting in the same size range of our work, <1 μm and a weak correlation in the larger size range of most fungi (ie, 5, 10, and 25 μm).[7,8] Some sampling locations had low particle counts but high numbers of fungal

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colonies and vice versa. Because of the inconsistent correlations, the use of a particle counter for a single point-prevalence sampling as a substitute for fungal activity is inappropriate.

Microbial air sampling and particle counts collected near the HEPA-filtered air exhaust were not statistically different from samples taken before work began (ie, controls). We sampled this location based on a report that 73% of 85 portable HEPA devices failed to provide HEPA level performance.[9] Although the MDCC HEPA filtration systems were performing effective filtering, there was no practical way to assess filter failure other than observing dust exhaust expulsion from the MDCC. Therefore, routine maintenance and a regular filter replacement schedule is critical given the amount of pathogenic fungi that could potentially be ejected into a patient care area from a failed HEPA filtering device.

Our study has several limitations. All 3 MDCCs were the same manufacturer model, although other manufacturers use a similar design. Different models may function better or worse depending on features such as a more robust HEPA system or no HEPA filtration. We had a single microbial air sampler and single particle counter, which required sequential sampling of the above-ceiling work instead of capturing simultaneous measurements. To account for this sequential sampling, we alternated the order for the outside and exhaust sampling on several occasions, and order did not appear to be related.

In conclusion, this evaluation provides quantitative evidence that MDCCs, when used correctly, are effective barriers for reducing the risk of potential pathogenic exposures during above-ceiling activities in areas with critically ill and immunocompromised patients. The use of particle counters in lieu of microbial air sampling can provide quick results but is not an accurate substitute for fungal counts and should be considered only one of several methods to evaluate construction barrier effectiveness.

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References

1. Kanamori H, Rutala WA, Sickbert-Bennett EE, Weber DJ. Review of fungal outbreaks and infection prevention in healthcare settings during construction and renovation. *Clin Infect Dis* 2015;61:433–444.
2. Guspiel A, Vogel, RA. Chapter 2: Construction documents. In: *Infection Prevention Manual for Construction & Renovation, first edition*. Arlington, VA: APIC; 2015:12–16.
3. Macher JM. Positive-hole correction of multiple-jet impactors for collecting viable microorganisms. *Am Ind Hyg Assoc J* 1989;50:561–568.
4. Lee S, Lee DK. What is the proper way to apply the multiple comparison test? *Korean J Anesthesiol* 2018;71:353–360.
5. Cho SY, Myong JP, Kim WB, *et al.* Profiles of environmental mold: indoor and outdoor air sampling in a hematology hospital in Seoul, South Korea. *Int J Environ Res Public Health* 2018;15(11):2560.
6. Chang CC, Ananda-Rajah M, Belcastro A, *et al.* Consensus guidelines for implementation of quality processes to prevent invasive fungal disease and enhanced surveillance measures during hospital building works, 2014. *Intern Med J* 2014;44:1389–1397.
7. Armadans-Gil L, Rodríguez-Garrido V, Campins-Martí M, Gil-Cuesta J, Vaqué-Rafart J. Particle counting and microbiological air sampling: results of the simultaneous use of both procedures in different types of hospital rooms. *Enferm Infecc Microbiol Clin* 2013;31:217–221.
8. Wong KY, Mohamed KH, Nazri K, *et al.* Correlation between particulate matter and microbial counts in hospital operating rooms. *Adv Environ Biol* 2018;12:1–4.
9. Newcomer DA, LaPuma P, Brandys R, Northcross A. Capture efficiency of portable high-efficiency air filtration devices used during building construction activities. *J Occup Environ Hyg* 2018;15:285–292.

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