The *Lancet* COVID-19 Commission Task Force on Safe Work, Safe School, and Safe Travel

The First Four Healthy Building Strategies Every Building Should Pursue to Reduce Risk from COVID-19

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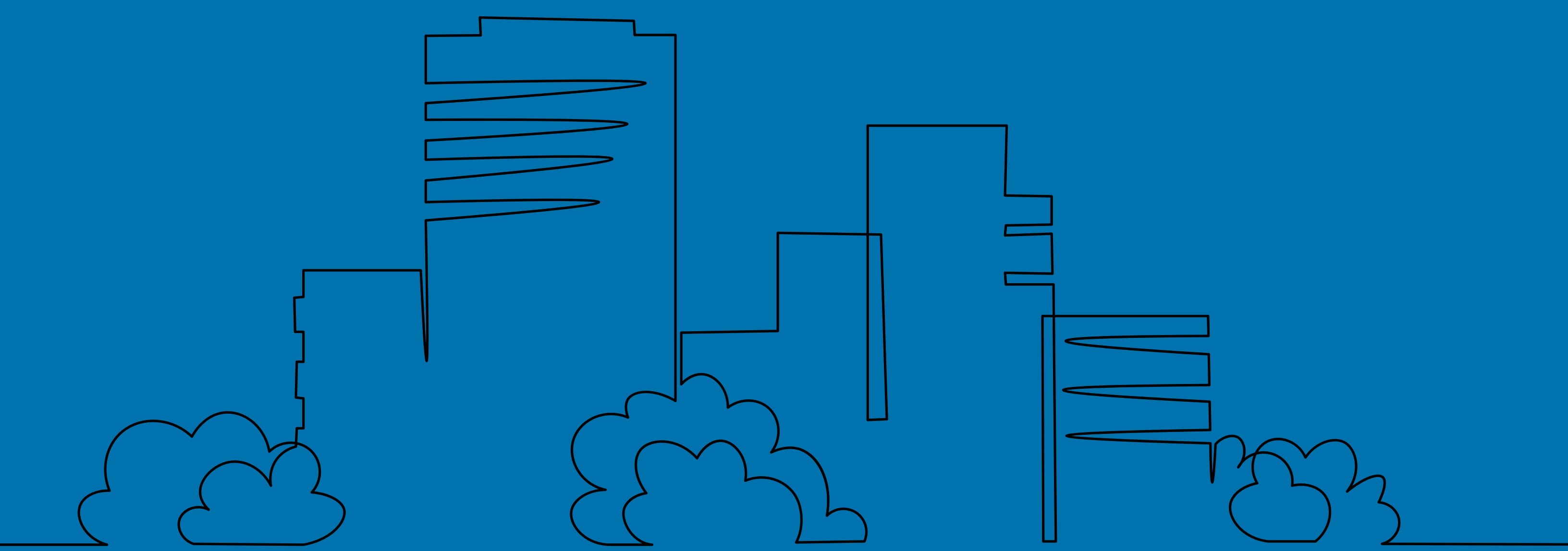

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Introduction

Understanding of the most probable transmission routes and identifying the risk environments for disease spread should always be among the first critical steps in the response to future disease threats. This is one of the most vital public health lessons of the COVID-19 pandemic: with a well-informed understanding of the dominant mode(s) of transmission of an infectious disease, effective control strategies can quickly be specified, higher risk activities and environments can be defined, and public health leaders may then set the course for a response that aims to efficiently and rapidly mitigate widespread transmission.

Laboratory, field, modeling, and case studies have demonstrated that airborne transmission via inhalation of virus-laden aerosols is important, if not dominant, for COVID-19.[1,2,3,4,5,6,7,8] Aerosols are small respiratory particles that are suspended in the air and can be carried on air currents over long distances.[9] They are released into the air during normal respiratory activities. Aerosols produced by infected individuals may contain pathogens and can be inhaled by others to cause new infection; when this occurs, it is known as airborne transmission. This can occur in both the near-field (within the vicinity of the infection source) and far-field (greater distance away from the infection source).

To combat the risk of airborne transmission of COVID-19, control strategies that reduce the concentration of (and therefore, the likelihood of inhaling) potentially infectious respiratory aerosols must be implemented. Increased outdoor air ventilation to dilute aerosols and reduce their concentration and/or enhanced filtration efficiency to remove particles from recirculated air have been shown to be effective as part of an overall strategy to reduce risk. These strategies should be prioritized in occupied environments in which aerosols accumulate most rapidly: indoor spaces with low outdoor air ventilation and/or low levels of (or no) filtration.[10,11,12,13]

Despite significant progress across other elements of pandemic response – including vaccines and boosters, rapid tests, treatments, and expanded access to high efficiency masks – ventilation and filtration have remained insufficiently addressed, even more than two years into the pandemic. This has finally shifted following the March 2022 Biden-Harris Administration launch of the Clean Air in Buildings Challenge, a key component of the National COVID-19 Preparedness Plan. This initiative calls on all building owners and operators across the domains of school, work, and travel to adopt key strategies to improve indoor air quality in their buildings and reduce the spread of COVID-19.[14] The Administration's announcement quickly elevated the discussion around the importance of indoor air quality and advanced a new framework for recognizing and rewarding science-based efforts in buildings that promote health and safety and improve resilience to future pandemics.

In light of the announcement of this new recognition system for buildings, experts from the Lancet COVID-19 Commission's Task Force on Safe School, Safe Work, and Safe Travel have identified the following four key actions that represent the most effective, fundamental steps toward promoting healthier indoor environments and reducing the risk of airborne infectious disease transmission indoors.

Key Strategies

1. COMMISSION OR RECOMMISSION BUILDING SYSTEMS

Commissioning is the process of verifying that building systems are operating as designed. The goal is to ensure that existing buildings are operating as designed and to determine what additional enhancements are needed. Recommissioning is the process of commissioning a building again, after it has previously been commissioned. Ideally buildings should be recommissioned every 3-5 years.[15,16]

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Commissioning can ensure building heating, ventilation, and air conditioning (HVAC) equipment is performing as intended. For example, common HVAC deficiencies that can be corrected by commissioning include imbalanced airflow, HVAC schedule mismatch with occupied hours, damper malfunction, and system controls malfunction.[17,18]
- **Benefits beyond disease transmission:** Commissioning leads to cost savings, energy savings, improved occupant thermal comfort, improved indoor air quality, and extended equipment life.[19] In a recent study involving 1,482 buildings, median energy savings due to commissioning in existing buildings was 6.4%.[17]
- **Feasibility:** Although there are up-front costs to commissioning (e.g., median cost in 985 projects in existing buildings was $0.26 per square foot), commissioning saves money over the long term, with a median payback time of 1.7 years for 656 commissioning projects in existing buildings.[17]

2. MAXIMIZE OUTDOOR AIR

Outdoor air ventilation can be mechanical (e.g., HVAC system) or natural (e.g., open windows). Buildings are typically designed to comply with guidance that specifies minimum outdoor air ventilation rates based on the building type, floor area, and occupancy (e.g., ASHRAE 62.1-2019[20]). These minimum ventilation rates, however, are not sufficient to mitigate airborne infectious disease transmission indoors. Higher ventilation rates of 10 L/s per person[21] and 4-6 air changes per hour[22] have been proposed to reduce the risk of airborne infectious disease transmission indoors.

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Increased outdoor air ventilation can dilute or displace airborne particles including those carrying viruses, resulting in lower (or no) inhaled viral doses for susceptible individuals in an indoor space.[23] Higher ventilation rates are associated with reduced sick leave and airborne infectious disease transmission.[24,19]
- **Benefits beyond disease transmission:** Higher ventilation rates are associated with improved cognitive function, work performance, and academic performance; reduced reports of building-related symptoms and illness; healthcare cost savings; reduced asthma; and reduced absenteeism.[25,26,27]
- **Feasibility:** Increasing outdoor airflow may increase building energy usage and may not be possible to achieve while maintaining occupant thermal comfort on very hot and very cold days. However, in many buildings on most days of the year, it is possible to modify HVAC controls to increase ventilation.[23] Appropriate professionals, such as HVAC engineers, can determine how best to modify HVAC controls and what additional HVAC modifications may be possible to increase outdoor airflow to a building.

3. UPGRADE AIR FILTERS TO MINIMUM EFFICIENCY REPORTING VALUE (MERV) 13

HVAC systems often have air filters to remove airborne particles from outdoor air that is brought indoors and from air that is recirculated within the building.

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Upgrading filters on recirculated air to those with ratings of MERV 13 or higher will reduce the transport of airborne particles while systems are operating, which may help reduce airborne infectious disease transmission within rooms and between rooms.
- **Benefits beyond disease transmission:** Enhanced filtration can reduce indoor concentrations of airborne particles of either indoor origin (e.g., cooking, cleaning or vacuuming, frequent use of printers) or outdoor origin (e.g., vehicle traffic, wildfires, desert dust storms). Exposure to fine particulate matter is associated with reduced cognitive function and reduced respiratory and cardiovascular health.[26,27,28,29,30,31,32,33,34,35,36,37]
- **Feasibility:** Filter upgrades may not be possible for all HVAC systems; HVAC professionals should be consulted before filter changes are made in a building. Annual material, labor, and fan energy costs associated with the use of MERV 13 filtration in a hypothetical 500 m^2 office are estimated to be $156.[38]

4. SUPPLEMENT WITH PORTABLE AIR CLEANERS, WHERE NEEDED

Free-standing, plug-in portable air cleaners with high efficiency particulate air (HEPA) filters capture airborne particles in rooms where they are deployed, when sized correctly.[39]

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Properly sized portable air cleaners with HEPA filters can reduce in-room concentrations of airborne particles, including those carrying viral material.
- **Benefits beyond disease transmission:** Portable air cleaners can reduce indoor concentrations of any airborne particles and reduce the risk of harmful particle-induced impacts on neurological/cognitive, respiratory, and cardiovascular health.
- **Feasibility:** Portable air cleaners are cost-effective, flexible solutions to reduce the risk of airborne infectious disease transmission in spaces where other ventilation and filtration modifications are impossible, or where building occupants seek additional reassurance about air quality.[40]

This is not intended to be a full and complete list of all building-related strategies organizations should pursue. Rather, these are strategies that can be implemented quickly in nearly all buildings, are feasible, do not require substantial or expensive investments in most cases, and would lead to significant benefits in terms of risk reduction at the individual, building, and societal level. Further, each recommendation contributes to an effective COVID-19 risk reduction strategy while simultaneously providing other long-term health benefits beyond the current pandemic. As a result, we recommend that these actions be considered for acknowledgment and recognition as part of the Administration's new Clean Air in Buildings Challenge.

Other Considerations

In addition to these first four measures to reduce the risk of airborne infectious disease transmission that every building should implement, other technologies such as germicidal ultraviolet (UV) lights may be warranted in many high-risk situations. When designed correctly, an upper room germicidal UV system consisting of lamps hung in the upper part of a room, or an in-duct system with lamps that radiate the air as it moves past the light, is very effective at inactivating airborne virus and bacteria.[41,42,43] These systems require specific expertise to install and maintain. Additionally, indoor air quality or carbon dioxide monitoring networks may be installed in buildings to gain an approximate sense in real time of whether outdoor air ventilation is sufficient for building occupancy.[40] Simultaneously, real-time CO_2 monitoring generates data that can be used to enhance the efficiency of building energy consumption. Indoor air quality data and information on ventilation and filtration improvements in buildings should also be shared with building occupants when possible to promote transparency regarding health and safety measures in the building.

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