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Airborne spread of SARS-CoV-2

Potential risks in indoor spaces

By Yasin Toparlar, MSc., PhD., and Paul van Gent MSc., PhD., senior experts at Deerns Netherlands

After months of intense measures, governments have started to relax their lockdown approaches against the SARS-CoV-2 pandemic. The relaxation efforts encouraged many firms to partly re-open their offices, although business is not as usual yet. Office workers are welcomed within the new 1.5 m normal, keeping sufficient distances between people, while following other well-known measures (e.g. washing hands regularly). These measures certainly help in avoiding the spread of disease through relatively large respiratory droplets. However, in indoor spaces, this might not be sufficient if the disease would turn out to be airborne.

Currently, the World Health Organization states that "there is no clear evidence the novel coronavirus is airborne in the smallest droplets ..."[1]. However, a recent article in Nature indicates that experts cannot agree whether the virus is airborne since the "evidence from preliminary studies and field reports that SARS-CoV-2 is spreading in aerosols is mixed."[2]. In comparison, one of the past coronaviruses, SARS-CoV-1, is thought to be airborne[3]. If airborne transmission would turn out to be a significant risk for the current disease too, then it would be very important to provide indoor spaces with ample fresh air and to minimize recirculation used air by the ventilation system[4,5].

Investigating secondary infection risk

The air in an occupied indoor space contains both fresh air and the exhaled breath of its users. If a person is infected with the SARS-CoV-2, and if the airborne transmission is a reality, then the exhaled air would carry the risk of causing secondary infections. To investigate the secondary infection risk, we use the concept of 'quanta generation'. Quanta generation can be thought of as the emission of the infectious doses of a virus by a person. A recent study[6] estimates the quanta generation rate for SARS-CoV-2 based on (measured) typical virus concentration in the mouth of infected persons, the number of droplets a person produces depending on physical and vocal activity, and the infectious doses of the earlier coronavirus (SARS-CoV-1).

Using an estimate of the quanta generation rate, we calculate the development of the quanta concentration over time for an indoor space with given dimensions and with a certain ventilation (and recirculation) rate. The risk of secondary infection is calculated by integrating the quanta generation rate in the Wells-Riley equation[7] and then by multiplying the calculated infection probability with the number of uninfected people in the room.

Testing the method for a room

We applied this method to a typical meeting room of 28 m^2, considering two common ventilation rates: 3/hour and 6/hour. We assume one person in the meeting room carries the virus and that this person is talking/giving a presentation. The figures below show the results for the two cases with different ventilation rates. Charts on the left show secondary infection risk ranging from 0 (green) to 1 and higher (red). Charts on the right show the CO_2 concentration in parts-per-million (ppm), ranging from the atmospheric CO_2 concentration (~400PPM) to rather poor air quality of 1200 ppm.

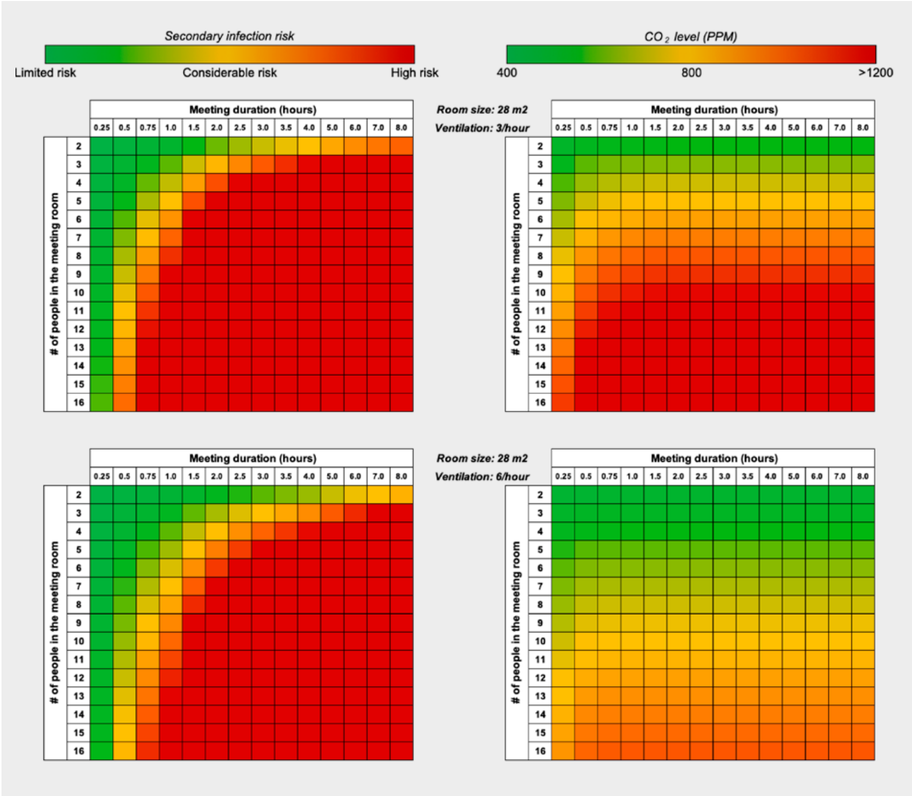
The top-left chart shows that for the meeting room with a ventilation rate of 3/hour and a meeting of 4 people, a secondary infection becomes likely after two hours. Interestingly, at this moment (4 people meeting for 2 hours), CO_2 levels would still be indicating moderate air quality. For a ventilation rate of 6/hour, all other things being equal, a secondary infection risk would only become likely after more than 3 hours (bottom-left chart).

1 World Health Organization Website (accessed 15 June 2020) Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations
2 Lewis, D. (2020) Is the coronavirus airborne? Experts can't agree. Nature 580, pp. 175. https://www.nature.com/articles/d41586-020-00974-w
3 Li Y. et al. (2007) Role of ventilation in airborne transmission of infectious agents in the built environment – a multidisciplinary systematic review. Indoor Air 17, pp. 2 – 18. https://doi.org/10.1111/j.1600-0668.2006.00445.x
4 Somsen G.A., van Rijn C., Kooij S., Bem, R.A., Bonn, D. (2020) Small droplet aerosols in poorly ventilated spaces and SARS-CoV-2 transmission. The Lancet Respiratory Medicine. https://doi.org/10.1016/S2213-2600(20)30245-9
5 Morawska L., et al. (2020) How can airborne transmission of COVID-19 indoors be minimized? Environment International 142, https://doi.org/10.1016/j.envint.2020.105832
6 Buonanno G., Stabile, L., Morawska, L. (2020) Estimation of airborne viral emission: Quanta emission rate of SARS-CoV-2 for infection risk assessment. Environment International 141, https://doi.org/10.1016/j.envint.2020.105794.
7 Riley E.C., Murphy, G., Riley R.L. (1978) Airborne spread of measles in a suburban elementary school. American Journal of Epidemiology 107, pp. 421-423, https://doi.org/10.1093/oxfordjournals.aje.a112560

Contact

If you are interested in understanding the secondary infection risk in ventilated indoor spaces, such as offices, theater halls, or healthcare facilities, we would be happy to advise you.

For more information,
please contact Yasin Toparlar
(yasin.toparlar@deerns.com)
or Paul van Gent
(paul.van.gent@deerns.com).



How to use these results?

The results suggest that secondary infection risk could be a more stringent criterion for ventilation systems than CO_2 levels alone. The results also show the beneficial impact of increasing the supply of fresh air. This may be achieved by changing the settings of the mechanical ventilation system (if possible) or by enhancing natural ventilation (e.g. by opening windows). Apart from that, the potential risk of secondary infection may be reduced by 1) Limiting the duration of indoor gatherings; 2) Limiting the number of people inside enclosed spaces; 3) Having regular breaks in long gatherings to allow the ventilation to wash out airborne droplets.

Certainly, our method has its limitations. Starting with, we consider that SARS-CoV-2 is an airborne disease, which after sufficient scientific research, may not be the case at all. Other limitations would be the consideration of well-mixed air and the assumptions regarding the virus. The parameters are still tentative since our knowledge of the virus and its transmission risk is improving over time with further research. The method is built based on the best available, up-to-date information. Like every model, this one too is an approximation to reality and should be used to understand risks, not for final design decisions and not for medical recommendations.

What is next?

We will further adjust and refine our model as more information about the SARS-CoV-2 virus becomes available. Parallel to this preliminary analysis, we can also conduct more in-depth studies. One of the options can be to use CO_2 sensors in the indoor space we would like to study. This way, we can see how rapidly that indoor space may reach high levels of exhaled air, which is a critical factor for the risk analysis. In rooms without CO_2 sensors, we can organize a temporary measurement campaign with mobile sensors.

A more in-depth study would be simulating airflow patterns in the rooms using detailed Computational Fluid Dynamics (CFD) simulations. This way, we can determine which seats might be exposed to more “exhaled air” and which seats might be better protected. This would allow us to specify an ideal seating arrangement concerning the ventilation system and to protect people from unfavorable airflows.

Going back to the offices with the 1.5 m normal is an unusual experience. There still is a lot unknown about the potential of airborne transmission of the SARS-CoV-2 virus. Finding out the exact secondary infection risks will probably require a lot of time and scientific research. In the absence of reliable information, it is impossible to accurately quantify the risk of airborne transmission. Until then we can combine the best information available with our knowledge of ventilation systems, to define safety guidelines to reduce any risks.

Deerns Nederland B.V.
Anna van Buerenplein 21F
2595 DA Den Haag
The Netherlands
+31 88 3740000
www.deerns.nl