Advising public for preventing against airborne transmission of SARS-CoV-2 in indoor environments for upcoming winter season based on scientific findings:

(a) Airborne transmission of SARS-CoV-2 via aerosol particles in poorly ventilated indoor environments:

The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and the resulting coronavirus disease 2019 (COVID-19), was first reported in Wuhan, China, in December 2019. It has severely impacted the global economy and created a global public health crisis. The World Health Organization declared this as a global pandemic on March 11 2020. [1]

Studies have implicated the role of emitted droplets and aerosol particles in the SARS-CoV-2 transmission, particularly termed as airborne transmission. The U.S. Centers for Disease Control and Prevention (CDC) has acknowledged that airborne aerosol particle transmission of SARS-CoV-2 can occur under certain specific circumstances, such as in enclosed places with inadequate ventilation. The Canadian, Belgian and Swiss governments have acknowledged SARS-CoV-2 airborne transmission and proposed some guidelines. There are many factors that affect airborne transmission such as temperature, humidity and sunlight. The role of relative humidity (RH) in airborne transmission of SARS-CoV-2 virus in indoor environments have been proved based on recent experimental and modeling studies. The indoor RH affects both the evaporation kinematics and particle growth. In dry indoor places i.e., less humidity (< 40% RH), the chances of airborne transmission of SARS-CoV-2 are higher than that of humid places (i.e., > 90% RH). [1]

Based on our findings, the relative humidity influences the spread of coronavirus indoors in three ways: (a) the behavior of the viruses inside the aerosol particles and droplets, (b) the survival or inactivation of the virus on surfaces and (c) the role of dry indoor air in the transmission of viruses through the air. If the relative humidity of the room air is below 40 percent, the droplets emitted by the infected people evaporates at a faster rate compared to higher RH values, since they do not sediment anymore. [1, 2] The residuals remain in air as aerosol particles and can be inhaled by healthy people. In addition, when the air is dry, the nasal mucous membranes in our noses become drier and more permeable to viruses. [1] The chances of virus survival inside the aerosol particles is highest at lower RH values i.e. < 40% RH. This is because the cumulative dose (i.e. product of solute concentration and time) is not sufficiently high at low RH values, which is the crucial factor needed to kill the virus inside. [1, 4] With higher humidity (i.e. >60 %), the droplets evaporate slower and may sediment to the ground after some time (not airborne anymore) but the virus viability inside the droplets is still be given because of lower values of cumulative dose. Also, virus viability will increase as humidity values are increased from 60 % to 80 or 90 % or higher. The cumulative dose factor should be high enough to destroy the virus by increasing the solute concentration inside the aerosol particles. [1, 4]

(b) Preventive measures/Guidelines for airborne transmission of SARS-CoV-2 in poorly ventilated indoor environments:

1. The intermediate RH between 40 to 60 % is considered the best for destroying the virus inside aerosol particles and for human respiratory immunity. The cumulative dose concept applies here also, where the solute concentration increases with time, i.e. cumulative dose becomes high. This cumulative dose is the measure of inactivation or killing of virus inside the aerosol particles. If the cumulative dose factor is high that refers virus would be killed by the increased solute concentration inside the aerosol particles. Based on previous scientific literature at intermediate RH i.e. 40-60 %, there is a high probability of better inactivation of the virus including SARS-CoV-2 inside aerosol particles [1, 2, 4, 5].
2. To control the SARS-CoV-2 airborne transmission indoors, especially in poorly ventilated places like certain hospitals, schools and public buildings, we advise the use of evaporative humidifiers to maintain the indoor RH within the range 40-60 % and reduce respiratory infection risk. This should be done carefully as pushing humidity limits over 60 % will create mold growth indoors. Also, it would be too much uncomfortable for the indoor residents at high RH values. [1, 2, 3]
3. To ensure further protection against viral aerosol particles, install portable air cleaners that have an American Home Appliance Manufacturers (AHAM) certified Clean Air Delivery Rate (CADR) [7]. These portable air cleaners will help in removing the small viral aerosol particles from the indoor places. [3,7]
4. In winter season, the indoor air spaces should have an adequate mechanical ventilation system strictly adhering to ASHRAE standards for controlling indoor outbreak of coronavirus. In addition, the Heating, Ventilating and Air Conditioning (HVAC) system should have air filters with a minimum efficiency of MERV 13. MERV stands for Minimum Efficiency Reporting Value. [7] These filters work well in filtering very small particles out of indoor air. [3,7]
5. High quality calibrated CO_2 monitors should be used for checking CO_2 levels indoors CO_2 is co-exhaled with aerosol particles containing SARS-CoV-2 by COVID-19 infected people in indoor places. The indoor CO_2 measurements using CO_2 monitors can be used for mass monitoring of indoor aerosol particles transmission risk for COVID-19 and other respiratory diseases. [3,6]
6. We also recommend that the Ultra-Violet (UV-C) technique should not be used too often; although known to destroy the SARS-CoV-2, it ultimately increases ozone concentrations in indoor settings which is harmful for human health. [3]
7. In indoor spaces, some practices should not be followed such as spraying disinfectants into air for e.g. HOCl, NaOCl, hydrogen peroxide (H_2O_2) etc. In an occupied space when someone spray these chemical stuffs in the air, they create toxic chemical reactions that generate more air pollutants and damage human central nervous system and lungs. [3,9,10]
8. In poorly ventilated indoor places with large gatherings, masks should always be on the priority. For better protection, wear non-valve particle filter masks known as

respirators such as N95 (tightly worn without leakages). The respirators which have an exhalation valve or vent are not sufficient for source control. [3,8]

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