

SYNOPSIS

Review of “Efficacy of portable air cleaners and masking for reducing indoor exposure to simulated exhaled SARS-CoV-2 aerosols — United States, 2021”

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One-minute summary

- In an experiment using respiratory simulators with headforms as the source and receiver of simulated exhaled aerosols, the addition of two air cleaners each with a high-efficiency particulate air (HEPA) filter in a conference room approximately 176 cubic metres (m³) reduced the exposure to the aerosols by at least 49.3% without universal masking (three-layer cloth, non-medical masks), and up to 90.4% with universal masking.
- In all experimental conditions, the use of HEPA air cleaners significantly reduced aerosol exposures compared to not using HEPA air cleaners (p = 0.001).
- The greatest reduction in exposure was achieved when the HEPA air cleaners were positioned close to the source respiratory simulator (in the center of the room); the reduction of exposure in this position was significantly more than when the HEPA air cleaners were positioned in other locations (left and right and front and back of the room, p < 0.01).
- Authors conclude that the use of portable HEPA air cleaners are effective in indoor environments for reducing exposure to aerosol particles, particularly when used in combination with universal masking.

Additional information

- Respiratory simulators with headforms with elastomeric skin were used as source and receivers (speaker and participant A and B). The source was located in the center of the room facing the speaker, with the mouth at 1 m above the floor (seated height). One receiver, the speaker, was located 1.8 m in front of the source, facing the source at a height of 1.5 m (standing height). Two

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receivers, participants A and B, were located on either side of the source facing the same direction as the source and spaced 0.9 m (participant A) and 1.8 m (participant B) away from the source with the mouths at 1 m above the floor (seated height).

- The rate of respiration of the source and two participant receivers was 15 litres per minute (L/min, normal breathing). The rate of respiration of the speaker was 28 L/min (simulated talking).
- The dimensions of the conference room were 6.3 m by 9.3 m by 3 m. The conference room ventilation was 2 air changes per hour, with no air recirculation prior to addition of HEPA air cleaners. Three air outlets were situated in the ceiling in the centre of the room and 6 air inlets were situated in the ceiling on the periphery of the room.
- Two portable HEPA air cleaners were used, which provided an additional 5.2 air changes per hour. The units have a fan that directs cleaned air from the top in a 360 degree direction. The four experiments involving HEPA air cleaners located the air cleaners at the:
 - center of the room on the floor behind source
 - left and right sides of the room on the floor and at least 1.8 m away relative to the source
 - left and right sides of the room elevated 0.8 m and at least 1.8 m away relative to the source
 - front and back of the room on the floor and at least 1.8 m away relative to the source
- Each experiment was repeated four times and the concentration of 0.3 μm to 3 μm aerosol particles was measured using an optical particle counter at the mouth (or inside masks if worn).
- The amount of aerosol exposure of the three receivers was measured over 60 minutes:
 - The aerosol exposure of the three receivers to simulated exhaled aerosol particles was reduced by 49.3% to 64.7% with HEPA air cleaners without universal masking, compared to no HEPA air cleaners and no masking ($P = 0.001$).
 - There was a 71.5% reduction of aerosol exposure with the use of masks without HEPA air cleaners, compared to no HEPA air cleaners and no masking ($P < 0.001$).
 - Combining masking and HEPA air cleaners reduced aerosol exposure by 82.9% to 90.4%, compared to no HEPA air cleaners and no masking ($P < 0.001$).
- The authors state the exposures of the receivers were similar; thus, the mixing of air in the room was homogenous over the 60-minute test period wherein the aerosol generator was cycled on for 20 seconds and off for 40 seconds to prevent exceeding the capabilities to measure exposures of the aerosol instruments.
- The authors noted several limitations related to the representativeness of the dispersion of aerosols in their experiment. The dispersion of aerosols in this study does not account for movement of occupants, multiple sources, differing ventilation conditions or HEPA air cleaners, or all aerosol sizes; therefore, may not be representative of other settings. There may be

situations in rooms that could have poor air mixing, leading to areas with higher concentrations of aerosols or reduce the effectiveness of air cleaners. Lastly, the study does not assess disease transmission which is modified by variables such as the viral load in particles, viral survivability in air, and vaccination status of occupants.

PHO reviewer's comments

- The room had a pre-existing ventilation system which likely promoted air mixing and thus efficiency of air-reaching air cleaners; hence, the study results may have overestimated the effectiveness of the HEPA air cleaners used.
- As the authors noted, in real-world settings occupants would be expected to move around the room and participate in activities that will produce variable levels of respiratory aerosols. As well, the relevant sources of respiratory aerosols (e.g., infectious person with coronavirus disease 2019 [COVID-19]) would often not be known. Thus, the position of HEPA air cleaners may be better determined by overall efficiency of particle removal in many cases, using appropriately sized devices to provide adequate filtration capacity for the size of the room according to manufacturer's recommendations and other contextual considerations, e.g., not introducing a tripping hazard, disruption to occupant activities – rather than position relative to a known source.
- The design of the air inlet and outlet on the HEPA air cleaner could change the air dispersion patterns (e.g., outlet directs air upwards versus downwards).
- The clean air delivery rate of HEPA air cleaners was not varied in this study; thus, the effect of more or less air changes per hour of the HEPA air cleaner is not known. Also, the size of the room was not varied, which may play a role in the ability to efficiently mix, clean and exchange air, particularly in very large rooms.
- The type of activity the source is engaged in could vary the exposures of the receivers. For example, coughing or sneezing could project a plume towards the speaker thus increasing their exposures more than at the position of the other receivers.
- The fit factor of the masks on headforms was not discussed so it is not clear if the fit and reduction of exposures would be similar with masking on a real person.

Citation

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