VIEWPOINT

Airborne Spread of SARS-CoV-2 and a Potential Role for Air Disinfection

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Supplemental content

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An April 2, 2020, expert consultation from the National Academies of Sciences, Engineering, and Medicine to the White House Office of Science and Technology Policy concluded that available studies are consistent with the potential aerosol spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), not only through coughing and sneezing, but by normal breathing.[1] This response to a White House request for a rapid review of the literature likely contributed to the recommendation from the US Centers for Disease Control and Prevention (CDC) that healthy persons wear nonmedical face coverings, when in public, to reduce virus spread from undiagnosed infectious cases.

Although clear evidence of person-to-person airborne transmission of SARS-CoV-2 has not been published, an airborne component of transmission is likely based on other respiratory viruses such as SARS, Middle East respiratory syndrome, and influenza. While air sampling for SARS-CoV-2, in a clinical setting, has demonstrated detectable viral RNA, the extent of transmission resulting from airborne particles relative to large respiratory droplets, directly and on surfaces, is not yet known. But if fitted N95 respirators can be justified as a prudent precaution against airborne infection for health care workers with regular exposure to patients with novel coronavirus 2019 (COVID-19) and nonmedical face coverings justified to be worn in public to reduce aerosol spread, should not air disinfection be deployed in intensive care units, emergency departments, waiting rooms, and ambulatory clinics? This approach may be especially important to prevent spread from asymptomatic persons with infection, who may be sources of transmission in selected public settings.

> Management of the current crisis and preparation for future respiratory viral pathogens should include consideration of the use of upper-room GUV to help mitigate airborne transmission.

Other than natural or mechanical ventilation, only 2 practical methods of air disinfection exist: room air cleaners (ie, using filters, UV, or other means of disinfection) and upper-room germicidal UV (GUV) fixtures (see eFigure in the Supplement). For effective air disinfection, ventilation with 6 to 12 room air changes per hour is recommended by the CDC.[2] This can be achieved with natural ventilation under favorable outdoor conditions and by mechanical ventilation systems designed for such high-flow rates—but at high operating costs when intake air must be heated or cooled and dehumidified. Portable room air cleaners may be a potential solution, but depending on room volume, their specified clean air delivery rates generally add too few equivalent air changes per hour to provide adequate protection against airborne infection. In contrast, commercially available upper-room GUV air disinfection (with an effective rate of air mixing) has been shown, in clinical settings, to reduce airborne tuberculosis transmission by 80%, equivalent to adding 24 room air changes per hour.[3]

In resource-limited settings, where air disinfection depends on natural ventilation, upper-room GUV may be increasingly important as windows are closed due to use of ductless air conditioners in response to global warming and severe outdoor air pollution. In resource-rich settings, upper-room GUV can be retrofitted into most areas with sufficient ceiling height. GUV technology is effective against viruses that have been tested, including influenza and SARS-CoV-1.[4,5]

Direct whole-room GUV is also used for room surface disinfection in unoccupied rooms (eg, between infectious patients), and GUV devices are being used to decontaminate respirators used for COVID-19 patient care. Although not its primary purpose, and as yet unproven experimentally, upper-room GUV in occupied rooms could possibly also reduce infectious virus settling on surfaces, and through 24/7 low-level reflected GUV exposure from the upper room, possibly accelerate virus inactivation on surfaces in the lower room. However, these additional beneficial effects require evidence from rigorously conducted studies.

Conventional thinking has been that person-to-person airborne spread of viral respiratory pathogens is the exception, although the term *airborne* has not been used uniformly. As defined by Wells and Riley in 1937, true airborne transmission is by infectious droplet nuclei, that is, the 1 to 5 μm dried residua of larger respiratory droplets that stop settling, buoyed by ordinary room air currents, and able to spread far beyond the trajectory of larger respiratory droplets that tend to settle within a meter or so of the infectious source. But other experts classify as airborne the direct spread of larger respiratory droplets from an infectious source to the eyes, nose, or mouth of another person, without the intermediary of transfer by hands or fomites. Recent modeling of cough- and sneeze-generated aerosol suggest the potential for projecting large respiratory droplets well beyond 2 m, but that is not droplet nuclei transmission.[6] Although many respiratory viruses are transmitted by all 3 pathways, direct and indirect contact with respiratory droplets, and inhalation of droplet nuclei, there are important differences between infections that are predominantly spread by larger respiratory droplets and those that are occasionally or usually spread as suspended droplet nuclei. Among those important differences are the interventions likely to interrupt airborne transmission, including fit-tested respirators (not surgical masks) for personal protection and air disinfection.

During the relatively short-lived 2003 SARS pandemic, airborne spread of infection on airplanes and in apartment buildings in Hong Kong was documented, the latter associated with aerosol generated by faulty plumbing systems, and virus in stool was thought to play a role in airborne transmission. A cluster of COVID-19 cases at the Hong Mei House, another Hong Kong apartment building, may also have been related to faulty plumbing and a fecal source of viral aerosol.[7] Among 3 reported aircraft-associated SARS-CoV-1 transmission events, 1 symptomatic passenger diagnosed with laboratory-confirmed disease was presumed to have infected 22 persons of whom 8 were seated in the 3 rows in front of the index case.[8] There have been a number of clusters of COVID-19 clusters, all associated with group settings, but that alone does not define the mode of transmission. An especially concerning cluster in the US was the 2½-hour choir rehearsal in Washington State, after which 45 of 60 members in attendance were diagnosed with COVID-19 or had compatible symptoms, including 3 hospitalizations and 2 deaths.[9] Choir members with respiratory symptoms were asked not to attend, and none were known to be present. While large droplet spread surely accounted for some transmission, the extent of spread associated with singing as a possible source of enhanced aerosolization makes airborne spread highly suspect.

Since the influenza A(H1N1) epidemic in 2009, research on viral transmission has accelerated. Airborne spread of influenza A virus been shown to occur routinely in the ferret model, and highly controversial research has shown specific genetic mutations associated with airborne transmission of H5N1 avian influenza. In an epidemiological analysis of influenza A transmission among 782 people, the airborne route was estimated to account for half of all cases.[10] The potential for SARS, MERS, and influenza to spread via airborne droplet nuclei is no longer in doubt. As emphasized in the recent National Academy of Medicine consultation to the White House, it is time to address the potential for airborne SARS-CoV-2 transmission.[1]

Given the ongoing risks of SARS-CoV-2 infection among health care workers, some hospitals are considering deployment of commercially available upper-room GUV air disinfection, although no published studies have demonstrated efficacy and GUV systems are not currently recommended in the infection prevention guidelines from the CDC or the World Health Organization. Upper-room GUV systems must be installed and maintained following evidence-based guidelines. Priority areas for air disinfection might be waiting rooms, emergency departments, intensive care units, bronchoscopy and endoscopy rooms, and other sites where aerosol is generated. COVID-19 will not likely be the last pandemic. Management of the current crisis and preparation for future respiratory viral pathogens should include consideration of the use of upper-room GUV to help mitigate airborne transmission.

ARTICLE INFORMATION

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