Fantech Covid-19 Airborne Risk Calculator Help

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Disclaimer

This calculator is for the propagation of COVID-19 by airborne transmission only.

The model is based on a standard airborne disease transmission (the Wells-Riley model) that is calibrated to COVID-19 per recent literature on quanta emission rate.

This model is a best scientific estimate, based on the information currently available. It is provided for specialists having basic understanding about air distribution. Results are sensitive to quanta emission rates which can vary in large range. The uncertainty of these values is high.

This model does NOT include close contact and fomite transmission, and assumes that 1.5 m physical distancing is respected (otherwise higher transmission will result).

The model assumes full mixing (equal concentration at every location) in studied spaces -- in reality, in large spaces a non-uniform concentration may affect the results

Full mixing assumption means that 1.5 m from an occupant the concentration will be constant within the full indoor space at given time step

Fantech excludes any liability for any direct, indirect, incidental damages or any other damages that would result from, or be connected with the use of the information presented in this calculator.

Fundamental Concept

This calculator is a simplified calculator based on the following tools

Airborne Infection Risk Calculator Version 3.0 Beta, A.Mikszewski, G.Buonanno, L.Stabile, A.Pacitto and L.Morawska, April 2021

Covid-19 Aerosol Transmission Estimator, J.L. Jimenez and Z. Peng, COVID-19 Aerosol Transmission Estimator, https://tinyurl.com/covid-estimator, accessed 22-MAR-2022

This calculator is limited to modelling simple scenarios where there is only one infectious individual who has a variant of Covid-19. For more advanced scenarios, or for different airborne viruses, the above mentioned calculators may be more appropriate.

This tool models a single event, where an event is gathering of people in an environment for a set period of time. The event could be a 45 minute lesson in a classroom, or a 3 hour meeting in a conference room, or 20 minutes waiting in a waiting room.

This calculator is based on a concept called Quanta (or infectious dose), which is the dose of virus that will infect 63% of susceptible people. The calculator uses the Quanta emission rate (which is the infectious dose exhaled by an infected person), the removal rate of the virus from the room, and the inhalation rate of susceptible occupants.

The removal rate of virus from the area is based on the sum of the air change rate, the viral inactivation rate (the rate at which the virus decays per hour), and the particle deposition rate (the rate at which virus impacts surfaces).

The viral inactivation rate is calculated based on humidity for SARS-CoV-2[1] and assumes there is no additional inactivation by Ultra Violet light or other means, while the particle deposition rate is assumed to be 0.24h-1[2]. (SARS-CoV-2 is the virus that causes the Covid-19 disease.)

A Susceptible person is a person who is susceptible to catching Covid-19. Factors that may make a person less susceptible include, recently having been infected by Covid-19 (and therefore possibly having immunity for a period afterwards), vaccination status including the type of vaccine, the number of doses and the time since the doses were taken, or any other factors that may change a persons' susceptibility to catching viruses.

The assumption is that the room is well mixed, and that the dose of quanta received by a susceptible person is integrated over the total time.

[1] Dabisch P, Schuit M, Herzog A, et al. The influence of temperature, humidity, and simulated sunlight on the infectivity of SARS-CoV-2 in aerosols, Aerosol Science and Technology. 2021;55(2):142-153.

[2] https://www.sciencedirect.com/science/article/abs/pii/S1296207418305922?via%3Dihub

Risk

This calculator determines the risk of an infection occurring.

It is important to understand that we can never achieve zero risk. We can minimise the risk of an infection, but there is always a risk.

If we aim to minimise the risk to be as low as possible the airflows required will become larger and this may be impractical or cost prohibitive.

Therefore controlling airflow rates may be a part of the strategy to reduce airborne transmission but it may need to be complemented by other strategies such as mask wearing and reducing occupancy as examples.

Calculator Fields

Floor Area and Room Height

Enter the room floor area in m^2
Floor area is the Width x length
(A 5m Wide x 6m Long room has a floor area of $30m^2$)

Enter the room height in m.

This calculates the volume of the room in m^3.

Clean Airflow

Enter the clean (virus free) airflow entering (or leaving) the room in l/s.
The clean airflow can be any of / or a combination of the following.

A supply or exhaust fan bringing virus free air into the area.
An air purifier that recirculates air in the space but also removes viruses[3]
Natural ventilation (by opening windows or doors as an example)
The virus free air from a recirculating air system such as an AHU. (The viruses may be removed be HEPA filters or UV light as examples).

Example.
Assume an area is served by an AHU with 200 L/s fresh air, 800 L/s recirculated air, and a UV light system that deactivates 90% of the virus.

We have 200 L/s of clean virus free air entering from outside.

The recirculated air is 800 L/s and the UV system is 90% effective.

The virus free recirculated air is
0.9 x 800 L/s = 720 L/s

The total clean (virus free) air supplied to the area is
200 L/s + 720 L/s = 920 L/s.

Note: The above example is most likely underestimates the clean air rate as it does not account for any virus impacting the duct as it travels through the duct system (which would further reduce the amount of virus being recirculated).

The calculator then calculates the Air changes / hour which is a simplified description of how often the air is replaced in a room every hour.

Note: This tool can theoretically be used for natural ventilation, but there is a high variability in natural ventilation rates due to wind speed and locations/geometry of open windows and doors, which will mean that the results are highly dependent on the conditions. As a rule of thumb, if doors and windows are closed 0.1-1.5 AC/hr could be expected for natural ventilation in a house, and if

[3] This is the virus free airflow being provided by the air purifier. This can also be referred to as a Clean Air Delivery Rate (CADR)

windows are open this could increase up to a maximum of 15 AC/hr depending on conditions. Since this tool calculates the Air Changes / Hour (AC/hr), a user would have to modify the clean airflow (l/s) until they obtain the desired AC/hr (if they want to use this metric).

Exposure time

Enter the exposure time in hours.

The exposure time is the amount of time that the infected and susceptible people share the same area.

This tool assumes that the infected and susceptible occupants enter and leave the room at the same time. It is also assumed that the virus concentration is zero beforehand. For a more advanced tool please refer to AIRC v3.0 Beta.

The longer people share an environment, the greater the chance there is of susceptible people being infected.

Humidity

Enter the humidity in %.

The inactivation rate of SARS-CoV-2 increases with humidity levels therefore the humidity affects the risk of infection[4]

Number of Susceptible People at Event

Enter the maximum number of people that could be infected, and are present in the room during the event.

This number excludes the infected occupant.

Pathogen Analysed

Choose the variant of SARS-CoV-2 desired.

At the time of writing the original, Delta and Omicron variants have been included.

The Quanta emission rates for the original strain of SARS-CoV-2 have been predicted by analysing known real life events.

For other variants an emission multiplier is used to adjust the Quanta Emission rates to account for an increase in transmissibility for other variants. This calculator uses an emissions multiplier of 2.0 for the Delta variant[5] and 2.5 for the Omicron variant[6]. For future/other variants, choose SARS-CoV-2 (Custom variant) and then the user can enter in the Variant emissions multiplier for any new variants not defined in this calculator.

This is the most uncertain value in the calculator as there can be significant variability in the Quanta Emission Rates.

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[4] Dabisch P, Schuit M, Herzog A, et al. The influence of temperature, humidity, and simulated sunlight on the infectivity of SARS-CoV-2 in aerosols, Aerosol Science and Technology. 2021;55(2):142-153.
[5] http://dx.doi.org/10.2807/1560-7917.ES.2021.26.24.2100509
[6] https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(21)00559-2/fulltext

Physical Activity Level.

This defines the breathing rates of the susceptible and infectious individuals. If an infected person is more sedentary and they are therefore breathing less heavily, then they will breathe out a lower volume of air compared to if they are breathing more heavily. The same is true for susceptible people and the amount of air they are breathing in.

Vocal Activity Level

Where physical activity level relates more to the breathing rate, the vocal activity level relates to the amount of virus released. As the level of vocal activity increases (from breathing, to speaking and then loudly speaking), the Quanta emission rate of virus increases.

Since this term is only associated with the release of a virus it does not apply to susceptible people.

Mask Wearing Strategy

The wearing of masks has the potential to limit the Quanta emission rate from an infected person and also reduce the quanta breathed in by susceptible people.

The efficiencies of masks differ depending on whether a person is exhaling on inhaling. See Covid-19 Aerosol Transmission Estimator, https://tinyurl.com/covid-estimator for estimates of mask wearing efficiencies.

This assumes that all susceptible occupants have the same mask wearing strategy. Eg. If cloth masks are chosen it is assumed all susceptible occupants are wearing cloth masks.

It should be noted that the efficiency of a mask in preventing transmission is dependent on the type of mask, how it is fitted and how it is worn. The mask efficiencies used in these calculations can be better or worse depending on the above factors.

Individual Risk

This is the likelihood of a single susceptible occupant being infected.

If the risk of infection is 10% and there are 10 susceptible people in the room, then each person has a 10% chance of being infected, but the risk of 1 person out of the 10 becoming infected is 100%.

Maximum Susceptible Occupants

This is the maximum number of susceptible occupants in the room before it is likely that a susceptible person becomes infected. If the number of people in the room exceeds this number, it is likely that an infection will occur.

Probable number of cases

This is the probable number of infections that occur during the event.

If as an example if we have a classroom with 30 students and the probable number of Covid cases arising during the event was 0.9, the most likely outcome is that no-one would get infected (as the likelihood is < 1).

If we had 2 separate identical classroom events, the probable number of infections across both classrooms is 1.8 (0.9 x 2).