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Safer Spaces Technical Memo

Executive Summary

Before a building is fully constructed, it is important to analyze of how pathogens spread throughout the building so suitable ventilation systems can be made beforehand. All 9 rooms where studied to determine how particles spread through diffusion as well as when they are filtered out by the HVAC system. During this study, the risk of infection was analyzed per room respective of the different shift conditions of the rooms. A risk analysis model was developed using the cumulative amount virus particles inhaled over the course of a shift. It was found that room 7 was the most dangerous room reaching infectious rates of 1.6% during the evening while room 8 was the safest. There were a lot of assumptions made during the study therefore the risk results of the study can be taken to be an underestimate of the true values.

Main findings and recommendations

Risk level analysis

After a thorough analysis of the all nine rooms, it has been concluded that the room with the highest risk of contracting a virus is room 7. In contrast, the safest room would be room 8. Given that room 7 is an office space while room 8 is large research space, the results of our analysis make logical sense. As the occupancy, air changes per hour (ACH), air recycling rate and filtration levels of the HVAC system varied throughout the day according to the different time shifts, the highest infection risk percentage was found to be 1.6% in room 7 during the evening shift. This is assuming that there is about 25% of the people in the room are infected at the beginning of the shift. The risk was defined to be $P = \frac{1}{1+10^{(10-1.2*log_{10}*V)}}$ while V was taken to be the total number of particles inhaled.

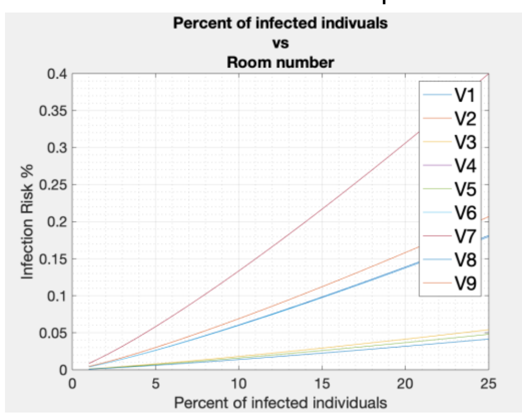

Figure 1 shows the percentage of risk of infection per room in the morning shift alone.

Decontamination analysis

One of the scenarios that was analyzed was one that involved people having to evacuate the building for an extended period of time given there was a prominent number of viral particles prior to the evacuation. It was found that it took about 700 minutes, which is equal to 11.7 hours, for the most dangerous room to reduce the risk to 3.3500e-06%. However, if the doors between the rooms were opened, that dramatically decreased the time to 400 minutes, which is equal to 6.7 hours. We also analyzed the building design's inherent risk when the HVAC's system is turned off to model a situation whereby there is no power supply. Assuming people evacuate the building during a power outage, the infection risk would still be the same as when they left it when they re-enter the building as there is currently no other ventilation system in place. However, if people stay in the building a during a power outage, the infection risk rises by to 10% by within 8 hours of being in the room. The result of this analysis would be to institute evacuation guidelines than advise people to evacuate the building during a power outage. This would limit the amount virus particles that are put into circulation and reduce the time taken to reduce the viral concentration to acceptable numbers when the power comes back. Another guideline that could be included should be that occupants should leave the doors open during the evacuation process as this will allow the virus particles to diffuse across a larger area thus reducing the equilibrium viral concentration in non-research rooms. One other recommendation would be consider having a backup power supply for the HVAC to system to filter out viral particles even during a power outage.

Table 2 shows the percentage of risk when 25% percent of the room's occupants are infected, and the power supply is turned off. The risk percentages displayed are after an 8-hour period.

Room #	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8	Room 9
Risk %	10.5733	10.933	10.3457	10.8866	10.0132	11.1074	11.0577	9.5057	10.8112

Building occupancy

We also analyzed the risk of infection as the number of infected occupants increased in every room. The most dangerous room was still room 7 which was consistent with our previous findings. When room 7 was analyzed alone, even if the 100% percent of the room had been infected, the maximum risk of infection was 8.3% after an 8-hour period. This means that even if the building is full of infectious people and a non-infectious person walks in, there would still be less that 10% chance of infection. Although this does not seem high, this could be seen as a an almost 10-fold increase compared to when the building is capped 25% of infectious people. We recommend that occupants should not come to work if they are feeling sick to reduce the number risk of infection for non-infected people.

System Efficiency

One way to reduce the risk of infection in the building is to increase the ACH rate of the HVAC system. If the ACH rates are doubled in each room, then the maximum percentage of risk reached becomes 0.86% reached in room 7. If the ACH is levels are increased by a factor of 20, then the maximum risk achieved among the rooms becomes 0.069%. Therefore, it can be concluded that to reduce risk threshold for the building, the ACH rates of each room can simply be increased. This can be done particularly during times of the seasonal flu or when there is an outbreak of very infectious virus. The only drawback is that increasing the ACH rate may increase the rate of power usage which may increase the cost of electricity as well. Changing the filtration levels to MERV 14 in all rooms does not reduce the risk levels much as the maximum risk reached is still above the 1%.

Table 3 shows the maximum percentage of risk of infection per room with 25% of the occupants infected per room. The different rows show the different factors by which the normal ACH rates of each room are multiply by.

Room #	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8	Room 9
1xACH	0.5178	0.621	0.1398	0.6169	0.1051	0.6317	1.6495	0.0765	0.7168
2xACH	0.2036	0.2765	0.0427	0.2748	0.0338	0.2806	0.8633	0.0278	0.3312
20xACH	0.0057	0.0181	0.0016	0.0181	0.0015	0.0182	0.0691	0.0015	0.0232

Qualifications and Conclusions

It should be noted that were a lot of assumptions made during the HVAC study. Firstly, we assumed that the virus particles were fully mixed instantly throughout the room. In real life scenarios, particles tend to concentrate closely in the area that they are released from. This means that there could be higher concentration of particles in one area of the room that would increase the risk of infection. We also assumed that a parson who is not infected, does not contribute to the total concentration of virus particles. Although this is a reasonable assumption, it is possible for non-infected people to breathe out some of the virus particles that they inhale. This would further increase the risk of infection per room if correctly accounted for. Adding windows to the model would have increased the escape rate of the particles. This could have resulted in lower risk infection rates per room however the number of windows per room was unknow as well as the flow rate through each window. Overall, our study is an underestimate of the risk levels in the rooms respective of the different time shifts. The main takeaways are to make sure to draft guidelines for the use of the building that go hand in hand with the recommendations stated above.