Do-It-Yourself Air Cleaners as an Emergency Measure to Reduce Indoor Exposure to Respiratory Aerosols

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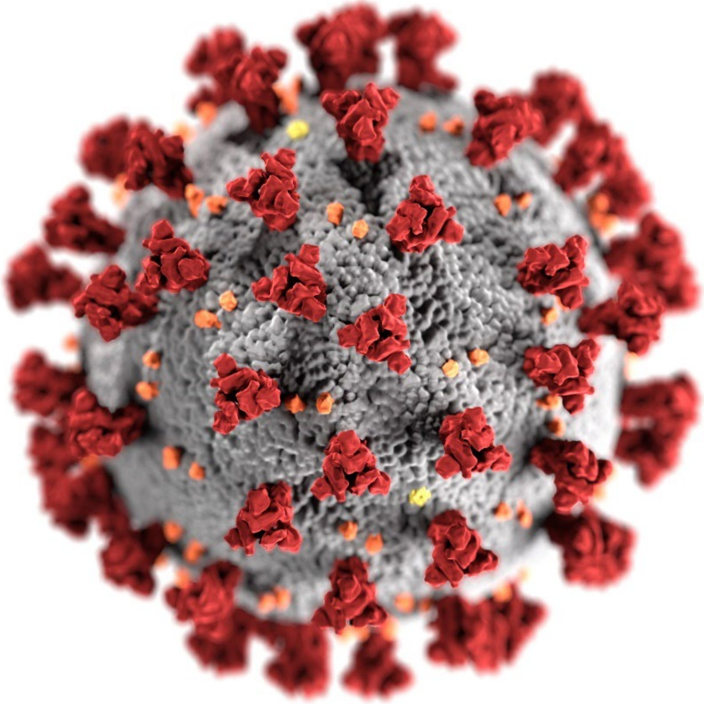


cdc.gov/coronavirus

How do you stop the spread of airborne infectious diseases?

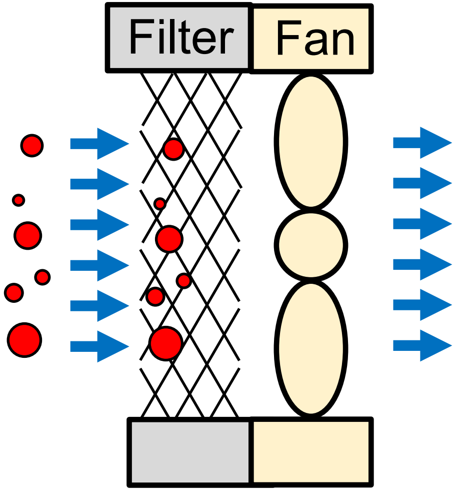
- Respiratory viruses like SARS-CoV-2 are spread primarily by aerosols expelled by infected people when they cough, speak, sneeze, sing, or breathe.
- One way to reduce the transmission of respiratory viruses is with portable air cleaners (air filtration devices).
- Advantages:
  - Quick and easy to add to a room.
  - Flexible.
  - Don’t require changes to the building ventilation system.
  - Also filters out other types of aerosol particles, such as pollen and air pollutants.
- Disadvantages:
  - Commercial air cleaners can be expensive, especially when outfitting an entire school or building.
  - Shortages of commercial air cleaners can occur during public health emergencies.
    - Disease pandemics like COVID-19.
    - Large wildfire outbreaks.

(Source: CDC Public Health Image Library http://phil.cdc.gov/ Credit: James Gathany)

Portable air cleaner

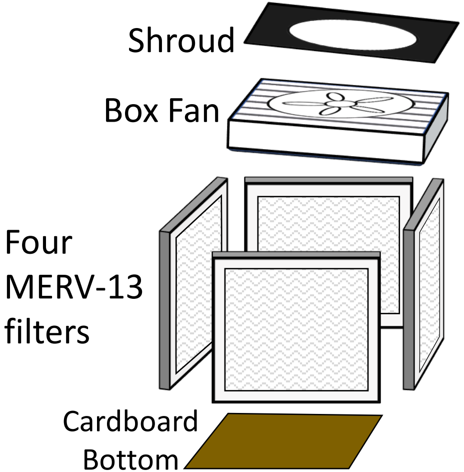
Do-it-yourself (DIY) air cleaners

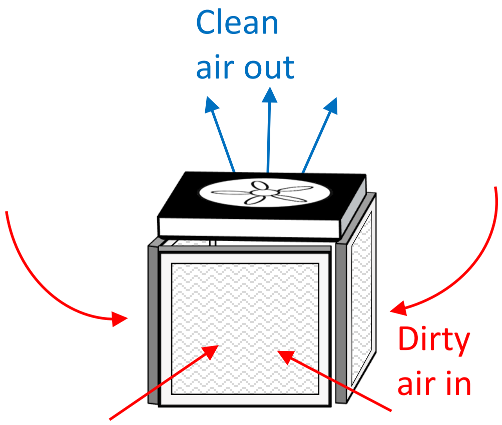
- Homemade or do-it-yourself (DIY) air cleaners are a popular alternative to commercial air cleaners in the United States.
  - Lower cost.
  - Materials widely available.
- DIY air cleaners typically are constructed using a box fan and 1 to 4 HVAC filters.
- In the US, DIY air cleaners have been widely used in homes to reduce indoor aerosols from wildfire smoke.
- During the COVID-19 pandemic, DIY air cleaners were deployed in schools and other public settings to reduce SARS-CoV-2 transmission.



Corsi-Rosenthal DIY air cleaner

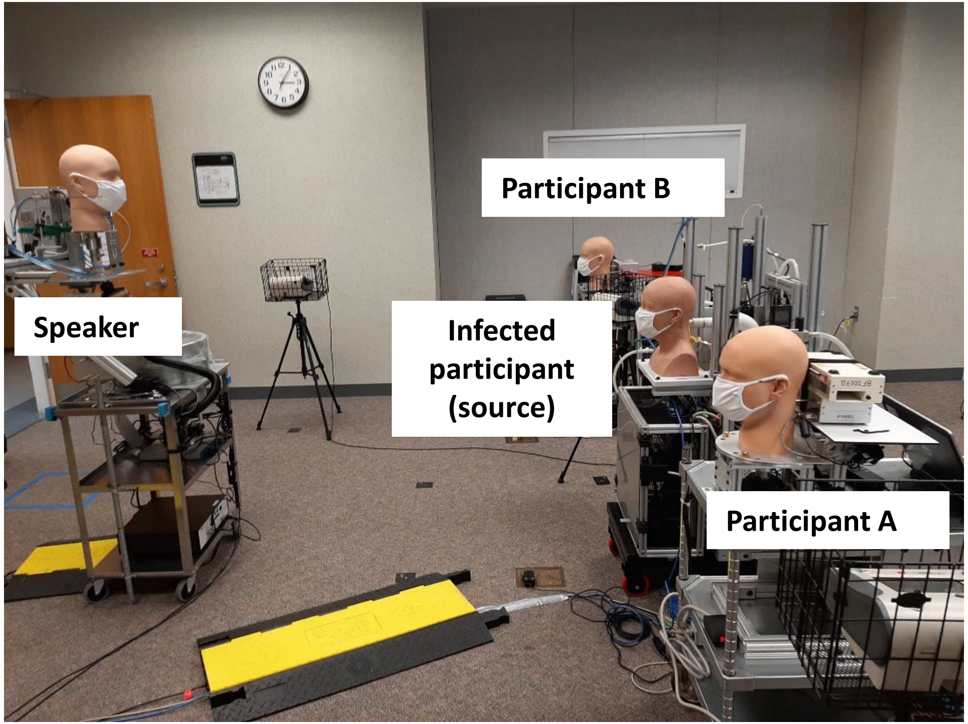
- Invented by Professor Richard Corsi (University of California Davis) and Jim Rosenthal (Tex-Air Filters).
- Uses four MERV-13 pleated filters taped together to form a box.
  - Box fan is attached to the top and blows upward.
  - MERV: Minimum efficiency reporting value
  - MERV-13 filtration efficiencies:
    - ≥ 90% for 3 to 10 µm particles.
    - ≥ 85% for 1 to 3 µm particles.
    - ≥ 50% for 0.3 to 1 µm particles.
  - Filters are 51 cm x 51 cm (20” x 20”)
  - Tested 2.5 cm (1”) and 5 cm (2”) filter thicknesses.





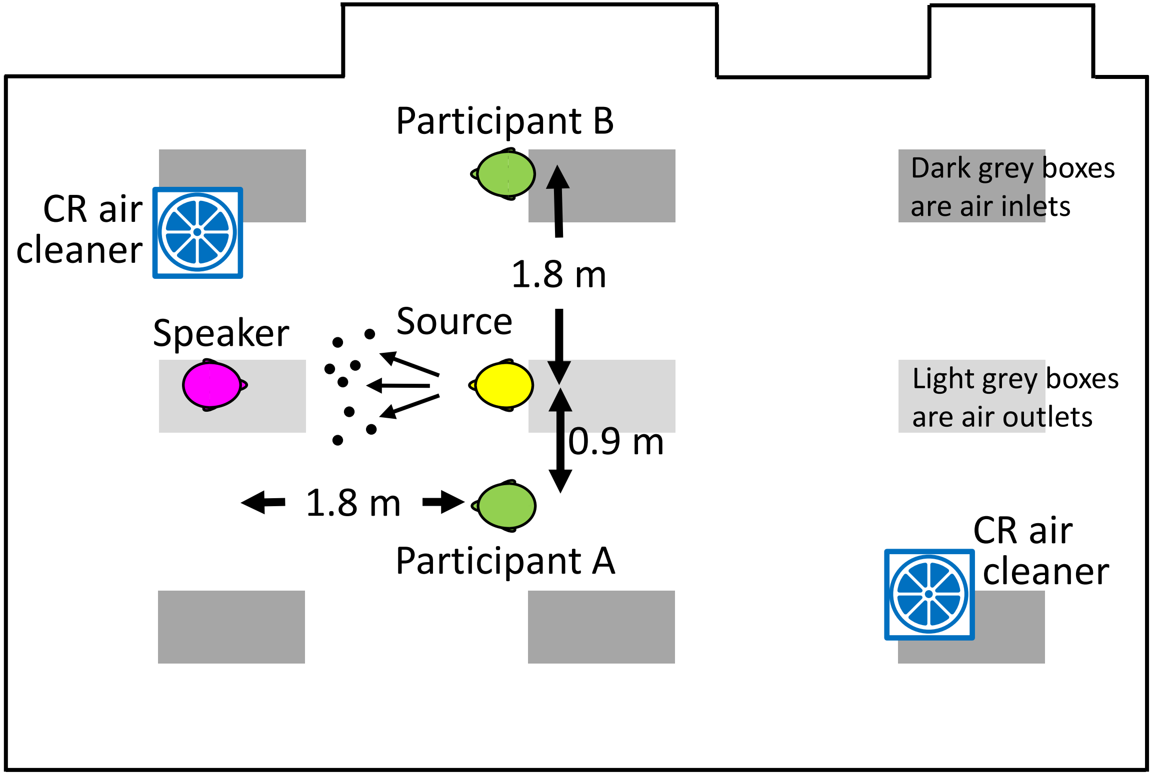
Simulation of people in a conference room

- Conference room contained four breathing simulators to mimic participants in a meeting or class.
- One simulator mimicked an infected person exhaling aerosols into the room (called the source).
- Three simulators mimicked uninfected people.
  - One speaker at front of room.
  - Two meeting participants to the left and right of the infected participant.
- Aerosol particle counters were used to monitor aerosol concentrations:
  - In the breathing zones of the uninfected person simulators.
  - At locations throughout the room.
- Measured exposure to 0.3 to 3 µm aerosol particles for 60 minutes.



DIY air cleaner testing in the conference room

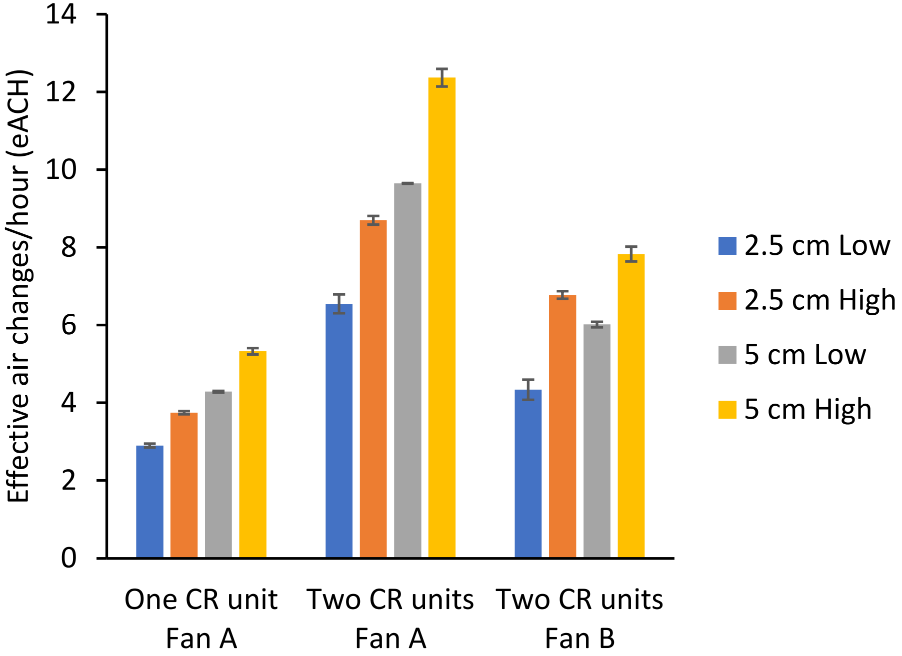
- Room air volume is 180 m^3 (6400 ft^3).
- Room ventilation rate set to 2 air changes/hour (ACH) for all experiments.
  - 2 ACH is typical for a classroom.
- One CR air cleaner placed at front of room and one at back of room.
- CR air cleaners tested with 2.5 cm and 5 cm pleated filters.
- Two fan models tested at low and high speeds.



Top view of conference room

Effective air change rate

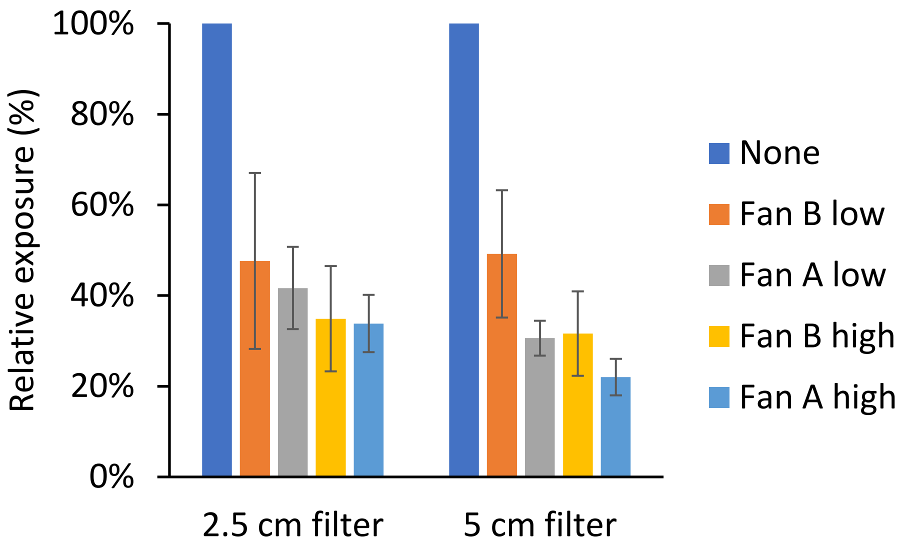
- Effective air change rate (eACH) is how many times the room air volume is filtered per hour.
- Rate was measured by filling room with aerosol and then measuring decrease in concentration of aerosol particles over time.
- At least 5 ACH total is recommended to reduce airborne disease transmission in a typical setting.
  - Combination of ventilation and filtration
- One CR air cleaner produced 2.9 to 5.3 eACH.
- Two CR air cleaners produced 4.3 to 12.4 eACH.
- Using thicker filters, more powerful fans, and higher fan speeds led to higher effective air change rates.
- Using two CR air cleaners increased air mixing compared with using only one air cleaner.



Effective air changes/hour with Corsi-Rosenthal air cleaners constructed with 2.5 cm or 5 cm filters and with fans at low or high speed

Reduction in exposure to simulated respiratory aerosols

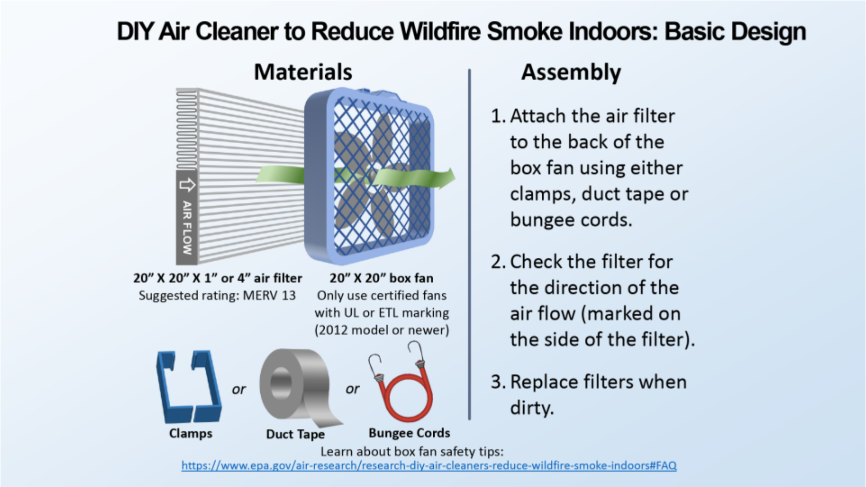
- For these experiments, two Corsi-Rosenthal air cleaners were placed in the front and back of the conference room.
  - Two fan models
  - 2.5 cm and 5 cm filters
  - Low and high fan speeds
- Measured the average exposure of the three uninfected participants to respiratory aerosols.
- The two CR air cleaners reduced the average exposure by 51% to 78% compared with using no CR air cleaners.
- Results were comparable to those seen with our previous studies using commercial air cleaners.



Average relative exposure of room occupants to simulated respiratory aerosols over 60 minutes

Drawback to DIY air cleaners: Lack of quality control

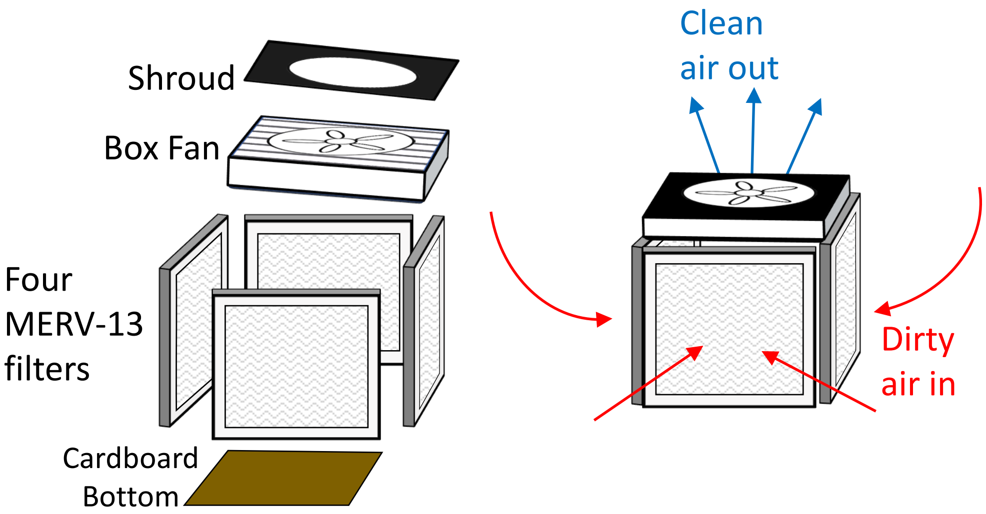
- Commercial air cleaners typically are tested and certified.
- DIY air cleaners can be effective if they are well designed and properly constructed.
- However, badly designed or constructed DIY air cleaners can have poor performance.
  - Leaks and other construction defects
  - Low quality filters
- Air cleaner performance can degrade over time.
  - Loss of electrostatic charge reduces filtration efficiency.
  - Filter loading reduces flowrate.
- Unfortunately, there is no simple way for the average person to test the performance of a DIY air cleaner.



Source: US Environmental Protection Agency

Conclusions

- Do-it-yourself air cleaners can perform as well as commercial air cleaners if they are well designed and properly constructed.
- In a public health emergency, DIY air cleaners can be an effective alternative to commercial units.
- However, the lack of simple quality control methods for testing DIY air cleaners limits their reliability.
- Simple methods are needed to allow DIY air cleaner makers to check the performance of their units.



For more information

Derk et al. (2023). Efficacy of Do-It-Yourself air filtration units in reducing exposure to simulated respiratory aerosols. *Building and Environment* 229: 109920.
https://doi.org/10.1016/j.buildenv.2022.109920

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Recent Publications

Blachere et al. (2022). Face mask fit modifications that improve source control performance. *Am J Infect Control* 50(2): 133-140. https://doi.org/10.1016/j.ajic.2021.10.041

Brooks et al. (2021). Maximizing Fit for Cloth and Medical Procedure Masks to Improve Performance and Reduce SARS-CoV-2 Transmission and Exposure, 2021. *MMWR Morb Mortal Wkly Rep* 70(7): 254-257. https://doi.org/10.15585/mmwr.mm7007e1

Coyle et al. (2021). Efficacy of Ventilation, HEPA Air Cleaners, Universal Masking, and Physical Distancing for Reducing Exposure to Simulated Exhaled Aerosols in a Meeting Room. *Viruses* 13(12): 2536. https://doi.org/10.3390/v13122536

Coyle et al. (2022). Reduction of exposure to simulated respiratory aerosols using ventilation, physical distancing, and universal masking. *Indoor Air* 32(2): e12987. https://doi.org/10.1111/ina.12987

Derk et al. (2023). Efficacy of Do-It-Yourself air filtration units in reducing exposure to simulated respiratory aerosols. *Building and Environment* 229: 109920. https://doi.org/10.1016/j.buildenv.2022.109920

Dowell et al. (2022). Reducing SARS-CoV-2 in Shared Indoor Air. *JAMA* 328(2): 141-142. https://doi.org/10.1001/jama.2022.9970

Lindsley et al. (2021). Efficacy of universal masking for source control and personal protection from simulated cough and exhaled aerosols in a room. *J Occup Environ Hyg* 18(8): 409-422. https://doi.org/10.1080/15459624.2021.1939879

Lindsley et al. (2021). A comparison of performance metrics for cloth masks as source control devices for simulated cough and exhalation aerosols. *Aerosol Sci Technol* 55(10): 1125-1142. https://doi.org/10.1080/02786826.2021.1933377

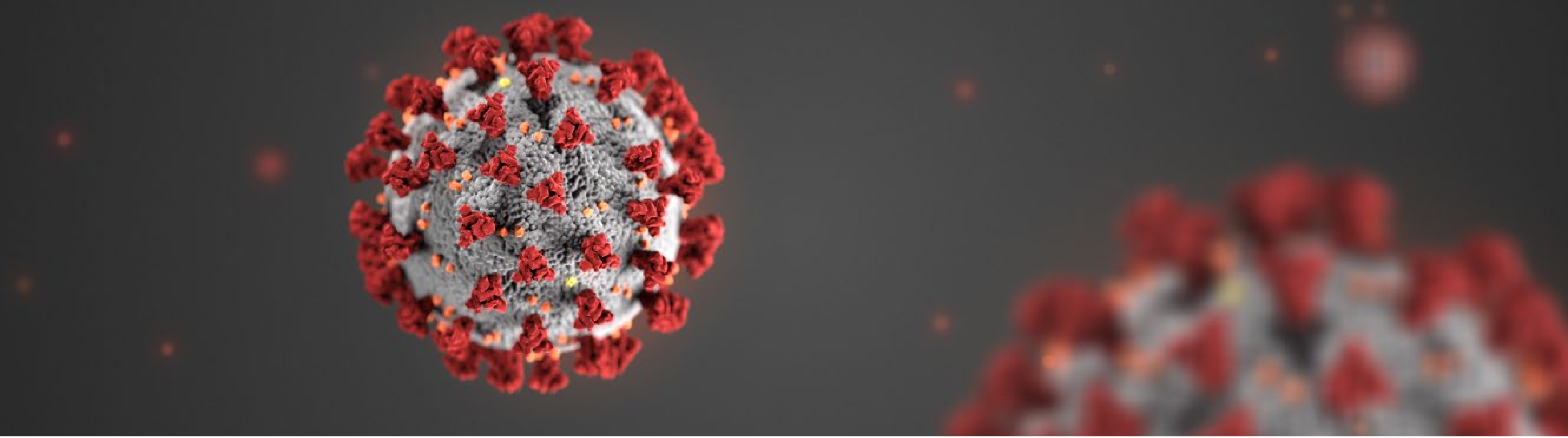
Lindsley et al. (2021). Efficacy of face masks, neck gaiters and face shields for reducing the expulsion of simulated cough-generated aerosols. *Aerosol Sci Technol* 55(4): 449-457. https://doi.org/10.1080/02786826.2020.1862409

Lindsley et al. (2021). Efficacy of Portable Air Cleaners and Masking for Reducing Indoor Exposure to Simulated Exhaled SARS-CoV-2 Aerosols - United States, 2021. *MMWR Morb Mortal Wkly Rep* 70(27): 972-976. https://doi.org/10.15585/mmwr.mm7027e1

Lindsley et al. (2022). Virus decay rates should not be used to reduce recommended room air clearance times. *Infect Control Hosp Epidemiol*: 1-2. https://doi.org/10.1017/ice.2021.494

Lindsley et al. (2023). Constant vs. cyclic flow when testing face masks and respirators as source control devices for simulated respiratory aerosols. *Aerosol Sci Technol* 57(3): 215-232. https://doi.org/10.1080/02786826.2023.2165898

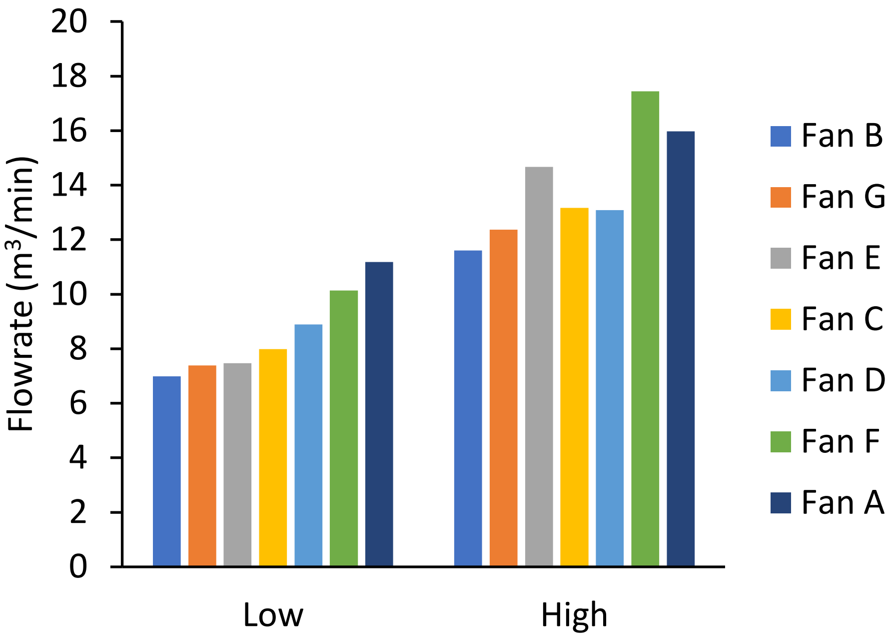
A full list of publications is available at https://www.researchgate.net/profile/William_Lindsley



For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

Tests of box fans

- We tested Corsi-Rosenthal air cleaners with seven different models of box fans using 2.5 and 5 cm MERV-13 filters.
- Flowrates varied with fan model and speed.
  - 7 to 11 m^3/min on low with 2.5 cm filters.
  - 12 to 17 m^3/min on high with 2.5 cm filters.
- Filter thickness affected flowrates.
  - On average, flowrates were 26% higher with 5 cm pleated filters compared with 2.5 cm pleated filters.
- We selected the two fan models with the highest and lowest flowrates for further testing.



Airflow through Corsi-Rosenthal air cleaner constructed with 2.5 cm filters