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Research Article

Effect of the Mass Vaccination Duration on the Spread of COVID-19-Evaluated by a Flexible Compartment Model

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SUPPLEMENTARY MATERIAL 1

Appendix 1: Explanations of independent variables and dependent variables used in the Excel file.

Independent variables of the model

For simulation, n starts from 1, and the independent variables of twenty terms can be set arbitrarily by the user as follows:

1) TN(1): The initial total population of the community, such as a city. TN(n) is changed by the number of susceptible individuals (NAP(n)) and/or infected individuals (UP(n)) who come in and/or leave the community. TN(n)=TN(n-1)+NAP(n)+UP(n) (101)

2) P(1): The initial number of infected individuals in the community. The infected individuals are those who have been infected and are capable of infecting susceptible individuals. Thus, they can be called the 'Spreader'. Infected individuals (UP(n)) other than the initial infected individuals can enter and/or leave the community. Additionally, when the initial incidence rate, ir(1), is given, P(1) is given by the product of ir(1) and TN(1), that is, ir(1)*TN(1), because ir(n) is usually given by P(n)/TN(1).

P(n) is the number of infected individuals in the morning on date n and is equal to P(n-1(night)). P(n) is given by Eq. (21), and P(n(night)) is given by Eq. (249). However, when P(n) is less than 0.49, P(n) is set to 0.

3) NAP(n): The value of increase and/or decrease in the number of susceptible individuals due to external factors such as traveling, self-isolation and migration (immigration/emigration). In addition, NAP(n) should be added to both TN(n) and RM(n) when NAP(n) is given a positive value, meaning that susceptible individuals enter the community. When NAP(n) is given a negative value, meaning that susceptible individuals leave the community, the value of NAP(n) should be subtracted from both TN(n) and RM(n). Emergency actions such as 'avoiding any unnecessary outings/travel', 'staying home (self-isolation)' and 'lockdown' for infection prevention practically induce a reduction in the number of susceptible individuals in the real community, indicating that NAP(n) should be given a negative value. By setting NAP(n) for the simulation, the effects of such interventions can be evaluated.

4) UP(n): The value of increase and/or decrease in the number of infected individuals due to external factors such as traveling, self-isolation and migration (immigration/emigration). UP(n) should be added to both TN(n) and P(n) when UP(n) is given a positive value, meaning that infected individuals enter the community. When UP(n) is given a negative value, meaning that infected individuals are not isolated but go out of the whole community, the value of UP(n) should be subtracted from both TN(n) and P(n). Since symptomatic infected individuals are isolated, most of the individuals given UP(n) are asymptomatic. By setting the value of UP(n) for the simulation in such a case that the asymptomatic infected travelers come in the community from other cities and/or foreign countries, the effect of the infected individuals coming in the community can be evaluated.

For the model proposed here, NAP(n) and UP(n) are each set once a certain day, and the condition is automatically kept until it is reset, although the other independent variables should be set every day. When the condition is to revert to its previous state, the positive/negative reverse value should be reset when needed.

5) T(n): The number of individuals with PCR and/or antibody test results. The test time should be set on the day when the test is performed.

6) bp(n): The magnification of the incidence rate for the test to the incidence rate in the community, ir(n) (=P(n)/TN(n)). Since those having the test are mainly close contacts, the incidence rate for the test would be biased to be higher than ir(n). The incidence rate for the test is given by the magnification with respect to ir(n). Namely, the number of infected individuals confirmed to be test positive, CP(n), is calculated by:

CP(n)=T(n)*bp(n)*ir(n) (102) (=5)

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The value of bp(n)*ir(n) indicates the positive rate of the test, tir(n).

7) v(n): The vaccination rate. The number of vaccinated individuals, V(n), is given by:

V(n)=TN(1)*(v(n) -b(n)) (103) (=24, 8)

where b(n) is the breakthrough rate. Vaccinated individuals are those who have immunity from vaccination. They live and work in the real community, as shown in figure 1. The value of b(n) should be set to 0 on the day when breakthrough infection does not occur.

For V(n), the value of V(n) is practically used as the adjusted number of vaccinated individuals who are vaccinated and have immunity; the value of (TN(n)-(CI(n)+CAP(n)+V(n)) should be greater than or equal to 0, that is, (TN(n)-(CI(n)+CAP(n)+V(n))≧0. Thus, V(n) should be less than or equal to the value of (TN(n)-(CI(n)+CAP(n)); that is, V(n)≦(TN(n)-(CI(n)+CAP(n))). Namely, when V(n) is larger than (TN(n)-(CI(n)+CAP(n)), V(n) should be set to (TN(n)-(CI(n)+CAP(n))); otherwise, V(n) should be given by Eq. (103). (See term 36) V(n) and term 37) V(n) of section 2: Dependent variables of the model)

8) b(n): The breakthrough rate, which indicates the ratio of the number of individuals who are vaccinated but could be infected to the number of vaccinated individuals. All vaccinated individuals do not always have immunity, and breakthrough infection occurs in individuals who do not acquire immunity. Breakthrough infection also occurs for individuals whose quantity of antibody decreases below a certain threshold. For both cases, Eqs. (103) and (24, 8) indicate that the vaccinated individuals who have turned to 'may get infected' are reset to be susceptible individuals on the date when breakthrough infection occurs. As a result, the value of the term (v(n)-b(n)) indicates an immunity acquisition rate for the purpose of calculation. However, note the following: For the individuals who were vaccinated and had once immunity, some of them would suffer breakthrough infection considerably later after the date when they were vaccinated. For example, when vaccination is carried out on date n, breakthrough infection could occur on date (n+m), where m would indicate dozens of days. Therefore, b(n) should be applied to individuals who were vaccinated on date (n-m) and were infected by 'breakthrough infection' on date n. The value of m is arbitrarily supposed/decided by you for simulation by referring to the durations that are reported in terms of the waning of vaccine effectiveness. The value of b(n) should be less than that of v(n), that is, b(n)<v(n).

9)icf(n): The infection reduction rate by infectious control measures preventing the spread of viruses, such as facemasks, partitions and disinfectants. When the reduction effect of infectious control measures does not need to be considered, the value of icf(n) should be set to 1. On the other hand, when the number of infected individuals is reduced to 0.9 by a control measure, the value of icf(n) is set to 0.9. Additionally, it consists of several reduction steps, for example, wearing a facemask, wearing icf1(n), partitioning, wearing icf2(n), disinfecting, wearing icf3(n), and others.

icf(n)= icf1(n)* icf2(n)* icf3(n) (104)

When icf1(n)=0.9 and icf2(n)=0.8, the reduction rate is given by:

icf(n)= icf1(n)* icf2(n)=0.9*0.8=0.72 (105)

The reduction effect increases with decreasing icf(n). By giving a value to icf(n), the effect of the control measure can be evaluated based on the differences in the number of infected individuals calculated.

10) i(n): The isolation rate for the individuals who are confirmed to be infected because of being test positive. All confirmed infected individuals are not always isolated. The number of isolated individuals, I(n), is given by:

I(n)=CP(n-1)*i(n-1) (106) (=4)

where CP(n) is the number of confirmed infected individuals. The value of i(n) indicates the ratio of the number of isolated individuals to the total number of infected individuals confirmed to be positive. When all confirmed infected individuals are isolated, the value of i(n) should be set to 1. The value of i(n) is controlled by medical environments. For calculation, as shown by Eqs. (4) , the individuals who must be isolated are isolated the next day. Namely, I(n) is practically given by the equation I(n)=CP(n-1)*i(n-1).

11) syr(n): The symptomatic rate of the individuals who are confirmed to be infected due to being symptomatic in the community and are isolated. Since not all infected individuals are symptomatic, all infected individuals are not always isolated. The number of isolated individuals, PI(n), is given by:

PI(n)= AP(n-(lp+1))* syr(n-(lp+1)) (107) (=10)

where (n-(lp+1)) indicates the previous day 'the latent period' before date n, meaning the day after the end of the latent period, because the infected individuals become symptomatic and are isolated on the day after the end of the latent period. The syr can be used as an isolation rate for infected individuals in the community.

The value of AP(n-(lp+1)) indicates the number of infected individuals who were newly infected on the (n-(lp+1)) and were isolated on date n, that is, the day after the end of the latent period. For example, when the latent period lp is 5 and n is 157, lp+1=6; then, (n-(lp+1))=(157-6)=151, indicating that the number of individuals isolated on the 157th is (the number of individuals newly infected on the 151st)*syr(151), that is, AP(151)*syr(151). The AP(n-(lp+1)) value includes the symptomatic infected individuals, the asymptomatic infected individuals in the community and the individuals who tested positive but were not isolated. When AP(n) becomes less than 'pfc(n)/rp(n)-0.0001', AP(n) is set to 0,

On the other hand, the number of asymptomatic infected individuals, AS(n), is given by:

AS(n) = AP(n-(lp+1))-PI(n) (108) (=11)

Asymptomatic individuals are not isolated. They continue to infect susceptible individuals until the recovery period ends and then become recovered individuals in the community, although the true number of recovered individuals is the value minus the number of deaths.

12) pfc(n): The potential (biological) infectious capacity of coronavirus (persons/person), which is an approximate value suggesting the number of susceptible individuals infected by an infected (infectious) individual during the latent period (and/or during the recovery period). Although infection starts two or three days before the end of the latent period, the infection rate given by the value of pfc(n)/lp(n) (persons/person/day) is used for calculation.

The infection rate is generally defined as the product of the biological infection rate pb (persons/person) and the contact number m of a person a day (persons/person/day), that is, pb*m (persons/person/day). The practical infection rate, however, is usually affected by the infection reduction effect induced by infection control measures such as facemasks. The model used here includes the effect of the infection reduction rate, icf (n), induced by the infection control measures. Namely, for calculation, the practical infection rate, p(n), which is the infection coefficient indicating the practical infection rate used in calculation and includes the effect of the infection reduction rate, is used here. p(n) is given by:

p(n)=(pfc(n)/lp(n))*(RM(n)/N(n))*icf(n)*(1-(AL(n)/N(n)))*(RP(n)/N(n)) (109) (= 19)

where AL(n)/N(n) is (alI(n)*(RI(n)+RT(n))+al(n)*RAS(n)+alV(n)*V(n))/N(n)), and the term (1-(AL(n)/N(n))) is the reduction rate of the contact rate, equivalent to the term (1-δ(R(n)/N(n))) of Eq. (1) . As previously explained, p(n) indicates an infectious capacity, including the contact rate changing with the number of susceptible individuals (RM(n)), recovered individuals (RI(n), RT(n), RAS(n)), vaccinated individuals (V(n)) , and the population excluding the individuals kept in isolation and dead but including the recovered individuals who returned to the community, that is, the total number of individuals living and working in the community (N(n)).

13) lp(n): The latent period, which is the time interval between when an individual is infected and when he/she is symptomatic. When an individual is symptomatic, he/she should be isolated for COVID-19. Thus, infected individuals do not infect susceptible individuals after the latent period. The latent period is usually defined as the time interval between when an individual is infected and when he/she is symptomatic and infectious. Namely, infected individuals can infect susceptible individuals after the latent period. However, for COVID-19, infection occurs and spreads even during the latent period. According to the model proposed here, infected individuals can infect susceptible individuals through the recovery period, including the latent period, until they are isolated.

14) rp(n): The recovery period, which is the time interval between when an individual is infected and when he/she is not capable of infecting. This period is also equivalent to the infectious period. However, for infected individuals who are isolated because of a positive test, the recovery period is equal to the isolation period, as explained by 15) rpI(n). The recovered individuals return to the community the day after the end of the recovery period.

The lp and rp are used in the following calculation:

RAS(n)=AS(n-(rp-lp))-DAS(n-(1+trunc((rp-lp)/2)))=AS(n-(rp-lp))-AS(n-(rp-lp))*fr(n-(rp-lp)) (110) (=13)

where RAS(n) is the number of 'recovered' individuals who were infected but did not become symptomatic, were asymptomatic, were not isolated, were staying in the community, had continued to infect until the recovery period ended, and then had become 'recovered' individuals on date n. AS(n-(rp-lp)) is the number of asymptomatic infected individuals who were infected on date (n-(rp-lp)), were not isolated, were staying in the community and could be recovered individuals on date n and is calculated by subtracting the PI from the AP, as shown in Eq. (108). The deaths of infected individuals occur on the middle of the isolation period; that is, 'trunc(rp-lp)/2'. Namely, some of the infected individuals who have been isolated on date n die on date (n+trunc(rp-lp)/2). For asymptomatic individuals, the same procedure is used. Namely, when the number of asymptomatic individuals infected on date n is AS(n) and the fatality rate for the asymptomatic infected individuals in the community is fr(n), the AS(n)* fr(n) individuals die on date (n+trunc(rp-lp)/2). Conversely, the death toll of asymptomatic individuals on date n, DAS(n), is given by Eq. (12). Thus, in the actual calculation, RAS(n), which is the number of individuals recovered from asymptomatic infected individuals excluding the death toll, is given by Eq. (110).

For an Excel file, the row and column number should be given not by function (and/or formula) but by a numerical value. For example, the column BD is assigned to the number of recovered individuals in the community, RAS, and BD(n) indicate the value of RAS(n) on date n. In the attached Excel file, the calculation of RAS(n) is expressed as follows:

[BD(n)]=IF(U(n)>M(n)+1,AP(n-(rp-lp))-AR(n-(1+trunc(rp- lp)/2)),0) (111)

where the column U is assigned to the time (n; the number of trials); the column M is the recovery period (rp); the column AP is the number of asymptomatic infected individuals in the community (AS(n)); and the column AR is the number of individuals who are asymptomatic and die of infection after the latent period in the community, that is, the death toll in the community (DAS(n)). When the time is 1, the row number, n, is 24. Since n-(rp-lp)=24-(14-5)=24-9=15 and (n-(1+trunc(rp-lp)/2))=24-(1+trunc(14-5)/2))=24-(1+trunc(9)/2)=24-(1+4)=24-5=19, formula (111) should be rearranged as follows:

[BD(24)]=IF((U24>M24+1, AP 15–AR19,0) (112)

As mentioned above, when the latent period and/or the recovery period are set, the row number of columns corresponding to the recovery and death periods should be assigned unique numerical values calculated in the same manner as (n-(rp-lp)) and (n-(1+trunc(rp-lp)/2)). When the values of lp, rp and rpI are set in the designated columns of the 24th row, the unique numerical values equivalent to '15' and '19', which are applied to the individual columns in the 24th row, are automatically calculated and shown in the columns necessary for rearranging in the 23rd row. After all of the columns to be changed in the 24th row are rearranged, the whole 24th row, from the column A to the column CF, should be copied and then pasted to the following rows (from the 25th row to the end necessary). When the paste is finished at the end row, the calculation is also finished, and the numerical results and a graph expressing the changes in the number of infected individuals and others are shown in the Excel table.

15) rpI(n): The recovery period, which is the time interval between when an individual is isolated because of a positive test, and when he/she returns to the community, that is, the 'isolation period'. It is set not only from a medical point of view but also from a political point of view. For the calculation of the number of recovered individuals returning to the community, the same procedure as rp(n) should be used.

16) alI(n): The activity level of the recovered individuals who returned from the isolated category. In other words, it is the activity level for the individuals who were isolated due to both being test positive and symptomatic and who returned to the community after the recovery period (after the isolation period).

17) al(n): The activity level of the recovered individuals who were asymptomatic, were not isolated and recovered in the community after the recovery period.

18) alV(n): The activity level of the vaccinated individuals who have immunity.

19) fr(n): The fatality rate for asymptomatic infected individuals in the community. Since symptomatic infected individuals should

be isolated, fr(n) is applied to asymptomatic infected individuals in the community. For the model proposed here, some infected individuals die on the middle date of the recovery period. Namely, some of the individuals infected and/or isolated on date n die on date (n+(rp-lp)/2). For asymptomatic individuals, when the number of asymptomatic individuals infected on date n is AS(n), the AS(n)* fr(n) individuals die on date (n+(rp-lp)/2). Conversely, the death toll of asymptomatic individuals on date n, DAS(n), is given by:

DAS(n)=AS(n-trunc((rp-lp)/2))*fr(n-trunc((rp-lp)/2)) (113) (=12)

20) frI(n): The fatality rate for the isolated individuals. Individuals who are confirmed to be infected due to being symptomatic in the community and/or due to being test positive are isolated and have some medical treatment. The fatality rate for isolated individuals is probably different from that for asymptomatic individuals in the community.

For the model proposed here, some isolated individuals die on the middle date of the recovery period; for example, rpI/2 is used for the individuals isolated because they were test positive, and/or (rp-lp)/2 is used for the individuals isolated because they were symptomatic. For example, some of the individuals isolated due to being test positive on date n die on date (n+rpI/2) days after date n. Namely, when the number of individuals isolated on date n is I(n), the I(n)* frI(n) individuals die on date (n+rpI/2) days after date n. Conversely, the death toll on date n, DTI(n), is given by:

DTI(n)=I(n-trunc(rpI/2))*frI(n-trunc(rpI/2)) (114) (=15)

The Excel table can also be used for the recovery period. For example, the column AL is assigned to the death toll, DTI, and AL(n) indicate the value of DTI(n) on date n. The calculation of the DTI(n) is expressed as follows:

[AL(n)]=IF(U(n)>trunc(N(n)/2),AE(n-trunc(rpI/2))*H(n-trunc(rpI/2)), 0) (115)

where the column U is assigned to the time (n, the number of trials); the column N is the recovery period for the isolated individuals because of a positive test ((rpI)); the column AE is the number of the individuals newly isolated because of a positive test (I(n)); and the column H is the fatality rate for the isolated individuals (frI(n)). For example, when the recovery period is 14 days and the time (the trial number) is 100, the row number, n, is 123. Since n-trunc(rpI/2))=123-trunc(14/2)=123-7=116, formula (115) should be rearranged as follows:

[AL123]=IF(U123>trunc(N123/2),AE116*H116,0) (116)

Consequently, the number of recovered individuals on date n, RI(n), is given by:

RI(n)=I(n-rpI)-DTI(n-(1+trunc(rpI/2)))=I(n-rpI)-I(n-rpI)*frI(n-rpI) (117) (=14)

For the individuals isolated due to being symptomatic, PI(n), for the calculation of the number of recovered individuals who return to the community, the same procedure as rp(n) is used.

In the calculation, the numbers below the decimal point are used, although, for the expression of the numbers of individuals, round off to the nearest whole number (0.5≦Number of Individuals, then Number=1; 0.5 >Number, then Number=0). However, when P (the number of infected individuals) <0.49, AP (the number of individuals newly infected a day) <(pfc/rp-0.0001), and RP (the number of infected individuals existing in the community, that is, the 'Spreaders') <0, the value of each individual must be set to 0 for the purpose of calculation. (for example, P(n)<0.49→P(n)=0). See term 50) P(n(night)) for P; term 12) AP(n) for AP; and term 40) RP(n) for RP in the following section 2: Dependent variables of the model)

Dependent variables of the model (results of simulation)

The values of the dependent variables are uniquely determined based on the independent values given by you. The meanings and calculation processes of the dependent variables are as follows:

1) N(n): The population excluding the individuals kept in isolation and dead in the real community in the morning. It is given by:

N(n)=TN(n-1)-(CI(n-1)+CPI(n-1)+CDAS(n-1)+CDT(n-1))+CRI(n-1)+CRT(n-1) (201) (=23)

while N(1) is TN(1).

2) ir(n): The incidence rate in the whole community:

ir(n)=P(n)/TN(n) (202) (=6)

3) tir(n): The positive rate for PCR test and/or antibody test:

tir(n)=bp(n)*ir(n) (203) (=7)

4) CP(n): The number of individuals confirmed to be infected due to being test positive:

CP(n)=T(n)*bp(n)*ir(n) (204) (=102,5)

5) CCP(n)=ΣCP(n)

6) truncCP(n): The number truncating the decimal point of the infected individuals confirmed because of being test positive. This figure is for your reference.

7) TCP(n)=ΣtruncCP(n)

8) I(n): The number of individuals isolated due to being test positive:

I(n)= CP(n-1)*i(n-1) (205) (=106,4)

where i(n) is the isolation rate for the individuals who are confirmed to be infected because of being test positive. The individuals confirmed to be infected on the previous day, the date of (n-1), are isolated on date n for the purpose of calculation. Thus, I(n) is given by I(n)= CP(n-1)*i(n-1).

9) CI(n)=ΣI(n)

10) RAI(n): The remaining number of isolated individuals minus the number of recovered individuals and death toll from the number of isolated individuals isolated due to being test positive:

RAI(n)=CI(n)-(RI(n)+DTI(n)) (206)

11) RPM(n): The remaining number of infected individuals in the community excluding the number of individuals isolated due to being test positive but including the individuals who tested positive but were not isolated and are staying in the community:

RPM(n)=P(n)+UP(n)-I(n-1) (207) (=25)

12) AP(n): The number of individuals newly infected for one day from the morning on date (n-1) to the morning on date n. Thus, AP(n) is the number of individuals newly infected a day on the previous day and can also be expressed as AP (n-1 (night)):

AP(n)=RPM(n)–RP(n-1) (208) (=24)

The value of AP(n) includes symptomatic infected individuals, asymptomatic infected individuals in the community and the individuals who tested positive but were not isolated and are staying in the community.

However, when AP(n) is less than (pfc(n)/lp(n)-0.0001), AP(n) must be set to 0 for the purpose of calculation.

Thus, in a real Excel file, AP(n) is given by:

[AI(n)]=IF((AH(n)-BM(n-1))<((E(n)/L(n))-0.0001),0,AH(n)-BM(n-1))

where the column AI is assigned to AP; the column AH is RPM; the column BM is RP; the column E is pfc; and the column L is lp, meaning that 'when (RPM(n)-RP(n-1))<(pfc(n)/lp(n)-0.0001), then AP(n)=0; otherwise, AP(n)=RPM(n)- RP(n-1)'

13) CAP(n)=ΣAP(n)

14) DTI (n): The death toll of the individuals isolated due to being test positive. The isolation period is rpI:

DTI(n)=I(n-trunc(rpI/2))*frI(n-trunc(rpI/2)) (209) (=114, 15)

15) CDTI(n)=ΣDTI(n)

16) PI(n): The number of isolated individuals who are isolated due to being symptomatic in the community:

PI(n)=AP(n-(lp+1))* syr(n-(lp+1)) (210) (=107,10)

17) CPI(n)=ΣPI(n)

18) AS(n): The number of asymptomatic infected individuals in the community, that is, the number of infected individuals excluding the individuals isolated due to being symptomatic in the community:

AS(n)=AP(n-(lp+1))-PI(n) (211) (=108,11)

Since asymptomatic individuals are not isolated, they continue to infect susceptible individuals in the community until the recovery period ends and then they become recovered individuals in the community.

19) CAS(n)=ΣAS(n)

20) DAS(n): The number of individuals who are asymptomatic and die of infection after the latent period in the community, that is, the death toll in the real community:

DAS(n)=AS(n-trunc((rp-lp)/2))*fr(n-trunc((rp-lp)/2)) (212) (=113, 12)

The date of death of asymptomatic infected individuals remaining in the community is the same as that of symptomatic/isolated infected individuals, as explained by Eqs. (12) and (113).

21) CDAS(n)=ΣDAS(n)

22) DT(n): The death toll of the individuals isolated due to being symptomatic in the community:

DT(n)=PI(n-trunc((rp-lp)/2))*frI(n-trunc((rp-lp)/2)) (213) (=17)

23) CDT(n)=ΣDT(n)

24) DDTI(n): The death toll of the individuals isolated due to being test positive and symptomatic:

DDTI (n)=DTI (n)+DT (n) (214)

25) CDDTI(n)=ΣDDTI(n)

26) DSUM(n): sum of the death tolls:

DSUM(n)=DTI(n)+DAS(n)+DT(n) (215)

27) CDSUM(n)=ΣDSUM(n)

28) RI(n): The number of recovered individuals who were isolated due to being test positive. They return to the community after isolation period ends. It is the number of isolated individuals excluding the death toll. The isolation period is rpI:

RI(n)=I(n-rpI)-DTI(n-(1+trunc(rpI/2)))=I(n-rpI)-I(n-rpI)*frI(n-rpI) (216) (=117, 14)

29) CRI(n)=ΣRI(n)

30) RT(n): The number of recovered individuals who were isolated due to being symptomatic in the community. They return to the community after isolation period ends. It is the number of isolated individuals excluding the death toll. The isolation period is the value after subtracting the latent period from the recovery period, that is, rp(n)-lp(n), because they are symptomatic and isolated on the day after the end of the latent period. They recovered from the disease after the recovery period including the latent period, and then return to the community:

RT(n)=PI(n-(rp-lp))-DT(n-(1+trunc((rp-lp)/2)))

=PI(n-(rp-lp)) -PI(n-(rp-lp))*frI(n-(rp-lp)) (217) (=16)

31) CRT(n)=ΣRT(n)

32) RAS(n): The number of recovered individuals who were infected but did not become symptomatic, were asymptomatic, were not isolated, were living in the community, continued to infect susceptible individuals until the recovery period ended, and subsequently recovered. It is equal to the number of asymptomatic infected individuals excluding the death toll:

RAS(n)=AS(n-(rp-lp))-DAS(n-(1+trunc((rp-lp)/2)))

=AS(n-(rp-lp))-AS(n-(rp-lp))*fr(n-(rp-lp)) (218) (=110,13)

33) CRAS(n)=ΣRAS(n)

34) irN(n): The incidence rate in the real community, (%). It is for your reference:

irN(n)=P(n)/N(n)*100 (219)

35) trCP(n): The positive rate for the test (%). It is for your reference:

trCP(n)=(CP(n)/T(n))*100 (220)

36) V0(n): The number of vaccinated individuals who are vaccinated and have immunity; calculated by Eq. (8) without adjustment:

V0(n)=TN(1)*(v(n) -b(n)) (221) (equivalent to 8)

where v(n) is the vaccination rate and b(n) is the breakthrough rate. The term (v(n)-b(n)) indicates the immunity acquisition rate for the purpose of calculation. However, note the following: b(n) should be applied to the individuals who were vaccinated on date (n-m) and were infected by 'breakthrough infection' on date n. The value of m is arbitrarily supposed/decided by you for simulation. The value of b(n) should be set to 0 on the day when breakthrough infection does not occur. The vaccinated individuals who became infected should be reset to be susceptible individuals on the date when breakthrough infection occurs.

37) V(n): The adjusted number of vaccinated individuals who are vaccinated and have immunity; the value of (TN(n)-(CI(n)+CAP(n)+V(n)) should be greater than or equal to 0, that is,

(TN(n)-(CI(n)+CAP(n)+V(n))≧0. Thus, V(n) should be less than or equal to the value of (TN(n)-(CI(n)+CAP(n)); that is, V(n)≦(TN(n)-(CI(n)+CAP(n)). Namely, when V(n) is larger than (TN(n)-(CI(n)+CAP(n)), V(n) should be set to (TN(n)-(CI(n)+CAP(n))); otherwise, V(n) should be set to V0(n). The expression is in the Excel file:

Thus, in a real Excel file, V(n) is given by:

'[BJ(n)]=IF(BI(n)>(T(n)-(AF(n)+AJ(n))),(T(n)-(AF(n)+AJ(n))),BI(n))'

where the column BJ is assigned to V; the column BI is V0; the column AF is TN; the column AF is CI; and the column AJ is CAP, meaning that 'when V0(n)>(TN(n)-(CI(n)+CAP(n)), then V(n)=TN(n)-(CI(n)+CAP(n)); otherwise, V(n)=V0(n)'

38) N (n(night)): The population excluding the individuals kept in isolation and the dead individuals in the real community at night:

$$N(n(night))=TN(n)-(CI(n)+CPI(n)+CDAS(n)+CDT(n))+CRI(n)+CRT(n) \quad (222)$$

39) RM(n): The number of susceptible individuals in the community at night:

$$RM(n)=TN(n)-(CI(n)+CAP(n)+V(n)) \quad (223)\ (=3)$$

where TN(n) is the total population of the community, that is, the number of living individuals and the toll of death in the community; CI(n) is ΣI(n), that is, the cumulative number of isolated individuals who test positive; CAP(n) is ΣAP(n), that is, the cumulative number of individuals newly infected a day, including the number of individuals who test positive but are not isolated; and V(n) is the number of vaccinated individuals who are living in the community.

40) RP(n): The 'Spreader': The number of infected individuals excluding the individuals kept in isolation and the dead:

$$RP(n)=\Sigma(AP(n)-PI(n-1)-DAS(n-1)-RAS(n))=CAP(n)-CPI(n)-CDAS(n)-CRAS(n) \quad (224)\ (=9)$$

RP (n) indicates the number of infected individuals who are practically infecting susceptible individuals in the real community; this parameter includes the number of individuals who test positive but are not isolated and should be categorized as the 'Spreader' to distinguish from P(n) and P(n(night)), each of which is the gross number of infected individuals before any isolated individuals and/or the dead individuals have been removed. For calculation, when the value of RP(n) is less than 0, the value of RP(n) is set to 0.

In an Excel file, for example, RP(n(night)) is given by:

[BM(n)]=IF(AJ(n)-AO(n)-AS(n)-BE(n)4<0,0,AJ(n)-AO(n)-AS(n)-BE(n))

where the column BM is assigned to RP; the column AJ is CAP; the column AO is CPI; the column AS is CDAS; and the column BE is CRAS; meaning that 'when (CAP(n)-CPI(n)-CDAS(n)-CRAS(n)<0, then RP(n(night))=0; otherwise, RP(n(night))=CAP(n)-CPI(n)-CDAS(n)-CRAS(n)'.

41) SRT (n)+V(n): The sum of the number of recovered individuals, SRT(n), and the number of vaccinated individuals who are vaccinated and have immunity, V(n). The value of SRT(n) is the sum of the number of recovered individuals who were isolated due to being test positive, CRI(n), the number of recovered individuals who were isolated due to being symptomatic in the community, CRT(n), and the number of recovered individuals who were asymptomatic infected individuals who continued infecting susceptible individuals in the community until the recovery period ended and then became recovered individuals, CRAS(n):

$$SRT(n))+V(n)=CRI(n)+CRT(n)+CRAS(n)+V(n) \quad (225)$$

From another point of view, the SRT+V is a group of individuals who are not infected, who will not be infected and who will not infect others in the community.

42) I2(n): The number of individuals who are kept in isolation:

$$I2(n)=(CI(n)-CDTI(n))+(CPI(n)-CDT(n))-CRI(n)-CRT(n) \quad (226)$$

$$\text{where } CI(n)= \Sigma I(n)=\Sigma(CP(n-1)^*i(n-1))=\Sigma(T(n-1)^*tr(n-1)) \quad (227)$$
(see 9)

$$CDTI(n)=\Sigma DTI(n)=\Sigma(I(n-trunc(rpI/2))^*frI(n-trunc(rpI/2))) \quad (228)$$
(see 15)

$$CPI(n)= \Sigma PI(n)=\Sigma(AP(n-(lp+1))^*syr(n-(lp+1))) \quad (229)$$
(see 17)

$$CDT(n)=\Sigma DT(n)=\Sigma(PI(n-trunc((rp-lp)/2))^*frI(n-trunc((rp-lp)/2))) \quad (230)$$
(See23)

$$CRI(n)= \Sigma RI(n)=\Sigma(I(n-rpI)-DTI(n-(1+trunc(rpI/2))))$$

$$=\Sigma(I(n-rpI)-I(n-rpI)^*frI(n-rpI)) \quad (231)$$
(see 29)

$$CRT(n)=\Sigma RT(n)=\Sigma(PI(n-(rp-lp))-DT(n-(1+trunc((rp-lp)/2))))$$

$$=\Sigma(PI(n-(rp-lp))-PI(n-(rp-lp))^*frI(n-(rp-lp))) \quad (232)$$
(see 31)

43) SN1(n): The population of the whole community for verification. It is the sum of the number of susceptible individuals in the community at night, RM(n); the number of infected individuals excluding the individuals kept in isolation and the number of dead individuals, RP(n); the number of recovered individuals, SRT(n); the number of vaccinated individuals, V(n); the number of individuals kept in isolation, I2(n); the death toll of the individuals isolated due to being test positive, CDTI(n); the death toll of the individuals isolated due to being symptomatic in the community, CDT(n); and the number of individuals who are asymptomatic and die of infection after the latent period in the community, CDAS(n):

$$SN1(n)=RM(n)+RP(n)+SRT(n)+V(n)+I2(n)+CDTI(n)+CDT(n)+CDAS(n) \quad (233)$$

44) SN2(n): The population of the whole community for verification. It is calculated using the different variables from the case of SN1(n): The sum of the population excluding the individuals kept in isolation and the dead individuals in the real community at night (N(n(night))+the number of individuals isolated due to being test positive (CI(n))+the number of individuals isolated due to being symptomatic in the community (CPI(n))+ the number of individuals who were asymptomatic and died of infection after the latent period in the community (CDAS(n))+the death toll of individuals isolated due to being symptomatic in the community (CDT(n))-the number of recovered individuals who were the individuals isolated due to being test positive (CRI(n))-the number of recovered individuals who were the individuals isolated due to being symptomatic in the community (CRT(n)):

SN2(n)=N(n(night))+CI(n)+CPI(n)+CDAS(n)+CDT(n)-CRI(n)-

CRT(n) (244)

45) AL(n): The sum of the activity levels of the recovered individuals and the vaccinated individuals:

$$AL(n)=alI(n)*(CRI(n)+CRT(n))+al(n)*CRAS(n)+alV(n)*V(n) \quad (245)\ (=20)$$

where alI (n) is the activity level of the recovered individuals returning from the isolated category, al(n) is that of the individuals recovered from the 'asymptomatic' category in the community and alV(n) is that of the vaccinated individuals. The term AL(n) is equivalent to the term δ*R(n) of Eq. (1).

46) cr(n): The contact rate between infected individuals and susceptible individuals:

$$cr(n)=(RM(n)/N(n))\,(1-AL(n)/N(n)) \quad (246)\ (\text{equivalent to Eq. (1)})$$

where RM(n) is the sum of the number of susceptible individuals in the community at night and N(n) is the population excluding the individuals kept in isolation and dead in the real community in the morning.

The term (1-(AL(n)/N(n))) is the reduction rate of the contact rate, equivalent to (1-δ*(R(n)/N(n)) of Eq. (1).

The contact rate is given by:

$$cr(n)=(S(n)/N(n))(1-\delta(R(n)/N(n))) \quad (1)$$

where S(n) is the number of susceptible individuals in the community and R(n) is the number of recovered individuals who returned to the community. In Eq. (246), considering the vaccinated individuals, S(n) is practically represented by RM(n), and (1-δ(R(n)/N(n)) is replaced by (1-AL(n)/N(n)).

47) p(n): The infection coefficient, which indicates the practical infection rate used in the calculation, indicating that the infectious capacity, including that the contact rate changing with the change in the number of susceptible individuals and recovered individuals:

$$p(n)=(pfc(n)/lp(n))*(RM(n)/N(n))*icf(n)*(1-(AL(n)/N(n)))*(RP(n)/N(n)) \quad (247)\ (=109,19)$$

48) AP(n(night)): The number of individuals newly infected on date n, that is, the number of infected individuals who increased for one day from the morning to the night on date n.

$$AP(n(night))=(pfc(n)/lp(n))*(RM(n)/N(n))*icf(n)*$$

$$(1-(alI(n)*(CRI(n)+CRT(n))+al(n)*CRAS(n)+alV(n)*V(n))/N(n))*(RP(n)/N(n))*RM(n) \quad (248)\ (=(18),2)$$

49) $CAP(n(night))=\Sigma AP(n(night))$

50) P(n(night): The number of infected individuals at night, that is, the total number of infected individuals in the morning and the individuals newly infected on date n:

$$P(n(night))=RP(n)+AP(n(night))=RP(n)+p(n)*RM(n) \quad (249)\ (=21)$$

where RP(n) is the number of infected individuals excluding the individuals kept in isolation and the dead individuals.

However, when RP(n) is less than pfc(n)/rp(n), P(n(night)) must be set to 0 for the purpose of calculation.

In an Excel file, for example, P(n(night)) is given by:

[BX(n)]=IF(BM(n)<(E(n)/M(n)),0,(BU(n)*BL(n))+BM(n)),

where the column BX is assigned to P(n(night)); the column BM is RP; the column E is pfc; the column M is rp; the column BU is p; and the column BL is RM; which means that 'when RP(n)<pfc(n)/rp(n), then 0; otherwise, p(n)*RM(n)+RP(n)'.

In addition, when P(n)<0.49, P(n) should be set to 0.

Thus, in an Excel file, P(n) is given by:

[X(n)]=(IF(BX(n-1)<0.49,0, BX(n-1)),

where the column X is assigned to P(n). This means that 'when P(n-1(night)<0.49, then P(n)=0; otherwise, P(n)=P(n-1(night))'

51) AP2(n): The number of individuals newly infected on date n for verification:

$$AP2(n)=P(n(night))+UP(n)-RP(n) \quad (250)$$

52) $CAP2(n)=\Sigma AP2(n)$

53) truncAP2(n): The number truncating the decimal point of the individuals newly infected on date n. It is for your reference.

54) $TAP2(n)=\Sigma truncAP2(n)$

55) ΔP1(n): The increment of newly infected individuals, AP, per day,

$$\Delta P1(n)=AP(n(night))-PI(n) \quad (251)$$

where AP(n(night)) is the number of individuals newly infected on the day,

$$AP(n(night))=p(n)*RM(n) \quad (252)\ (=18,(2))$$

And PI(n) is the number of individuals isolated due to being symptomatic in the community,

$$PI(n)=AP(n-(lp+1))*syr(n-(lp+1)) \quad (253)\ (=210, 107, 10)$$

56)ΔP2(n): The increment of infected individuals, P, per day for verification:

$$\Delta P2(n)=P(n(night))-P(n-1(night)) \quad (254)$$

where P(n(night)) is the number of infected individuals at night,

$$P(n(night))=RP(n)+AP(n(night)) \quad (255)\ (=249, 21)$$

57)ΔP3(n): The increment of infected individuals, P, per day on the previous day, for verification,

$$\Delta P3(n)=P(n)-P(n-1) \quad (256)$$

where P(n) is the number of infected individuals in the morning on date n (=P(n-1(night))

SUPPLEMENTARY MATERIAL 2

Appendix 2: Part of Excel for the simulation specific to COVID-19.

A	B	C	D	E	F	G	H	I	J	K	L	M
												$rp(n)$: the
					$syr(n)$: the symptomatic rate of the individuals who are confirmed to be infecte							
				$pfc(n)$: the potential (biological) infectious capacity of coronavirus which is an approxima								
			$b(n)$: the breakthrough rate which indicates the ratio of the number of individuals who are vaccinat									
							$frI(n)$: the fatality rate for the isolated individuals.					
	$i(n)$: the isolation rate for the individuals who are confirmed to be infected due to being test positive.											
										$alV(n)$: the activity level of t		
								$alI(n)$: the activity level of the recovered individu				
									$al(n)$: the activity level of the individua			
						$fr(n)$: the fatality rate for the asymptomatic infeced individuals in the						
		$v(n)$: the vaccination rate.									$lp(n)$: the latent pe	
Time: Trial, *n*	$i(n)$	$v(n)$	$b(n)$	$pfc(n)$	$syr(n)$	$fr(n)$	$frI(n)$	$alI(n)$	$al(n)$	$alV(n)$	$lp(n)$	$rp(n)$
0												
1	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0
2	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0
3	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0
4	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0
5	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0
6	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0
7	1.000	0.000	0.000	1.000	1.000	0.0000	0.0000	1.00	1.00	1.00	5.00	14.0

AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
$CP(n)$: the number of infected individuals confirmed due to being test positive: $CP(n)=T(n)*bp(n)*ir(n)$.												
ck to the community, that is, the 'isolation period'.												
ation and dead in the community: $N(n)=TN(n)-(CI(n)+CPI(n)+CDAS(n)+CDT(n))+CRI(n)+CRT(n)$.												
ate in the community: $ir(n)=P(n)/TN(n)$).												
d individuals truncating the decimal point for reference.											$DTI(n)$: the death t	
infectant.		truncCP(n): the number truncating the decimal point of infected individuals confirmed due to being test positive.										
	$CCP(n)=\Sigma CP(n)$.		TCP(n)= ΣtruncCP(n).					$AP(n)$: the number of infected individuals having inc				
h as travelling and migration.					$CI(n)=\Sigma I(n)$.		$RPM(n)$: the remainder of infected individuals in the community					
ors such as travelling and migration.						$RAI(n)$: the remainder of isolated individuals subtracting the number of reco						
ow 23. $TN(n)$ is changed by coming in/going out of the susceptible ($NAP(n)$) and/or the infected ($UP(n)$).												$CDTI(n)$=
ial number of infected individuals in the community, arbitrarily set in the cell W of row 23.									$CAP(n)=\Sigma AP(n)$.			
positive rate for the test: $bp(n)*ir(n)$.				$I(n)$: the number of individuals isolated due to being positive for PCR test: $I(n)=i(n-1)*CP(n-1)=I$								
$CP(n)$	$CCP(n)$	truncCP(n) for reference	TCP(n) for reference	$I(n)$	$CI(n)$	$RAI(n)$	$RPM(n)$	$AP(n)$	$CAP(n)$	**Time: Trial, *n***	$DTI(n)$	$CDTI(n)$
				AAx,Bx							AEx,Hx	
				23				指定すべきコラムNo. x		0	17	
0	0	0	0	0	0	0	1	1	1	1	0	0
0	0	0	0	0	0	0	1	0	1	2	0	0
0	0	0	0	0	0	0	1	0	1	3	0	0
0	0	0	0	0	0	0	2	0	2	4	0	0
0	0	0	0	0	0	0	2	0	2	5	0	0
0	0	0	0	0	0	0	2	0	2	6	0	0
0	0	0	0	0	0	0	3	0	3	7	0	0

AN	AO	AP	AQ	AS	AS	AT	AU	AV	AW	AX	AY	AZ
						DT(n): the death toll of the individuals isolated due to being symptomatic in the comm						
				DAS(n): the number of individuals who are asymptomatic and die of infection after the latent period in the co								
		AS(n): the number of asymptomatic infected individuals in the community: AS(n)=AP(n-(lp+1))-PI(n).										
oll of the individuals isolated due to being test positive: DTI(n)= I(n-trunc(rpI/2)*frI(n-trunc(rpI/2)).										DSUM(n):sum of the death toll:DSU		
	CPI(n)= ΣPI(n).											RI(n): the r
eased for one day from the previous day: AP(n)= RPM(n) – RP(n-1).								DDTI(n):the death toll of the individuals isolated due to being				
excluding the individuals isolated due to being test-positive: RPM(n)=P(n)+UP(n)-I(n-1).									CDDTI(n) =ΣDDTI(n).			
vered individuals and death toll from the number of individuals isolated due to being test positive: RAI(n)=CI(n)-(RI(n)+DTI(n)).												
=ΣDTI(n).			CAS(n)=ΣAS(n).		CDAS(n)= ΣDAS(n).							
PI(n): the number of individuals isolated due to being symptomatic in the community: PI(n)= (AP(n-(lp+1))* syr(n-(lp+1)).											CDSUM(n) =ΣDSUM(n	
T(n-1)*tr(n-1).							CDT(n)= Σ DT(n)					
PI(n)	CPI(n)	AS(n)	CAS(n)	DAS(n)	CDAS(n)	DT(n)	CDT(n)	DDTI(n)	CDDTI(n)	DSUM(n)	CDSUM(n)	RI(n)
AIx,Fx		AIx		APx,Gx		ANx,Hx						AEx,
18		18		20		20						10
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0

BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
unity: DT(n)=PI(n-trunc((rp-lp)/2))*frI(n-trunc((rp-lp)/2)).												
mmunity, that is, the death toll in the community: DAS(n)=AS(n-trunc((rp-lp)/2))*fr(n-trunc((rp-lp)/2)).												RP(n),'Sprea
											RM(n): the number of su	
M(n)=DTI(n)+DAS(n)+DT(n).			RAS(n): the number of recovered individuals who have been asymptomatic infected individuals, having continued infecting									
number of recovered individuals who were isolated due to being test positive: RI(n)=I(n-rpI)-DTI(n-(1+trunc(rpI/2)))=I(n-rpI)-I(n-rpI)*frI(n-rpI).												
test positive and ymptomatic: DDTI(n)= DTI(n)+DT(n).										N(n(night)): the population excluding		
	RT(n): the number of recovered individuals who have been isolated due to being symptomatic in the community: RT(n)=PI(n-(rp-lp))-DT(n-trunc											
								V0(n): the number of vaccinated individuals who are vaccinate				
									V(n): the number of vaccinated individuals who a			
).				CRAS(n)=ΣRAS(n).			trCP(n) : the positive rate for the test: trCP(n)=(CP(n)/T(n))*100.					
CRI(n)=Σ RI(n)		CRT(n) =Σ RT(n)				irN(n): the incidence rate in the real community: irN(n)=(P(n)/N(n)))*100.						
CRI(n)	RT(n)	CRT(n)	RAS(n)	CRAS(n)	Time: Trial, n	irN(n), %	trCP(n), %	V0(n)	V(n)	N(n(night))	RM(n) ; (night)	RP(n); (night)
ALx	ANx,	ATx	APx,	ARx								
16	15	19	15	19	0							0
0	0	0	0	0	1	0.000	0.000	0	0	1,000,000	999,999	1
0	0	0	0	0	2	0.000	0.000	0	0	1,000,000	999,999	1
0	0	0	0	0	3	0.000	0.000	0	0	1,000,000	999,999	1
0	0	0	0	0	4	0.000	0.000	0	0	1,000,000	999,998	2
0	0	0	0	0	5	0.000	0.000	0	0	1,000,000	999,998	2
0	0	0	0	0	6	0.000	0.000	0	0	1,000,000	999,998	2
0	0	0	0	0	7	0.000	0.000	0	0	999,999	999,997	2

BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ

$SN2(n)$: the population of the whole community: $SN2(n)=N(n(\text{night}))+CI(n)+CDAS(n)-CRI(n)-CRT(n)$.

$SN1(n)$: the population of the whole community: $SN1(n)=RM(n)+RP(n)+SRT(n))+V(n)+II(n)+CDTI(n)+CDT(n)+CDAS(n)$.

ıder': the number of infected individuals excluding the individuals kept in isolation and the dead: $RP(n)=CAP(n)-CPI(n)-CDAS(n)-CRAS(n)$.

sceptible individuals in the community at night: $RM(n)=TN(n)-(CI(n)+CAP(n)+V(n))$.

$CAP(n(\text{night}))=\Sigma AP(n(\text{night}))$.

ʒ in the community until the recovery period was ended and then have become the recovered individuals: $RAS(n)=AS(n-(rp-lp))-DAS(n-(1+\text{trunc}(rp-lp)/2))=AS(n-(rp-lp))-AS(n-(rp-lp)$

$cr(n)=(RM(n)/N(n))\,(1-AL(n)/N(n)$

$AP(n(\text{night}))$: the number of individuals newly infected on the day: $AP(n(\text{ni}$

the individuals kept in isolation and dead in the real community at night: $N(n)=TN(n)-(CI(n)+CPI(n)+CDAS(n)+CDT(n))+CRI(n)+CRT(n)$.

$CAP2(n)=\Sigma A$

:$((rp-lp)/2))$.

$p(n)$: the infection coefficient: $p(n)=(pfc(n)/lp(n))*(RM(n)/N(n))*icf(n)*(1-AL(n)/N(n))$ *

d and have immunity: $V0(n)=TN(1)*(v(n)-b(n))$.

$AL(n)$: the sum of the activity levels of the recovered individuals and vaccinated individuals: $AL(n)=alI(n)*(CRI(n)+CRT($

re vaccinated and have immunity: $V(n)=TN(1)*(v(n)-b(n))$. However, $V(n)\leqq TN(n)-(CI(n)+CAP(n))$

$P(n(\text{night}))$: the number of infected individua

$I2(n)$=the number of individuals kept in isolation: $I2(n)=CI(n)-DTI(n)+CPI(n)-CDT(n)-CRI(n)-CRT(n)$.

$AP2(n)$: the number of indiv

$SRT(n))+V(n)$: the sum of the number of recovered individuals, $SRT(n)$, and the number of vaccinated individuals who are vaccinated and have immunity, $V(n)$.

$SRT(n))+V(n)$ (night)	$I2(n)$ (night)	$SN1(n)$ for verification	$SN2(n)$ for verification	Time: Trial, n	$AL(n)$ (night)	$cr(n)$ contact rate	$p(n)$ (night)	$AP(n)$ (night)	$CAP(n)$ (night)	$P(n(\text{night}))$	$AP2(n)$ for verification	$CAP2(n)$ for verification
				0						1.0		
0	0	1,000,000	1,000,000	1	0.00	1.00	0.0000002	0.2000	1.200	1.2000	0	1
0	0	1,000,000	1,000,000	2	0.00	1.00	0.0000002	0.2400	1.440	1.4400	0	1
0	0	1,000,000	1,000,000	3	0.00	1.00	0.0000003	0.2880	1.728	1.7280	0	2
0	0	1,000,000	1,000,000	4	0.00	1.00	0.0000003	0.3456	2.074	2.0736	0	2
0	0	1,000,000	1,000,000	5	0.00	1.00	0.0000004	0.4147	2.488	2.4883	0	2
0	0	1,000,000	1,000,000	6	0.00	1.00	0.0000005	0.4977	2.986	2.9860	0	3
0	1	1,000,000	1,000,000	7	0.00	1.00	0.0000004	0.3972	3.383	2.3832	0	3

CA	CB	CC	CD	CE	CF

trunc($AP2(n)$) : the number truncating the decimal point of individuals newly infected on the day.

$)*fr(n-(rp-lp))$.

$\text{ght}))=p(n)*RM(n)$.

$P2(n)$.

$TAP2(n)=\Sigma\text{trunc}(AP2(n))$.

$(RP(n)/N(n))$

$n))+al(n)*CRAS(n)+alV(n)*V(n)$

ls at night: $P(n(\text{night}))=RP(n)+AP(n)$

$\Delta P2=P(n(\text{night}))-P(n-1(\text{night}))$

iduals newly infected on the day: $AP(n)2=P(n(\text{night}))+UP(n)-RP(n)$.

$\Delta P3=(P(n)-P(n-1))$

$\Delta P1=AP(n(\text{night}))-PI(n)$

trunc($AP2(n)$) for reference	$TAP2(n)$ for reference	Time: Trial, n	$\Delta P1(AP(n(\text{night}))-PI(n))$	$\Delta P2$ for verification	$\Delta P3$ for verification
		0			
0	1	1	1.20	1.20	1.00
0	1	2	0.24	0.24	0.20
0	1	3	0.29	0.29	0.24
0	1	4	0.35	0.35	0.29
0	1	5	0.41	0.41	0.35
0	1	6	0.50	0.50	0.41
0	1	7	-0.60	-0.60	0.50

CG	CH	CI	CJ	CK	CL	CM	CN
$TN(1)$= 1,000,000		$P(1)$= 1.000		pfc= 1.000		lp= 5.00	
rp= 14.0		alI= 1.000		al= 1.000		alV= 1.000	
		activity level of Iso.		act. level in city		act. level of Vac.	
syr= 1.000		fr= 0.000		frI= 0.000			
symptomatic rate		fatality rate in city		fatality rate of Iso.