A Research of Infectivity Rate of Seasonal Influenza from Pre-infectious Person for Data Driven Simulation

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Abstract. I had proposed a discrete mathematical SEPIR (Susceptible – Exposed - Pre-infectious – Infectious - Recovered stage) model for seasonal influenza. In a subsequent previously study, focusing on infections by a pre-infectious person using pre-existing data, I showed that there super-spreading of seasonal influenza occurred before D-day that the first patients are discovered at Japan Coast Guard Academy. In this study, I found that the infectivity rate from pre-infectious people is 0.041 when the surrounding people don't take counter-measures against the infection. After D-day in the community, the countermeasures taken reduce the infectivity rate to 0.002 in working spaces and 0.013 in living spaces. And the number of infectious people can be estimated simply by the summing up each group in the community.

Keywords: Epidemic model · Seasonal influenza · Super-spread · Infectivity rate

1 Introduction

The US Centers for Disease Control and Prevention (CDC) [1] has reported that the symptoms of seasonal influenza, what is called flu, arise within one to four days after the virus enters the body. Thus, a person can transmit it to others before they know that they are sick, as well as while they are sick. In other words, flu has an incubation period. Moreover, it has two periods, the exposed period and the infectious period, but neither have any symptoms at this stage.

By retrospective investigation of activities in closed spaces used by the students using epidemic data, we just have to deal with dormitories and classrooms as closed spaces for infection channels [2]. Then, almost all infections were transmitted on campus. For this investigation, a refinement was introduced to a previous epidemic model to account for the incubation period and proposed a discrete-time SEPIR (Susceptible – Exposed - Pre-infectious – Infectious - Recovered) model for flu. In this manner, I derived an incubation period of three days from epidemic data and showed that students can infect others beginning two day before symptoms show [2].

Focusing on the infectivity rate, simulation of a flu epidemic using the SEPIR model with a multi-agent simulation and a real spatio-temporal model was performed [3]. To

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perform a realistic simulation, the infectivity rate from epidemic data was calculated. This simulation of the epidemic with various infectivity rates calculated by the average for the whole academy, for type of rooms, for each year, for double lessons and for multi-year classes were compared. However, the simulation results are very different from the epidemic data and the peak of the simulated epidemic is higher than the real one. Infection in classroom is a key point because the number of students in classroom is more than that of dormitories.

By retrospective investigation of all infected students at the pre-infectious stage, but have no symptoms, some students super-spread flu until the day that first patients are discovered, which is defined D-day. After D-day, a few students were infected [4]. Students were directed to start wearing masks, washing hands and better ventilating rooms, amongst other measures, when flu is first discovered. After D-day, the measures seem to take effect after about one day and the infectivity rate become lower.

2 Proposed SEPIR Model

Traditional epidemic mathematical model is SIR model [5], and the state transition diagram of an individual is shown in Fig. 1(a). Keeling et al. [6] deal with incubation period and propose mathematical SEIR model which many childhood infectious diseases (such as measles, rubella, or chickenpox) follow. The state transition diagram of an individual is shown in Fig. 1(b). In those models, only an infected "I" individual can infect a susceptible "S" individual.

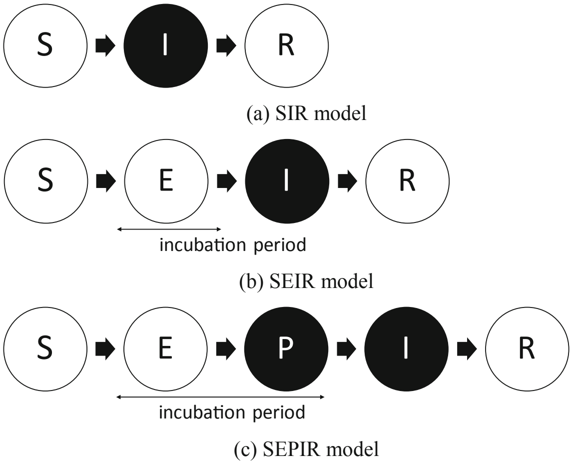


Fig. 1. The state transition diagram of an infected individual: the circles show the state of individual. S: Susceptible state, E: Exposed state, P: Pre-infectious state, I: Infectious state and R: Recovered state. The black circle mean that they can affect others.

The pre-infectious state "P", that is asymptomatic was introduced into the SEIR model and proposed the discrete mathematical SEPIR model for flu [2]. The incubation period is divided into two periods, the exposed period and the infectious period, with neither having any symptoms. The former was set as the exposed state "E" and the latter as the pre-infectious state "P". The state transition diagram is shown in Fig. 1(c).

An individual of "I" or "P" can infect a "S" individual. The probability of contact between individuals of susceptible "S" and infectious "I" is determined by their respective numbers. Considering a mean infectivity rate β, an individual of "S" moves to exposed "E", which is shown in Eq. (1) [5]. The probability of contact between individuals of "S" and "P" is also determined by their respective numbers. By introducing infectivity rate α, an individual of "S" moves to "E" as given in Eq. (1) [2]. By introducing transmission rate σ, an individual of "E" moves to "P" as given in Eq. (2) [2]. By introducing transmission rate τ, an individual of "P" moves to "I" as given in Eq. (3) [2]. By introducing recovery rate γ which is the inverse of the infectious "I" period, this leads to a far more straightforward equation as shown in Eq. (4) [5]. Here, S(t), E(t), P(t), I(t) and R(t) is the number of individuals of "S", "E", "P", "I" and "R", t representing day.

$$\Delta S = S(t + 1) - S(t) = -\alpha S(t)P(t) - \beta S(t)I(t) \tag{1}$$

$$\Delta E = E(t + 1) - E(t) = \alpha S(t)P(t) + \beta S(t)I(t) - \sigma E(t) \tag{2}$$

$$\Delta P = P(t + 1) - P(t) = \sigma E(t) - \tau P(t) \tag{3}$$

$$\Delta I = I(t + 1) - I(t) = \tau P(t) - \gamma I(t) \tag{4}$$

$$\Delta R = R(t + 1) - R(t) = \gamma I(t) \tag{5}$$

3 Epidemic Situations

3.1 Situation A

In January, 2017, an epidemic of flu occurred at the Japan Coast Guard Academy (JCGA). JCGA is a residential college. At that time, there were 150 undergraduate students, consisting of 56 freshmen, 47 sophomores, 44 juniors and just 3 seniors due to the others being on away for on ship training. After a three-day holiday from January 7th to 9th, students returned to their dormitories and resumed to take classes. On Friday January 13th, two students, a freshman and a sophomore, showed symptoms of flu. 37 students, that is 20 freshmen, 13 sophomores and 4 juniors, showed symptoms in the next two weeks.

3.2 Situation B

In January, 2019, an epidemic of flu also occurred on the JCGA training ship. After winter vacation until January 3rd, students returned to the academy and started embarkation training. On Friday January 10th, one student showed signs of flu. Within two weeks there were 18 cases out of 56 freshmen.

3.3 Situation C

In January, 2019, a separate flu epidemic occurred at JCGA. At that time, there were 109 undergraduate students excluding freshmen[1] (54 sophomores, 51 juniors and just 4 seniors) as the others were conducting on board training. After the winter vacation until January 3rd, students returned to the dormitories and resumed to take classes. On Thursday January 9th, six students exhibited flu. 13 students, that is 11 sophomores and 2 juniors, showed symptoms within two weeks.

4 Parameters

4.1 Infectivity Rate

We adopted SIR model and input our academy's data. The estimated parameters are $\beta = 0.0014$ per day (normalized $\beta = 0.21$) and $1/\gamma = 4.0$ days in situation A using a simple squares method. And the basic reproductive ratio R0, which is determined by normalized $\beta/\gamma = 0.83$. The initial results [2] were found to be incorrect so were recalculated. These results were then found to be out of range for human's influenza, between 3 and 4 [5]. In situation B, estimated parameters are $\beta = 0.0034$ per day (normalized $\beta = 0.19$) and $1/\gamma = 4.5$ days, given an R0 of 0.85. In situation C, estimated parameters are $\beta = 0.0008$ per day (normalized $\beta = 0.045$) and $1/\gamma = 6.7$ days, given an R0 of 0.30. Situation B and C are also out of range of human influenza. According to the parameter β and SIR model, no one was infected in situation A, B and C. Then, SIR model doesn't match JCGA situations.

At JCGA, though patients are isolated in sick rooms, a flu epidemic occurred. It is assumed that pre-infectious students infected others. The infectivity rate β by "I" in Eq. (1) is set as 0. Students had already infected many students until the day of the first patients being discovered, which is defined as D-day. I calculated the infectivity rate α from "P" of situation A and B in the classrooms and dormitories before D-day and after D-day using epidemic data in Table 1, where cases of super-spreading occurred [4]. In Table 1, the average, the standard deviation, maximum value and minimum value of the infectivity rate are shown. I found that the average infectivity rate (α_bC) before D-day in situation A and B is about 0.04. And the average infectivity rate (α_aC) after D-day is smaller than that before D-day. It seems that the countermeasures against flu after D-day were effective. N refers to the number of infections. Infection occurred a few times in situation B. In situation C, the average infectivity rate was small, where super-spreading didn't occurred.

Table 2 shows the infectivity rate in the dormitories in all of situations A, B and C. The average infectivity rate (α_bB) before D-day in situation A and B was about 0.04. And the average infectivity rate (α_aC) after D-day was smaller than that before. It seems that the countermeasures against flu after D-day were effective. Infections occurred a few times in situation B. The average infectivity rate in situation C was very small and infection occurred a few times, as super-spreading didn't occur.

[1] In January 2019 the freshmen had no contacts with other students and were trained by different staff.

In situation A and B, where super-spreading occurred, the total average infectivity rates before D-day was about 0.041 as shown in Table 3. This shows that two "S" students were infected and become "E" the next day if there was a "P" student in the room of 50. The infectivity rate in the classrooms and dormitories after D-day are small. This suggests that students are more infectious before D-day than after. And the total average infectivity rate (α_aC) in the classrooms after D-day is 0.002 and that in dormitories 0.013. This suggests that students in the dormitories are seven times more infectious than in the classrooms. That is, after D-day, the infectivity rate must be calculated for type of rooms.

Table 1. Infectivity rate in classrooms.

Infectivity rate	situation A		situation B		situation C
	α_bC	α_aC	α_bC	α_aC	α_C
The average	0.0423	0.0019	0.0431	0.0008	0.0021
Standard deviation	0.0886	0.0049	0.0192	0.0015	0.0017
Max	0.3200	0.0185	0.0648	0.0038	0.0035
Min	0	0	0.0182	0	0
N	25	29	3	5	5

Table 2. Infectivity rate in dormitories.

Infectivity rate	situation A		situation B		situation C
	α_bB	α_aB	α_bB	α_aB	α_B
The average	0.0391	0.0152	0.0373	0.0014	0.0068
Standard deviation	0.0853	0.0430	0.0105	0.0030	0.0304
Max	0.2857	0.1667	0.0500	0.0082	0.1429
Min	0	0	0.0244	0	0
N	21	34	3	6	21

Comparing all situations, super-spreading didn't occur in situation C, which is the situation where infections occurred a very few times in the classrooms compared with the dormitories. In situation C, infection times is very small in the classrooms for all days compared with situation A. This fact is considered to be the reason why super-spreading didn't occur. In other words, super-spreading is more likely to occur in the classrooms.

Table 3. The total average infectivity rate in situation A and B.

Infectivity rate	By D-day		After D-day	
	classrooms	dormitory	classrooms	dormitory
	α_bC	α_bB	α_aB	α_aB
The average	0.041		0.002	0.013

4.2 The Number of Susceptible Students

In a former study, I investigated multi-layer activities, such as in the classrooms, study rooms or dormitories. In situation A, it is estimated that 16 students were infected in the classrooms, one in the dormitories and five in one of the two locations on weekdays [2]. That is, the majority of the students were infected in the classrooms. The number of infected students relates to the number of “S” students.

In situation A, the number of infected students in the classrooms before D-day was 19 (excluding the lecture hall where all students attended) and that after is two as shown in Table 4. In the dormitories, that in the classrooms before D-day was six and that after is four. Many students were infected before D-day in classrooms.

The average number of susceptible “S” students in the classrooms before D-day was 33 (excluding the lecture hall where all students attended) and that after is 50. And that in the classrooms before D-day was 7.3 that after is 6.8. That is, I found that students were infected even in small classrooms before D-day.

Table 4. The number of infected students in situation A.

	In classrooms		In dormitories	
	Before D-day	After D-day	Before D-day	After D-day
Infected students	19	2	6	4
Average number of “S”	33.0	50.0	7.3	6.8

5 Near Decomposability

5.1 Definition

On theoretical grounds, Simon shows the following [7]. Hierarchic system has a property, near decomposability, that is interactions within each subsystem are stronger than the interaction among subsystems. For example, in an organization, there will generally be more interaction within employees who belong to the same department than among employees from different departments. In organic substances intermolecular forces will generally be weaker than molecular forces, and molecular forces weaker than nuclear forces. Then, we can distinguish between the interactions among subsystems and the interactions within subsystems and that simplifies the behavior. Here, the former is set as contact network in the bedrooms and the latter is set as contact network in the classrooms.

According to Eq. (1), the number of infected students relates to the number of the students in the rooms because the infectivity rates before D-day were almost same in the classrooms and dormitories. And 20 cases out of 26 were campus transmissions before D-day [4]. D-day is January 13th in situation A.

In this study, I adopt near decomposability to JCGA situations and I roughly estimate the epidemic. Focusing on classrooms, I subdivided situation A [4] into school year as shown in Table 5. Rows G1, G2 and G3 refer receptivity to the daily number of infected freshmen, senior and junior students by pre-infectious “P” students in the classrooms. The dates underlined refer to days off. According to a former study, super-spreading (SS) is defined that when people directly infected more than 6.7% of people in their community in one day [4]. The threshold of SS in italics are shown in Table 5, which is 3.7 of 56 freshmen, 3.1 of 47 sophomores, 2.9 of 44 juniors. I found that SS occurred in the classrooms of freshmen on January11th, which is shown in bold. It is almost SS in the classrooms of sophomores on January 11th.

Table 5. Epidemic of flu at JCGA in January, 2017 (situation A) divided by school year.

	9	10	11	12	**13**	14	15	16	17	18	19	20	21	22	23	24	25	26	SS
G1			**10**	3	0	1	0	0	1	0	0	0							*3.7*
G2			3	2	0	2	0	1	0	0	0								*3.1*
G3				1	1	1	0	0	0										*2.9*

5.2 Rough Estimation

Table 6 is the rough estimation of infection for each school year. For freshmen, the epidemic data of students 1, 4, 7, 17 and 35 are used, and it is assumed that student 1 infected 51 freshmen in the classrooms.

There are no “P” students before January 10th. On January 11th, the number of S and P in freshmen’s classrooms were 51 and 1, ΔS is -2 ($= -0.041 * 51 * 1$) using Eq. (1). That is, two students (A1, A2) were exposed and changed “E” from “S” the next day. On January 12th, the number of S and P in the classrooms was 49 and 1, two students (B1, B2) were exposed. The number of S and P in the classrooms was 47 and 2 on January13th, four students (C1–C4) were exposed. There were no classes on that weekend. The number of S and P on January 16th in the classrooms were 43 and 4, ΔS is 0 ($= -0.002 * 43 * 4$) and no one got infected. Then, 8 freshmen were estimated to be infected in the classrooms. Similarly, the epidemic data of students 2, 3, 5, 6 and 31 are used and it is assumed that student 2 infected 42 sophomores in the sophomore’s classrooms as shown in Table 7.

Table 6. Rough estimate for freshmen (56 students) in situation A

ID	D	Date																	
		9	10	11	12	**13**	14	15	16	17	18	19	20	21	22	23	24	25	26
1	1	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	R	R
A1	1	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R
A2	1	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R
B1	1	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R
B2	1	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R
C1	1	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R
C2	1	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R
C3	1	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R
C4	1	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R
	S	52	51	51	49	47	43	43	43	43	43	43	43	43	43	43	43	43	43
	E	0	1	0	2	2	4	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	1	1	2	4	6	4	0	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	1	1	3	5	8	8	4	1	0	0	0	0	0	0
	R	0	0	0	0	0	0	0	0	1	1	5	8	9	9	9	9	9	9
	ΔS	0	0	−2	−2	−4	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R
7	1	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R	R	R
17	1	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R
35	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R

As for situation B, the epidemic data of students 1, 2, and 18 are used and it is assumed that student 1 and 2 infected 53 freshmen in the classrooms as shown Table 8. D-day is January 10th in situation B. There are no “P” students before January 7th. On January 8th, the number of S and P in freshmen’s classrooms were 53 and 1, ΔS is −2 (= −0.041 * 53 * 1) using Eq. (1). That is, two students (G1, G2) were infected and changed “E” from “S” the next day. The number of S and P on January 9th in the classrooms were 51 and 2, four students (H1–H4) were infected. The number of S and P on January10th in the classrooms were 47 and 3, six students (I1–I6) were infected. The number of S and P on January 11th in the classrooms were 41 and 6, ΔS is 0 (= −0.002 * 41 * 6) and no one got infected. There are no classes on that weekend. Then, 12 freshmen are estimated to be infected in the classrooms.

Table 7. Rough estimation for sophomores (47 students) in situation A

ID	D	Date																	
		9	10	11	12	**13**	14	15	16	17	18	19	20	21	22	23	24	25	26
2	2	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	R	R
D1	2	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R
D2	2	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R
E1	2	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R
E2	2	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R
F1	2	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R
F2	2	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R
F3	2	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R
	S	43	42	42	40	38	35	35	35	35	35	35	35	35	35	35	35	35	35
	E	0	1	0	2	2	3	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	1	1	2	4	5	3	0	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	1	1	3	5	7	7	5	3	0	0	0	0	0	0
	R	0	0	0	0	0	0	0	0	1	1	3	5	8	8	8	8	8	8
	ΔS	0	0	−2	−2	−3	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R
5	2	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R
6	2	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	R
31	2	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R

As for situation C, the epidemic data of students from 1 to 10 and 12 are used and it is assumed that students from 1 to 6 students infected 43 sophomores in the classrooms as shown Table 9. Here, super-spreading didn't occurred and the infectivity rate is set as 0.002. 2 sophomores are estimated to be infected in the classrooms.

On January 7th, the number of S and P in sophomores' classrooms were 43 and 6, ΔS is -1 ($= -0.002 * 43 * 6$) using Eq. (1). That is, one student (J1) was infected. The number of S and P on January 8h in the classrooms were 42 and 6, one student (K1) was infected.

Table 8. Rough estimation for freshmen (56 students) in situation B

ID	D	4	5	6	7	8	9	**10**	11	12	13	14	15	16	17
							Date								
1	1	S	S	S	E	P	P	I	I	I	I	I	I	R	R
2	1	S	S	S	S	E	P	P	I	I	I	I	I	R	R
G1	1	S	S	S	S	S	E	P	P	I	I	I	I	R	R
G2	1	S	S	S	S	S	E	P	P	I	I	I	I	R	R
H1	1	S	S	S	S	S	S	E	P	P	I	I	I	I	R
H2	1	S	S	S	S	S	S	E	P	P	I	I	I	I	R
H3	1	S	S	S	S	S	S	E	P	P	I	I	I	I	R
H4	1	S	S	S	S	S	S	E	P	P	I	I	I	I	R
I1	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I
I2	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I
I3	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I
I4	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I
I5	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I
I6	1	S	S	S	S	S	S	S	E	P	P	I	I	I	I
	S	55	55	55	54	53	51	47	41	41	41	41	41	41	41
	E	0	0	0	1	1	2	4	6	0	0	0	0	0	0
	P	0	0	0	0	1	2	3	6	10	6	0	0	0	0
	I	0	0	0	0	0	0	1	2	4	8	14	14	10	6
	R	0	0	0	0	0	0	0	0	0	0	0	0	4	8
	ΔS	0	0	0	0	-2	-4	-6	0	0	0	0	0	0	0
18	1	S	S	S	S	S	S	S	S	S	S	S	S	S	S

ID	D (cont.)	18	19	20	21	22	23	24	25	26	27	28	29	30
							Date							
1	1	R	R	R	R	R	R	R	R	R	R	R	R	R
2	1	R	R	R	R	R	R	R	R	R	R	R	R	R
G1	1	R	R	R	R	R	R	R	R	R	R	R	R	R
G2	1	R	R	R	R	R	R	R	R	R	R	R	R	R
H1	1	R	R	R	R	R	R	R	R	R	R	R	R	R
H2	1	R	R	R	R	R	R	R	R	R	R	R	R	R
H3	1	R	R	R	R	R	R	R	R	R	R	R	R	R
H4	1	R	R	R	R	R	R	R	R	R	R	R	R	R
I1	1	R	R	R	R	R	R	R	R	R	R	R	R	R
I2	1	R	R	R	R	R	R	R	R	R	R	R	R	R
I3	1	R	R	R	R	R	R	R	R	R	R	R	R	R
I4	1	R	R	R	R	R	R	R	R	R	R	R	R	R
I5	1	R	R	R	R	R	R	R	R	R	R	R	R	R
I6	1	R	R	R	R	R	R	R	R	R	R	R	R	R
	S	41	41	41	41	41	41	41	41	41	41	41	41	41
	E	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	0	0	0	0	0	0	0	0	0
	R	14	14	14	14	14	14	14	14	14	14	14	14	14
	ΔS	0	0	0	0	0	0	0	0	0	0	0	0	0
18	1	S	E	P	P	I	I	I	I	I	I	R	R	R

Table 9. Rough estimation for sophomores (54 students) in situation C

		Date													
ID	D	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1	S	S	E	P	P	I	I	I	I	I	I	R	R	R
2	1	S	S	E	P	P	I	I	I	I	I	I	R	R	R
3	1	S	S	E	P	P	I	I	I	I	I	I	R	R	R
4	1	S	S	E	P	P	I	I	I	I	I	I	R	R	R
5	1	S	S	E	P	P	I	I	I	I	I	I	R	R	R
6	1	S	S	E	P	P	I	I	I	I	I	I	R	R	R
J1	1	S	S	S	S	E	P	P	I	I	I	I	R	R	R
K1	1	S	S	S	S	S	E	P	P	I	I	I	I	R	R
	S	49	49	43	43	42	41	41	41	41	41	41	41	41	41
	E	0	0	6	0	1	1	0	0	0	0	0	0	0	0
	P	0	0	0	6	6	1	2	1	0	0	0	0	0	0
	I	0	0	0	0	0	6	6	7	8	8	8	1	0	0
	R	0	0	0	0	0	0	0	0	0	0	0	7	8	8
	ΔS	0	0	0	-1	-1	0	0	0	0	0	0	0	0	0
7	2	S	S	S	E	P	P	I	I	I	I	I	I	R	R
8	2	S	S	S	E	P	P	I	I	I	I	I	I	R	R
9	2	S	S	S	E	P	P	I	I	I	I	I	R	R	R
10	2	S	S	S	S	E	P	P	I	I	I	I	I	I	R
12	2	S	S	S	S	S	S	S	S	E	P	P	I	I	I

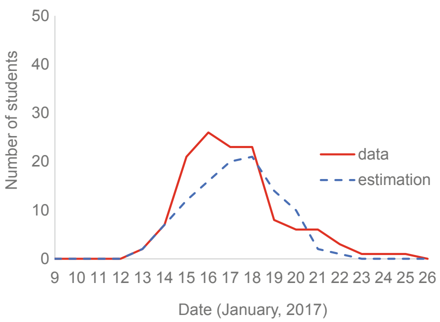
	cont.	Date												
ID	D	18	19	20	21	22	23	24	25	26	27	28	29	30
1	2	R	R	R	R	R	R	R	R	R	R	R	R	R
2	2	R	R	R	R	R	R	R	R	R	R	R	R	R
3	2	R	R	R	R	R	R	R	R	R	R	R	R	R
4	2	R	R	R	R	R	R	R	R	R	R	R	R	R
5	2	R	R	R	R	R	R	R	R	R	R	R	R	R
6	2	R	R	R	R	R	R	R	R	R	R	R	R	R
J1	2	R	R	R	R	R	R	R	R	R	R	R	R	R
K1	2	R	R	R	R	R	R	R	R	R	R	R	R	R
	S	41	41	41	41	41	41	41	41	41	41	41	41	41
	E	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	0	0	0	0	0	0	0	0	0
	R	8	8	8	8	8	8	8	8	8	8	8	8	8
	ΔS	0	0	0	0	0	0	0	0	0	0	0	0	0
7	2	R	R	R	R	R	R	R	R	R	R	R	R	R
8	2	R	R	R	R	R	R	R	R	R	R	R	R	R
9	2	R	R	R	R	R	R	R	R	R	R	R	R	R
10	2	R	R	R	R	R	R	R	R	R	R	R	R	R
12	2	I	I	I	R	R	R	R	R	R	R	R	R	R

6 Discussion

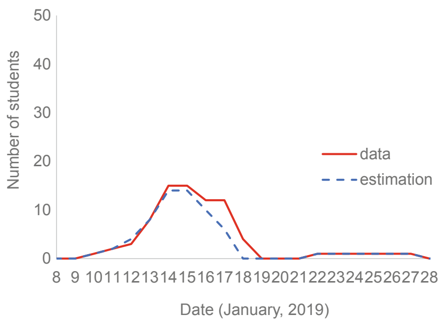
Figure 2(a) shows a rough estimation of infections in situation A. Compared with the epidemic data, the rough estimation looks low because it is assumed that students have one class in a day. In fact, freshmen had four classes on January 11th and two classes on January 12th (from epidemic data) [2]. Figure 2(b) is the transmission of rough estimation of situation B. Compared with the epidemic data, the rough estimation looks little low as well. Figure 2(c) is the transmission of rough estimation of situation C. Compared with the epidemic data, the rough estimation looks little low as well. Sophomores had four classes on January 7th and three classes on January 8th (from epidemic data).

Here, on January 12th in 2017, there was a lecture for all 150 students. The number of S and P was 129 and 7, ΔS is -37 ($= -0.041 * 129 * 7$) using Eq. (1). That is, 37 students got infected and changed "E" from "S" the next day. Super-spreading might be expected but it didn't occur as seats were set separately for each school year. It is similar to the summing up for each school year.

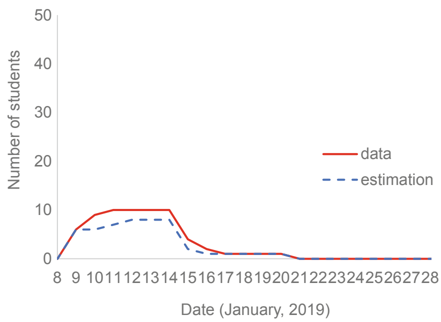
I could roughly estimate the epidemic by near decomposability, that is I subdivided the situations into school years. This shows that it is a key point to prevent the contact of many people in closed spaces such as classrooms as a counter-measure against flu.



(a) situation A(only freshmen and sophomores)



(b) situation B



(c) situation C(only sophomores)

Fig. 2. Rough estimation of infections

7 Conclusion

By examining infections by a pre-infectious person using pre-existing data at JCGA, I found that the infectivity rate from pre-infectious people is 0.041 when the surrounding people don't take counter-measures against the infection. After D-day the first patients are discovered in the community, the countermeasures taken reduced the infectivity rate to 0.002 in working spaces and 0.013 in living spaces. And the number of infectious people can be estimated simply by the summing up each group in the community.

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