Using pathogen-free air to reduce infection risks in buildings

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ABSTRACT

The risk of long-range airborne transmission of pathogens in buildings is dependent on the number of infectious people present and the number of susceptible people. Early work on airborne transmission, such as Riley's seminal study on a school measles outbreak, determined that the virus emission rate must vary between infectious people. Work during the COVID-19 pandemic has also illustrated high heterogeneity in viral loads and virus emission rates of people infected with COVID-19. The likelihood of having infectious and susceptible people both correlate with the number of occupants, and the virus emissions from infectious people varies by several orders of magnitude. The delivery of virus free air into a space is posited as a means to reduce the infection probability. This might include ventilation, and air cleaning, and is known as an equivalent ventilation rate.

A simple model is used to explore the relationship between the probability of infection and the number of occupants, space geometry, the viral load to show how they might affect an individual person in a single indoor space and a population of people located in the same space.

The model indicates that as the equivalent ventilation increases personal risk decreases, but the relationship follows a law of diminishing returns. Therefore, it is better to treat under-ventilated spaces before improving spaces that already comply with local codes and standards.

The impact of the equivalent ventilation rate on the infection risk of a population depends on the dose-response relationship and the virus emission rate in a space. If the virus emission rate is low, the inhaled doses are so small that the probability of infection is negligible. Then, increasing the equivalent ventilation rate makes little difference on the risk of infection. If the virus emission rate is so high that the inhaled doses have a high probability of infection then the equivalent ventilation rates may be insufficient to reduce the dose enough to effect the probability of infection. There is, therefore, a *Goldilocks zone* where everything is *just right* for the equivalent ventilation rate to be effective at reducing the inhaled dose sufficiently to also reduce the probability of infection.

Acknowledging the limitations of the equivalent ventilation to reduce infection risks at personal and population scales is important when making decisions about mitigation measures.

KEYWORDS

COVID-19, Airborne, Transmission, Risk