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An agent-based model to investigate various scenarios in transmission of COVID-19 in confined area scenes

1. Background

Many scientists and researchers have predicted that winter will be a more harsh season when it comes to the transmission of covid-19. However, many countries in the summer are showing an early second wave unlike expected.
In the case of Korea, where also currently suffering with the second wave of Covid-19, another unexpected factor other than mass gathering or not wearing a mask, arises as a critical reason for increased indoor virus transmission. New interesting factor that can cause mass spread of viruses is air-conditioning in closed areas such as cafes or restaurants. As Victoria is looking to reopen the state in the upcoming summer, this seems to be an interesting topic to investigate to get an idea of creating rules for preventing or slowing down virus transmission when reopened. Therefore, by creating an agent-based model using netlogo, we intend to investigate virus transmission in an enclosed space in various situations.

2. Questions

1) Is using air-conditioning really causes the acceleration of spreading virus aerozol?
2) Does ventilation reduce the chance of getting infected by virus particles in the air?
3) Does increasing the time spent in a confined room increase the likelihood of getting infected from indoors?

3. Experimental design

The model can be used to explore some hypothetical scenarios to get answers about the questions above. Scenarios to explore are listed below:

1) Air conditioning accelerates the spread of virus infection
2) Proper ventilation would help to slow down the virus transmission
3) Staying indoor time and the likelihood of viral transmission are not correlated.

Four settings have been prepared to confirm the hypotheses for the above scenarios, and the corresponding settings are shown in the table below.

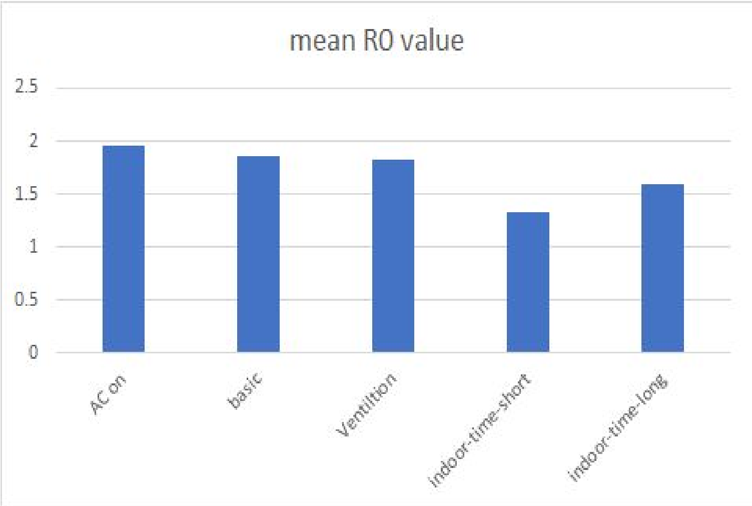
	MODEL SETTINGS								
setting name	air-conditioning?	average-recovery-time	caughing-chance	mask-wearing-tendency	stay-time	infection-chance	number-of-people	ventilation?	recovery-chance
AC on	TRUE	210	18	12	forever	30	300	FALSE	60
Basic	FALSE	210	18	12	forever	30	300	FALSE	60
Ventilation	FALSE	210	18	12	forever	30	300	TRUE	60
little indoor time	FALSE	210	18	12	25	30	300	FALSE	60
longer indoor time	FALSE	210	18	12	50	30	300	FALSE	60

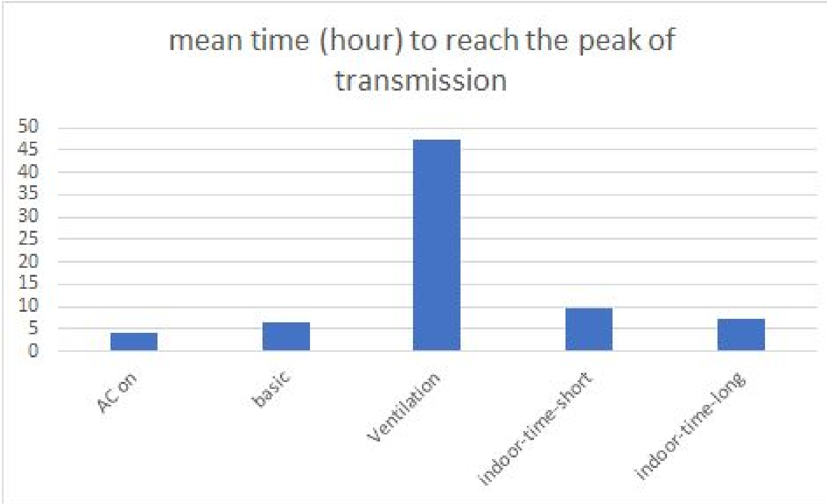
[table 1] Model settings for each scenarios

Each setting was simulated 20 times, and we want to compare the average value of r_0 for each situation through the simulation result.

4. Results

To experiment scenarios above, I've compared R0 value of 4 different settings: (a) with Air-conditioning, (b) basic (without Air-conditioning or ventilation) (c) with Ventilation,
(d) basic with short indoor time, (e) basic with a bit longer indoor time.
Note that in setting (a) - (c) , people are always staying indoor and not going out.
Figures below are produced charts to visualize and compare the R0 value of each setting.





[figure 1. Compare mean R0 value of each setting]

[figure 2. Mean time to hit the pick of the transmission]

Result Analysis

From the chart above, we can find that air conditioning in an enclosed space has the highest R0 value when other conditions are the same. This is interpreted as because the increase in the movement range of virus particles due to the use of air conditioners increases the likelihood of infection in people far from the infected person. This proves the hypothesis of the first scenario, and it can be seen that using an air conditioner without ventilation in an enclosed space increases the probability of infection in the space.

In the case of ventilation without people entering in a closed space, the value of r0 was slightly lower than that of the basic case without ventilation. It can be interpreted that proper ventilation lowers the concentration of virus particles in the atmosphere, thereby lowering the possibility of diffusion in the space.

However, the previous three cases had higher r0 values than the other two cases in which people left the confined space after a certain period of time. Comparing the latter two cases, the shorter the time spent indoors, the lower the R0 value. There is an interesting result about the time to reach the peak of the virus transmission in each scenario. From the graph above, we can see that the ventilation scenario has the longest time to reach the peak, while its R0 value is the third highest among the 5 settings. This means that in the scenario where people leave the place, they are out of the virus contact so that the lower proportion of the population will be infected in the end hence, reach the peak faster. As we mentioned in the model description that we don't consider or count the case of the additional transmission situation at outdoor (i.e., we purposely ignore the cases of infected individuals going out and sneezing/infect susceptible people outdoors) as we are only interested in the indoor transmission.

5. Conclusion

Based on the above analysis, it can be seen that ventilation is required to slow or reduce virus transmission in indoor spaces, and the time spent in an enclosed place must be minimized.

With the upcoming state reopening, we can use it to think about what indoor quarantine rules should be made. The above experiment was tested by considering only one variable at a time, but in actual situations, it is expected that appropriate defense measures can be established for each location by considering various variables at the same time.

6. Reference

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