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Estimating the Effect of Preventing the Spread of COVID-19 Infection by Restricting Movement in an Environment with Vaccinated Persons

N. Hashimoto [1] Y. Uwate [1] Y. Nshio[1]
(Tokushima University[1])

1. Introduction

Currently, a vaccine against COVID-19 has been developed and many countries are trying to spread it. In the United Kingdom, it has been reported that about 50% of the population has already completed vaccination [1]. British Prime Minister Johnson has announced that it will lift restrictions on COVID-19 measures such as movement restrictions. These Measures have been shown to be effective by MAS (multi-agent simulation) [2]. However, the effect in an environment with vaccinated persons has not yet been shown. Therefore, the object of this study is to investigate the change in the movement restriction effect due to the difference in vaccination rate.

2. Proposed Model

MAS was performed using the SEIR model. The SEIR model is a model in which an agent is given four status, S (Susceptible), E (exposed), I (infected), and R (recovered/dead), and each state changes . We also added the state V (vaccinated) to the SEIR model. V does not get infected when it comes in contact with an infected person. By changing the ratio of V, the change in the movement restriction effect due to the difference in the vaccination ratio was evaluated. The effect of movement restriction is shown by Eq. (1).

3. Conditions

$$Effect = \frac{I_{No\ restrict} - I_{restrict}}{I_{No\ restrict}} \quad (1)$$

$I_{No\ restrict}$: $Number\ of\ infected(No\ restrict)$

$I_{restrict}$: $Number\ of\ infected\ (restrict)$

In this study, the simulation was performed with the total number of agents: 200 and the number of initial infections: 10. The exposed period is 5.1 days and the infection period is 15 days. Agents' rules of conduct are that they gather at work or school during the daytime, move freely in the town in the evening, and stay at home at night. On holidays, agents can move around the town freely. Where if movement restrictions is implemented, 50% of agents will stay at home.

4. Results

Figure 1 shows the changes in the number of infected persons with or without movement restrictions at 0%, 25%, and 50% vaccination rates. From Fig. 1, it can be confirmed that the movement restriction not only reduces the total number of infected persons, but also slows down the peak of infections.

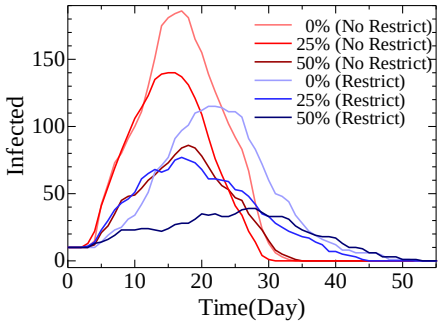

Fig. 1. Changes in the number of infected people

Table 1 shows the final total number of infected persons and the effect of movement restriction. From Table 1, it was confirmed that if the vaccination rate increases, the number of infected people decreases, however the effect of movement restriction does not change significantly. From this, it was found that even after the vaccine has become sufficiently widespread, there is an effect of reducing the risk of infection by restricting movement for non-vaccinated persons.

Table 1. Final number of infected people and the effect of movement restrictions

Ristriction	Vaccination rate (%)	infected person(person)	Effect
No	0	193	0.212
Yes		152	
No	25	141	0.241
Yes		107	
No	50	96	0.229
Yes		74	

Reference

[1] NHK, “World Vaccination Status” https://www3.nhk.or.jp/news/special/coronavirus/vaccine/world_progress/ (refer in 2021/7/21)

[2] Vyklyuk,Y., Manylich,M., ˇSkoda,M., Radovanovi,M.M., &Petrovi,M.D., “Modeling and analysis of different scenarios for the spread of COVID-19 by using the modified multi-agent systems – Evidence from the selected countries”, SienceDirect Result in Physics , 2021, vol. 20, 103662, https://www.sciencedirect.com/science/article/pii/S2211379720320878?via%3Dihub