

# Baseline 3: Prediction of age-structured model for SARS-CoV-2 in Seoul and Gyeonggi

Yunjeong Lee <sup>1</sup>    Jeongjoo Seok <sup>2</sup>

<sup>1</sup>School of Mathematics and Computing (Computational Science and Engineering)

<sup>2</sup>School of Mathematics and Computing (Mathematics)

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# Data

1. Daily confirmed cases in Seoul and Gyeonggi
2. Vaccine
  - ▶ Daily number of vaccination for 1st dose (by age)
  - ▶ Daily number of vaccination for 2nd dose (by age)
  - ▶ Vaccine efficacy
3. Proportion of  $\delta$  variant

# Data processing

## 1. Daily number of vaccination for 1st dose (all ages)

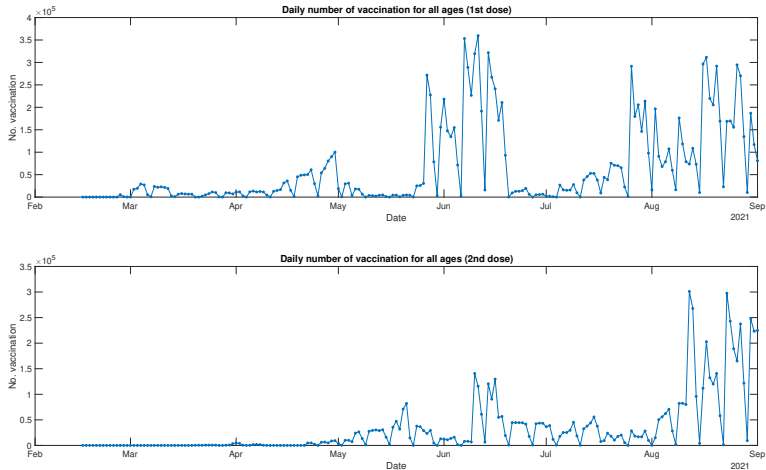


Figure 1: The daily number vaccination for 1st dose and 2nd dose from 2021/02/15 to 2021/09/01

## Data processing

### 1. Daily number of vaccination for 1st dose (by age)

- ▶ The daily number of vaccination by age is generated by the ratio between ages of vaccinated people.
- ▶ The ratio is based on KDCA reports.

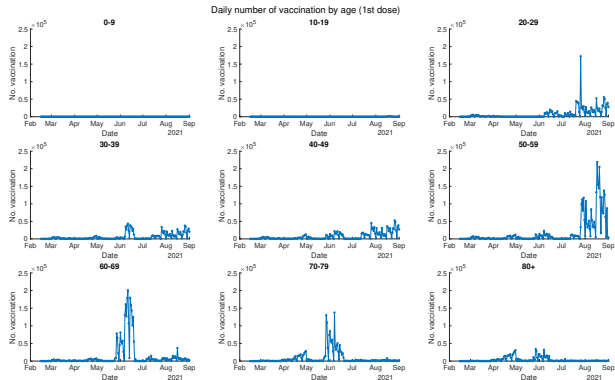


Figure 2: The daily number vaccination for 1st dose by age from 2021/02/15 to 2021/09/01

## Data processing

### 2. Daily number of vaccination for 2nd dose (by age)

- ▶ The daily number of vaccination by age is generated by the ratio between ages of vaccinated people.
- ▶ The ratio is based on KDCA reports.

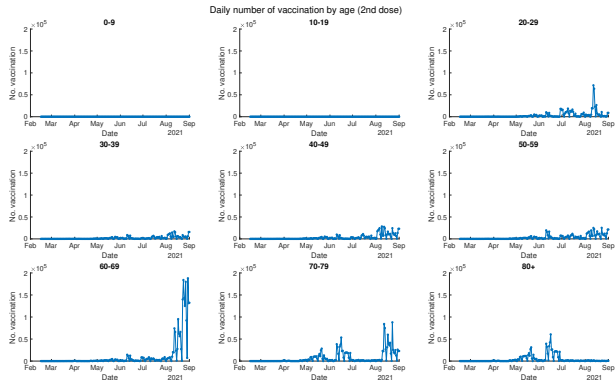


Figure 3: The daily number vaccination for 2nd dose by age from 2021/02/15 to 2021/09/01

## 3. Vaccine efficacy

- ▶ The vaccine efficacies for  $\alpha$  variant and  $\delta$  variant are different.<sup>1</sup>
- ▶ We use weighted sum of vaccine efficacies where weights are based on proportion of  $\delta$  variant

|                  | Dose     | Astrazeneca | Pfizer |
|------------------|----------|-------------|--------|
| $\alpha$ variant | 1st dose | 48.7%       | 47.5%  |
|                  | 2nd dose | 74.5%       | 93.7%  |
| $\delta$ variant | 1st dose | 30.0%       | 35.6%  |
|                  | 2nd dose | 67%         | 88%    |

Table 1: The vaccine efficacies according to the vaccine type, variant and dose.

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<sup>1</sup>Jamie Lopez Bernal et al. (2021). “Effectiveness of Covid-19 vaccines against the B. 1.617. 2 (Delta) variant”.  
In: *New England Journal of Medicine*

## 3. Vaccine efficacy

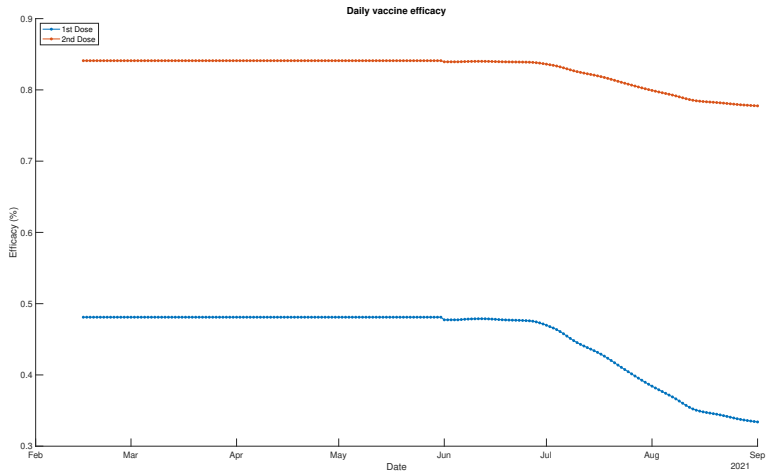


Figure 4: The estimated daily vaccine efficacy for 1st dose and 2nd dose.

## 4. Proportion of $\delta$ variant

| Date   | $\delta$ proportion (%) |
|--------|-------------------------|
| 6월 1주차 | 2.4                     |
| 6월 2주차 | 1.4                     |
| 6월 3주차 | 2.5                     |
| 6월 4주차 | 3.3                     |
| 6월 5주차 | 9.9                     |
| 7월 1주차 | 23.3                    |
| 7월 2주차 | 33.9                    |
| 7월 3주차 | 48.0                    |
| 7월 4주차 | 61.5                    |
| 8월 1주차 | 73.1                    |
| 8월 2주차 | 85.3                    |
| 8월 3주차 | 89.6                    |
| 8월 4주차 | 94.3                    |
| 9월 1주차 | 97.0                    |

Table 2: 질병관리청에서 보도된  
검출된 델타 변이 비율

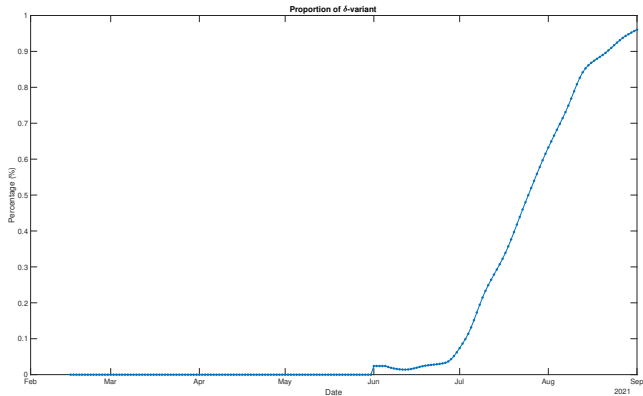


Figure 5: Estimates of proportion of  $\delta$  variant.



## Vaccine efficacy preventing deaths

| VE preventing deaths |                    |
|----------------------|--------------------|
| 1st dose             | 85% <sup>3</sup>   |
| 2nd dose             | 96.1% <sup>4</sup> |

Table 3: Vaccine efficacy preventing deaths for each dose.

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<sup>3</sup>Jamie Lopez Bernal et al. (2021). “Effectiveness of Covid-19 vaccines against the B. 1.617. 2 (Delta) variant”.  
In: *New England Journal of Medicine*

<sup>4</sup>kdca2021

# Proportion of used beds

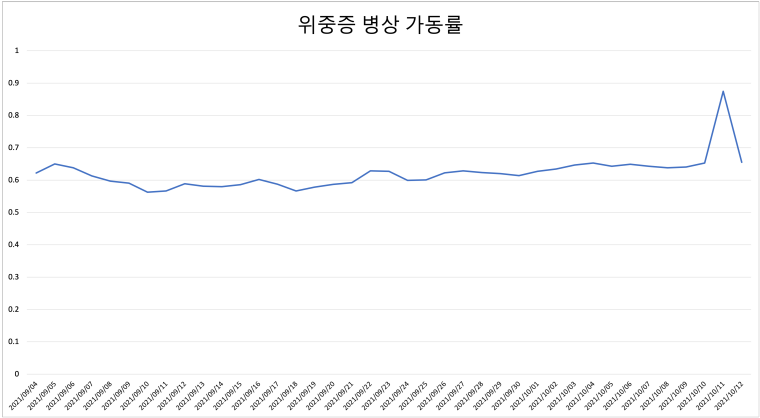


Figure 6: 준중증 및 중증 병상 가동률

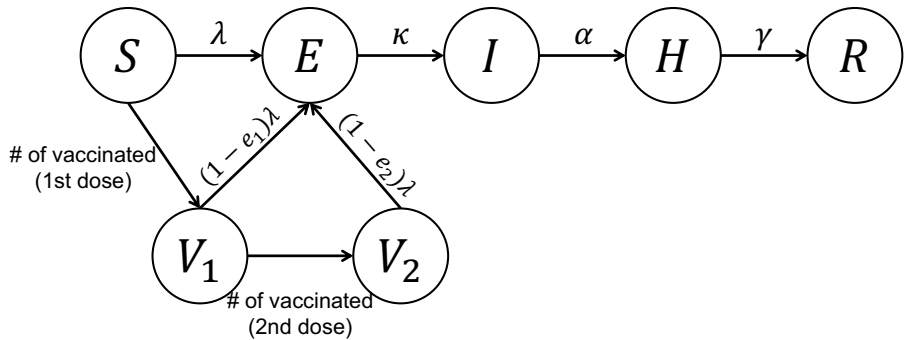


Figure 7: Diagram of age-structured model for SARS-CoV-2.

| Notation  | Interpretation                |
|-----------|-------------------------------|
| $S$       | Susceptibles                  |
| $E$       | Exposed                       |
| $I$       | Infectious                    |
| $H$       | Hospitalized                  |
| $R$       | Removed (or recovered)        |
| $V_1$     | Vaccinated (1st dose)         |
| $V_2$     | Vaccinated (2nd dose)         |
| $\lambda$ | Force of infection            |
| $\kappa$  | Latent period                 |
| $\alpha$  | Infectious period             |
| $\gamma$  | Hospitalization period        |
| $e_1$     | Vaccine efficacy for 1st dose |
| $e_2$     | Vaccine efficacy for 2nd dose |

Table 4: Definition of states and parameters.

### Social distance level

- ▶ 0.5단계 감소: transmission rate 전단계 대비 40% 증가
- ▶ 0.5단계 증가: transmission rate 전단계 대비 32% 감소

| Date                               | Social distancing level | Change of transmission rate    |
|------------------------------------|-------------------------|--------------------------------|
| 2021/02/15-2021/06/30              | 2                       |                                |
| 2021/07/01-2021/07/11              | 1.5                     | $\beta \times 1.4$             |
| 2021/07/12-2021/12/31 <sup>2</sup> | 4                       | $\beta \times 1.4 \times 0.68$ |

**Table 5:** The change of transmission rate according to the social distancing level from 2021/02/15 to 2021/12/31.

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<sup>2</sup>It will be changed according to the experiments.

## Definition of $\lambda$

### Motivation

- ▶ In general,  $\lambda(t)$  is defined by  $W \times I(t)$  where  $W$  is the WAIFW matrix, and  $I(t)$  is the number of infectious at time  $t$ .
- ▶ To reflect the non-pharmaceutical intervention, we consider time-dependent  $W(t)$ .

### Definition of WAIFW matrix

Let  $p(t)$  and  $SD(t)$  be the proportion of  $\delta$  variant and proportionate of the corresponding social distancing level at time  $t$ . Let  $C(t)$  be the contact rate at time  $t$ .

- ▶  $W(t) = ((1 - p(t) + p(t)\delta) \times \beta \times SD(t) \times C(t)$

## 사회적 거리두기 (11월 이후)

- ▶ 현 상태 유지 (현 4단계 → 4단계)
- ▶ 1단계 완화 (현 4단계 → 3단계)
- ▶ 2단계 완화 (현 4단계 → 2단계)

## 등교 수준

- ▶ 현 상태 유지
- ▶ 현 1단계 수준 완화
- ▶ 현 2단계 수준 완화
- ▶ 전면 등교 및 마스크 미착용

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 same단계

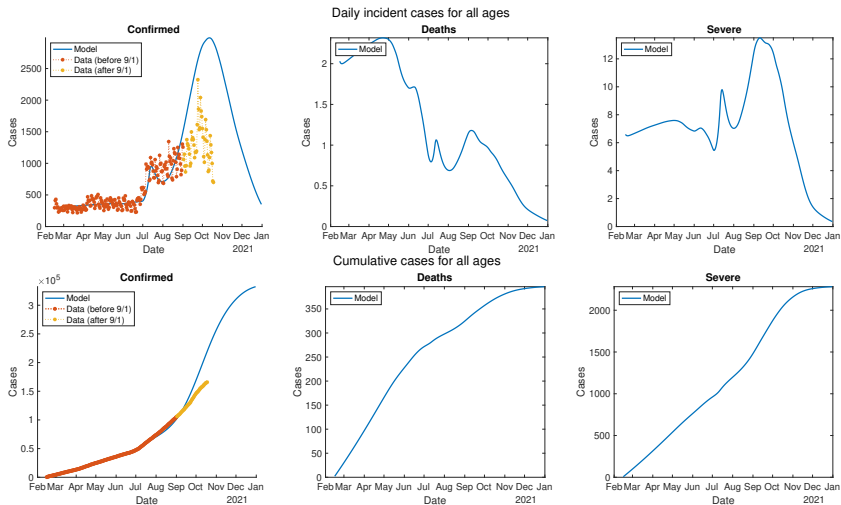


Figure 8: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).



현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 same단계

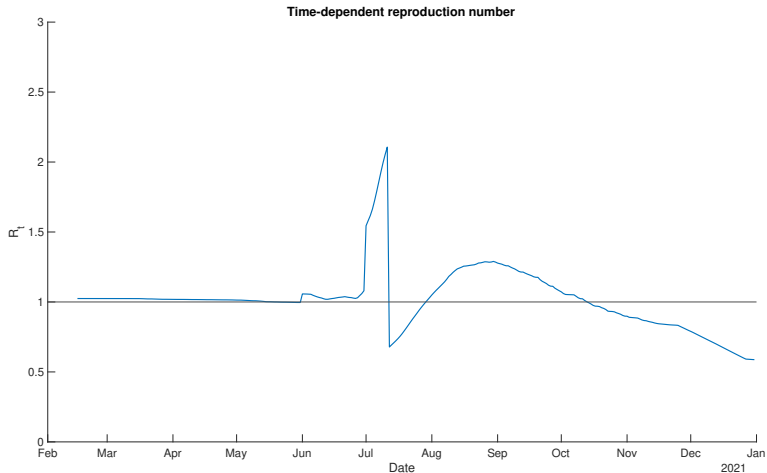


Figure 9: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 same단계

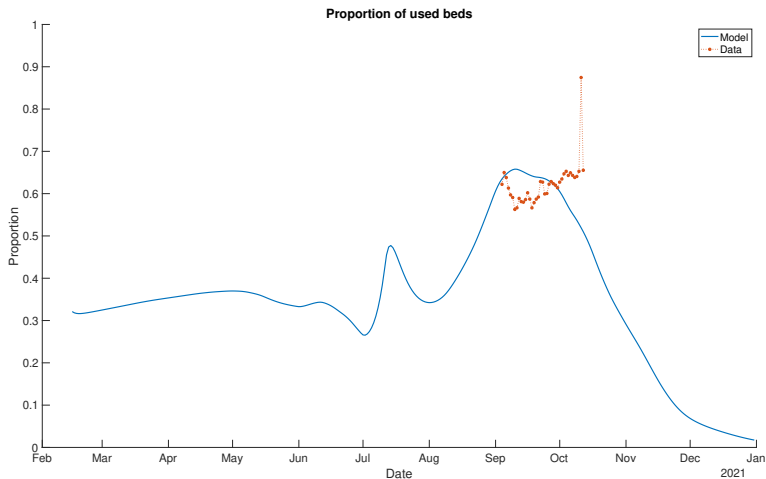


Figure 10: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 1단계

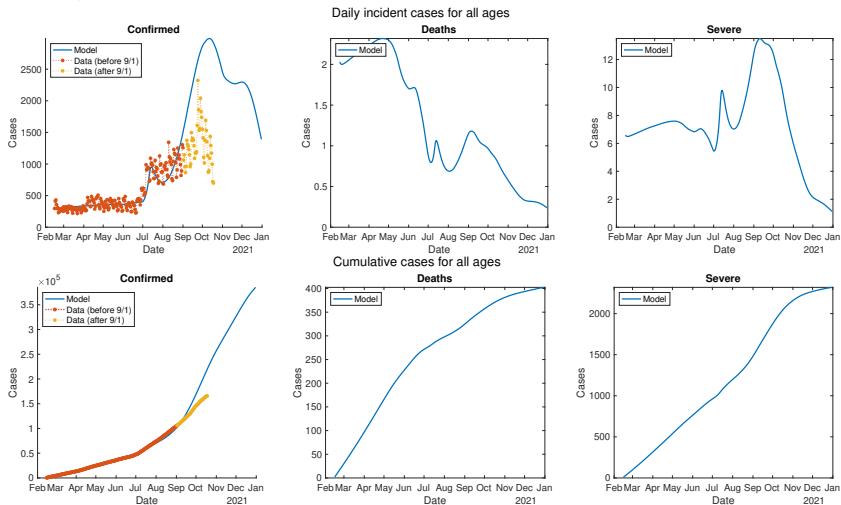


Figure 11: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 1단계

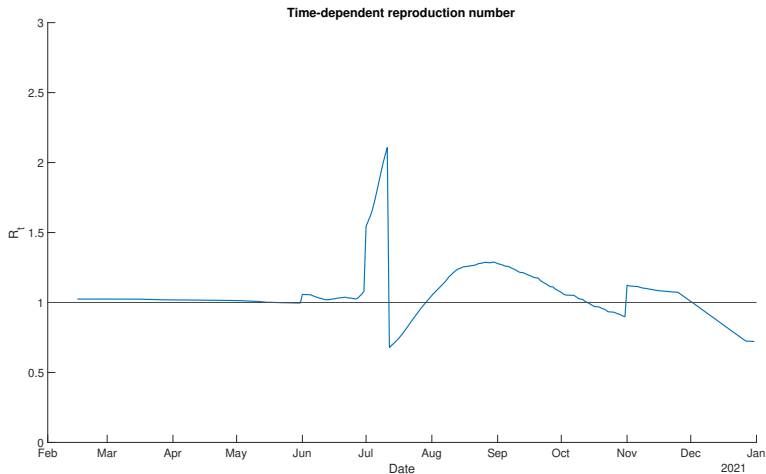


Figure 12: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 1단계

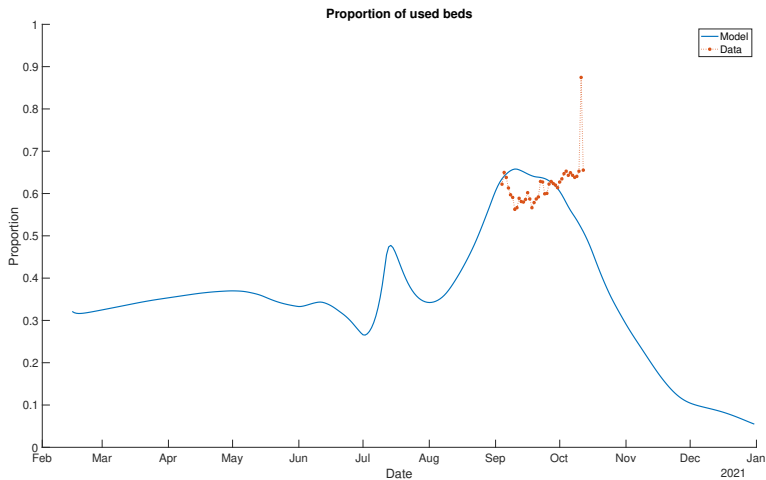


Figure 13: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 2단계

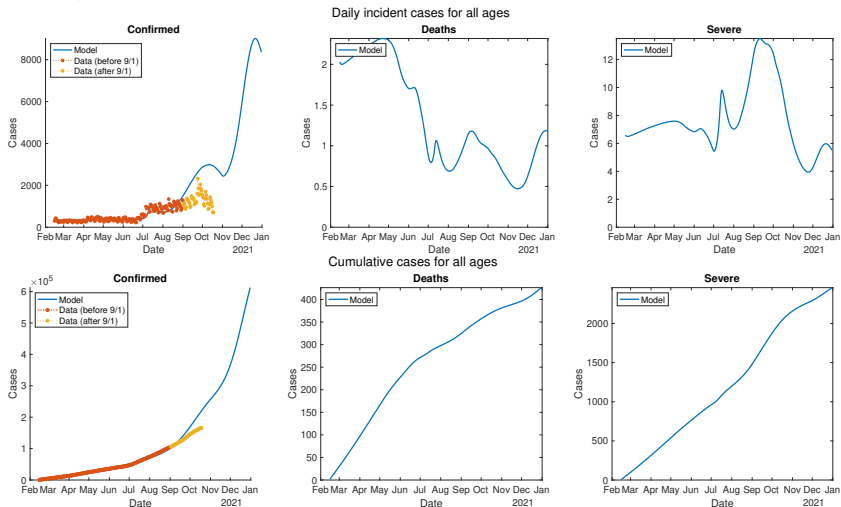


Figure 14: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 2단계

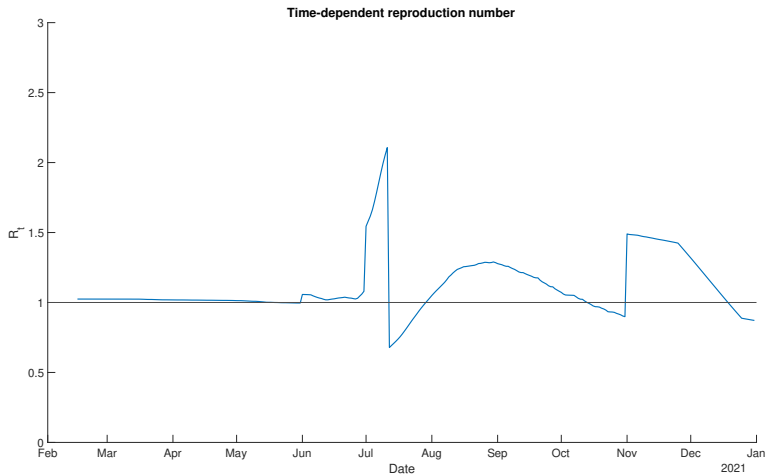


Figure 15: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 2단계

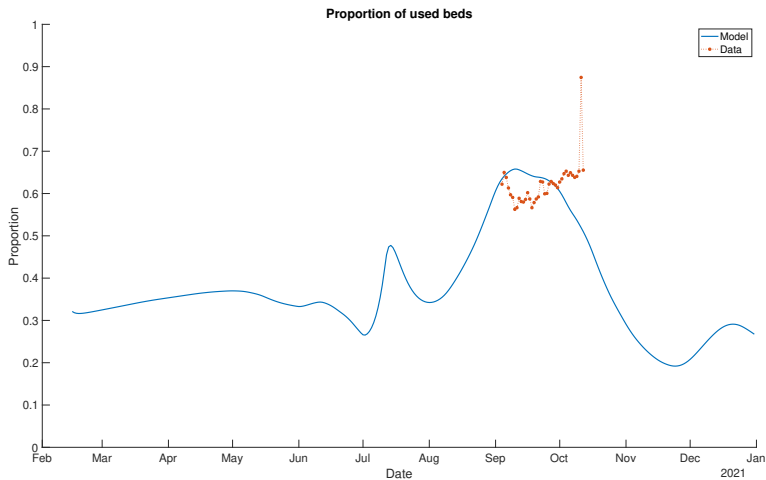


Figure 16: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.



현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 max 단계

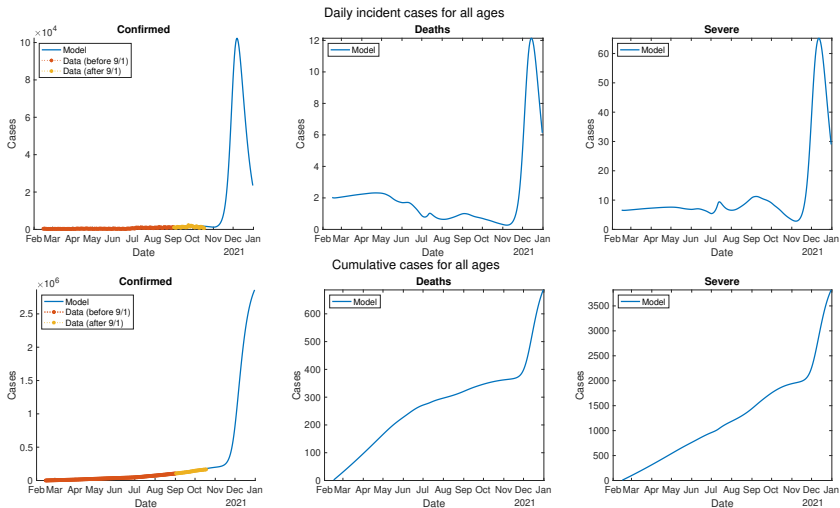


Figure 17: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 max 단계

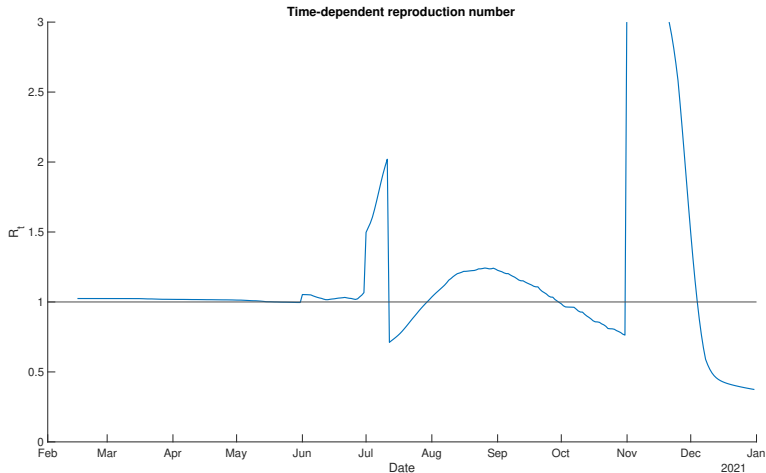


Figure 18: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 same단계, 등교 완화 수준 max 단계

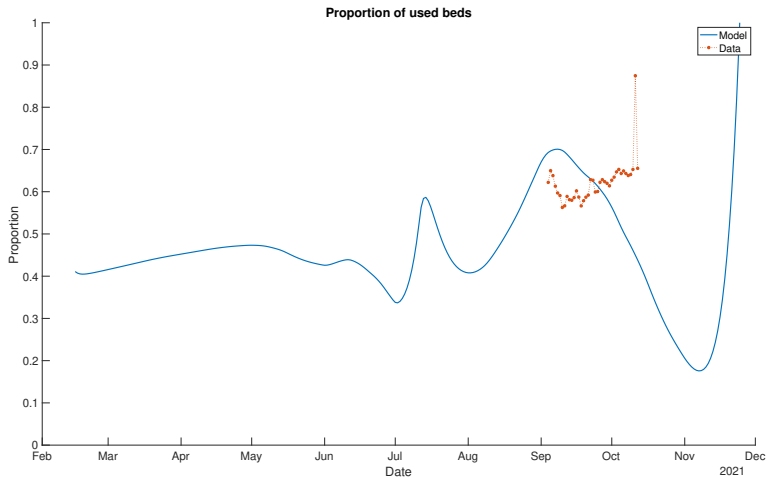


Figure 19: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 same단계

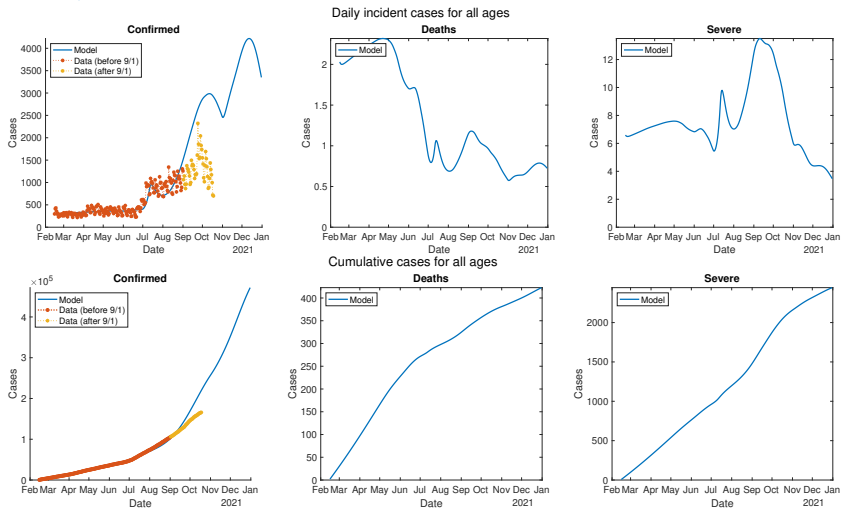


Figure 20: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 same단계

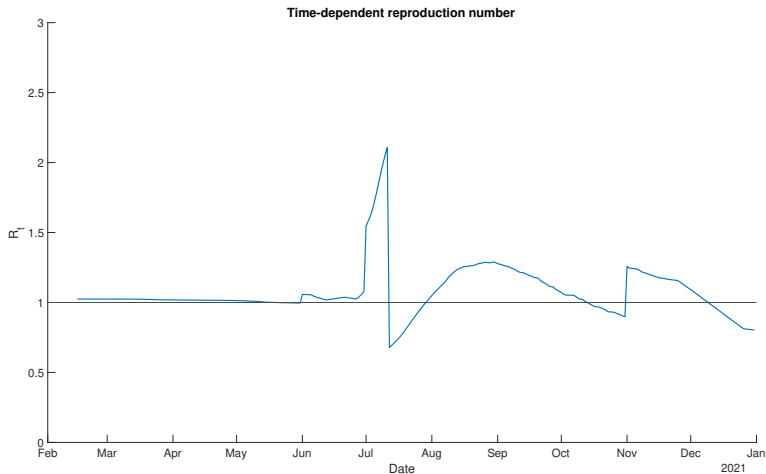


Figure 21: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 same단계

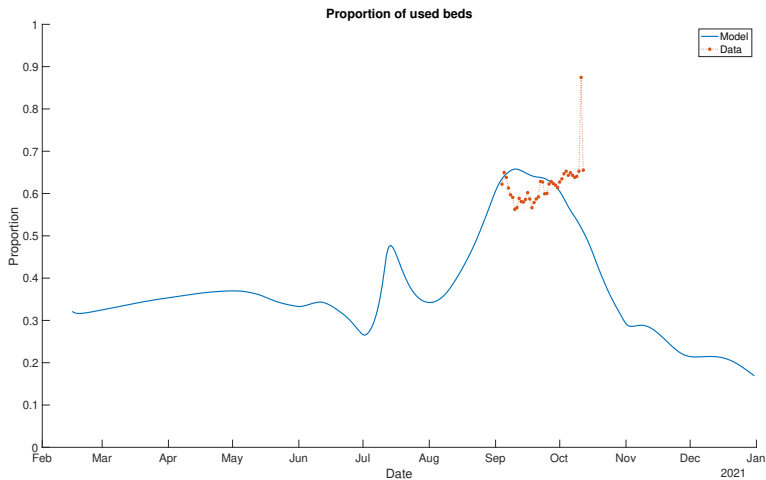


Figure 22: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 1단계

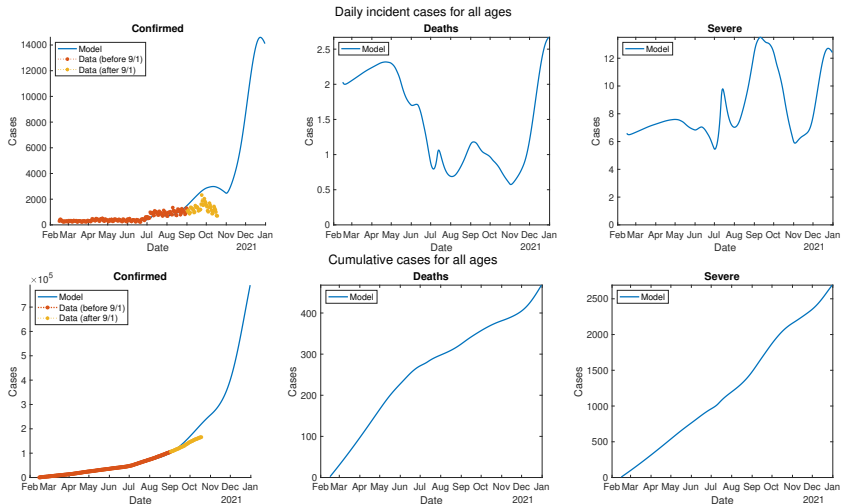


Figure 23: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 1단계

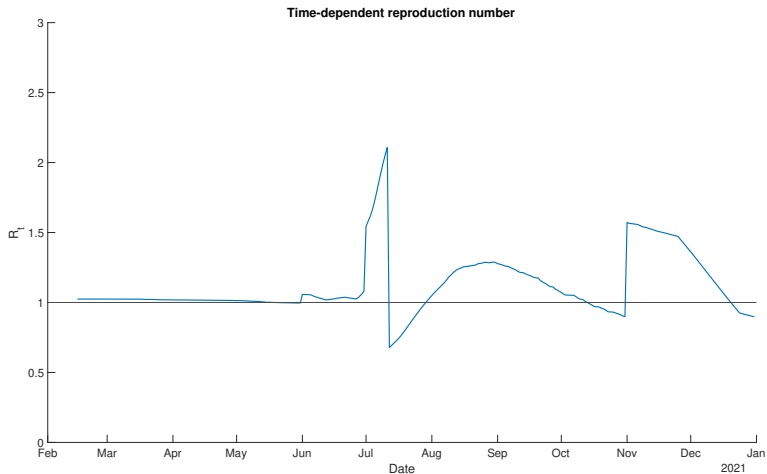


Figure 24: The estimated reproduction number from 2021/02/15 to 2021/12/31.



## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 1단계

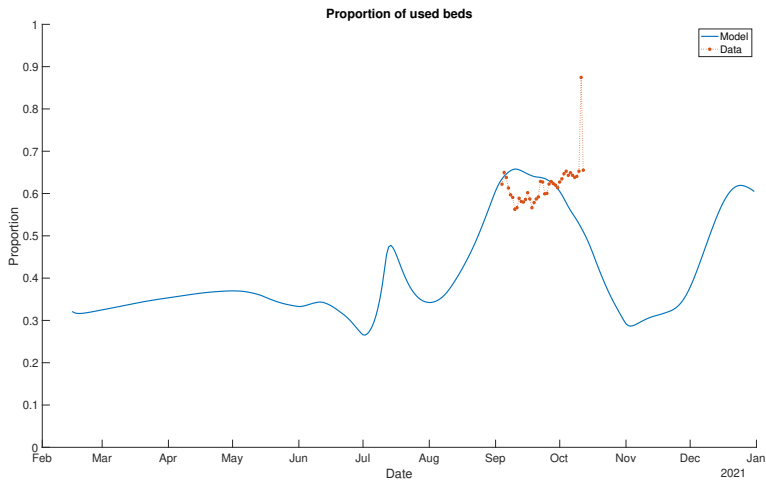
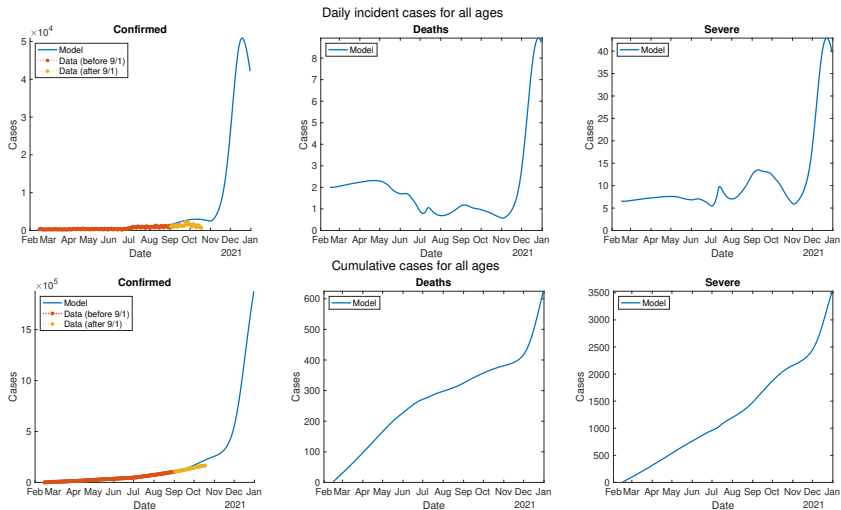


Figure 25: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 2단계



**Figure 26:** The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 2단계

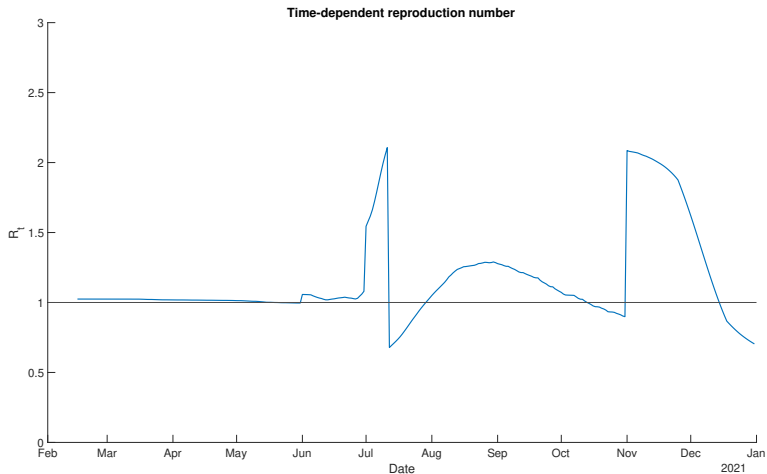


Figure 27: The estimated reproduction number from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 2단계

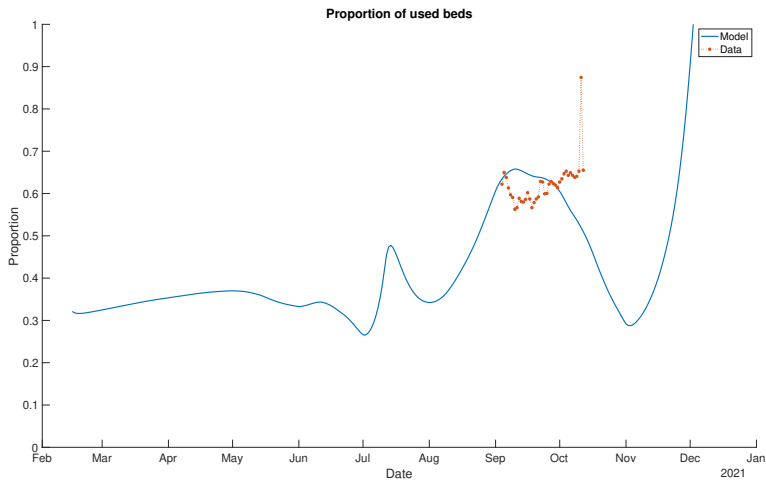


Figure 28: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 max단계

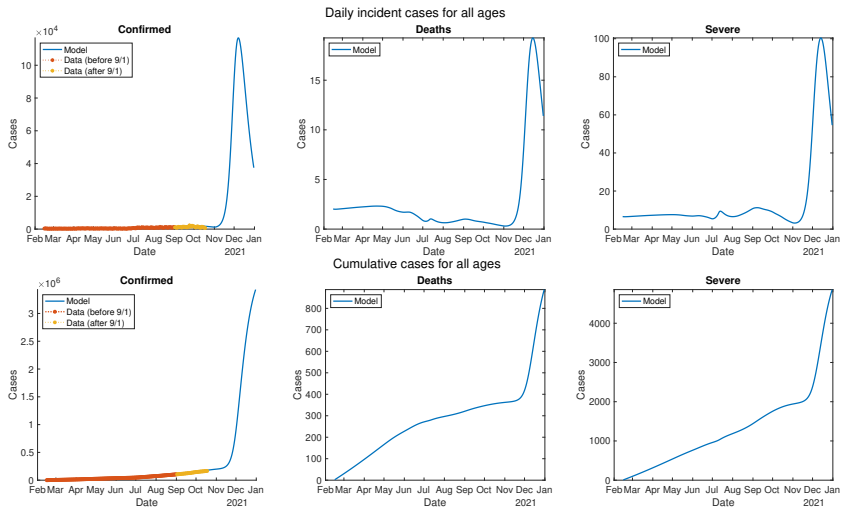


Figure 29: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 max단계

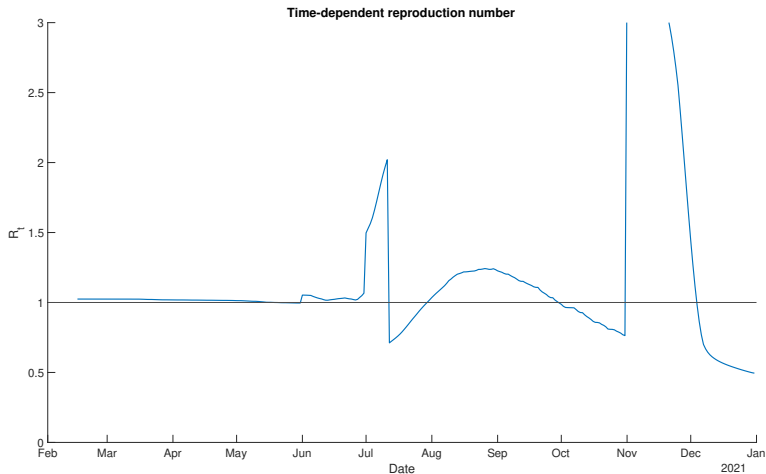


Figure 30: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 1단계, 등교 완화 수준 max단계

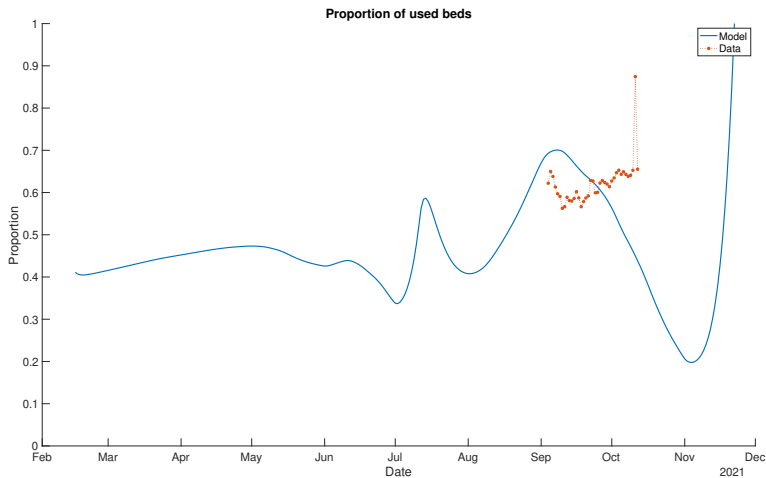


Figure 31: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 same단계

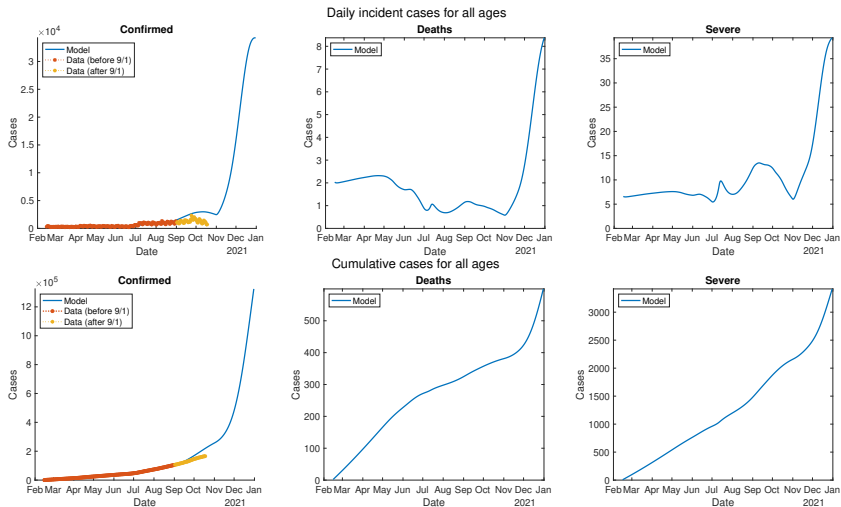


Figure 32: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).



현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 same단계

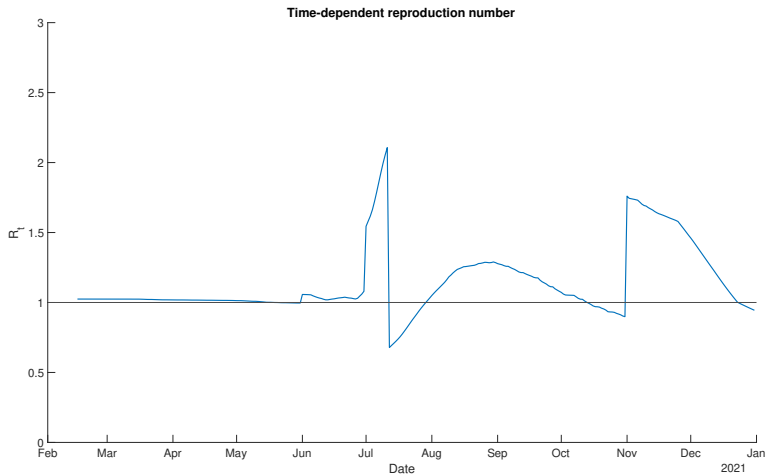


Figure 33: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 same단계

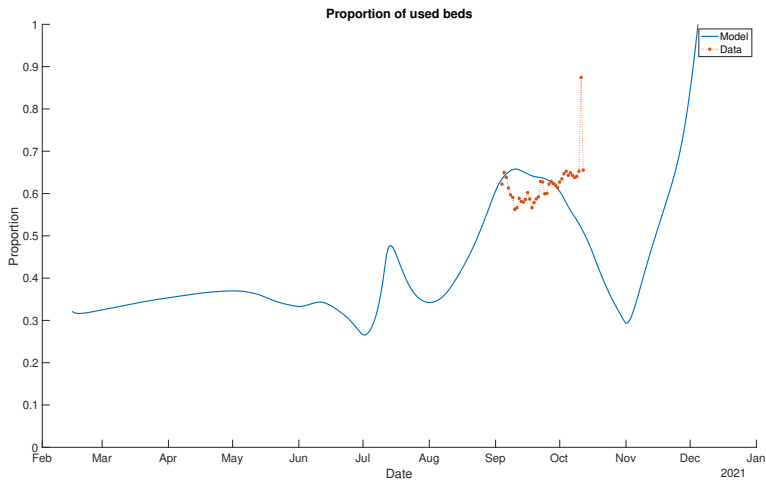
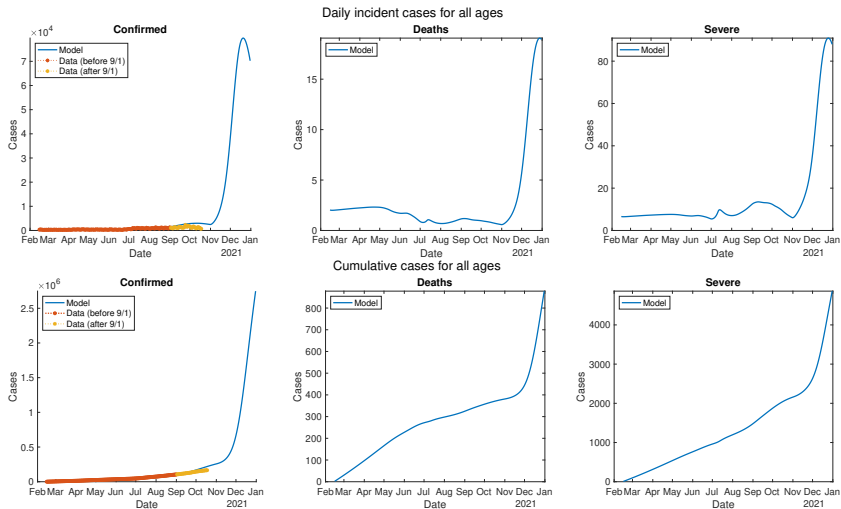


Figure 34: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 1단계



**Figure 35:** The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 1단계

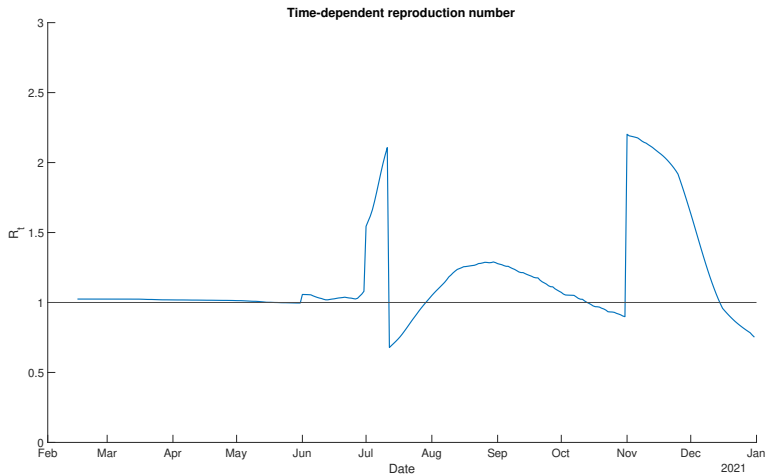


Figure 36: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 1단계

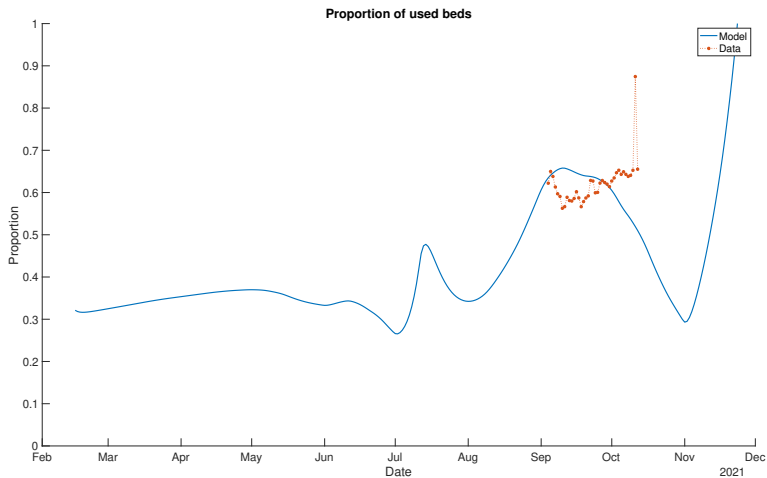
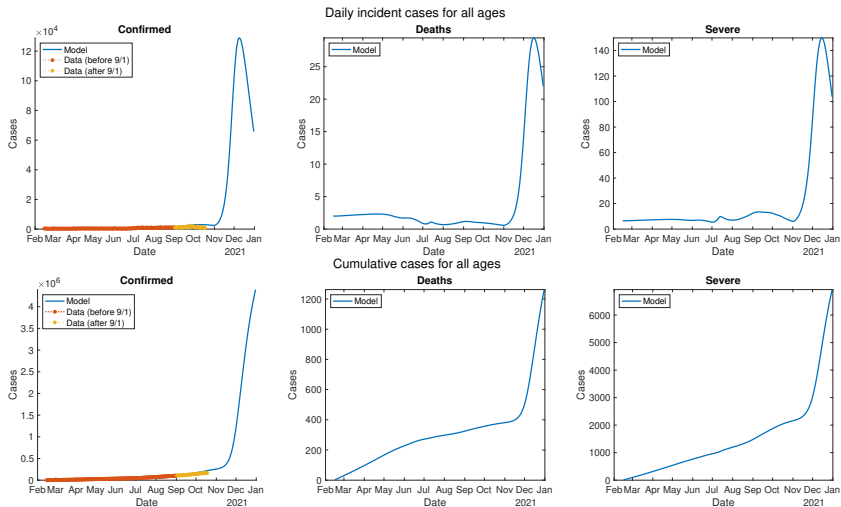


Figure 37: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.

## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 2단계



**Figure 38:** The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 2단계

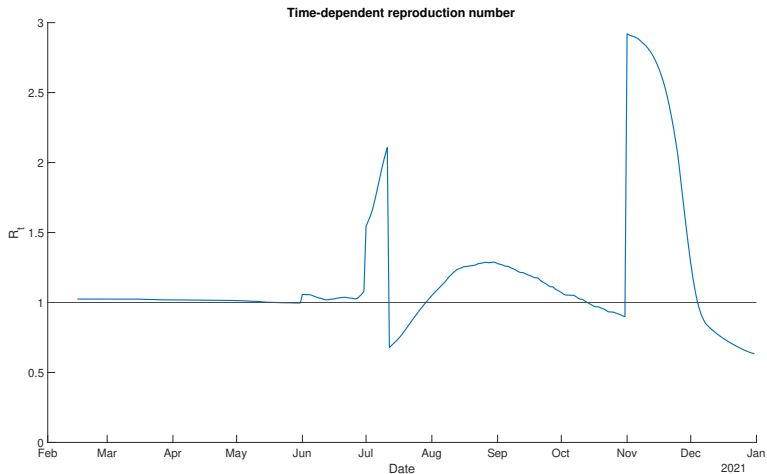


Figure 39: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 2단계

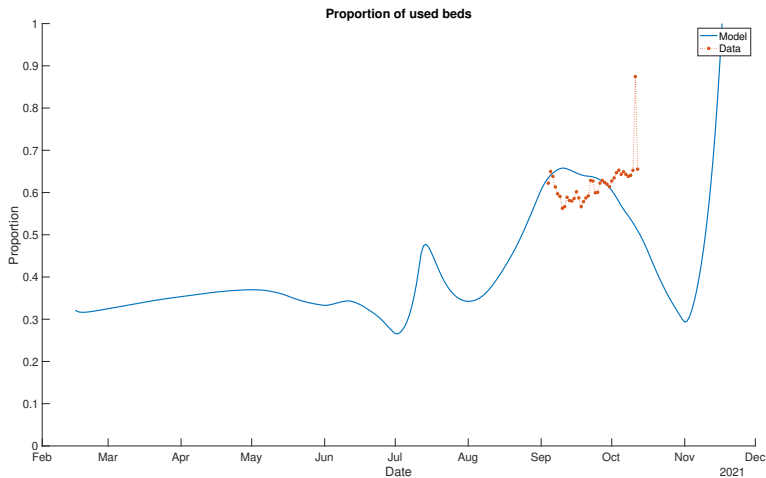


Figure 40: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.



## 현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 max단계

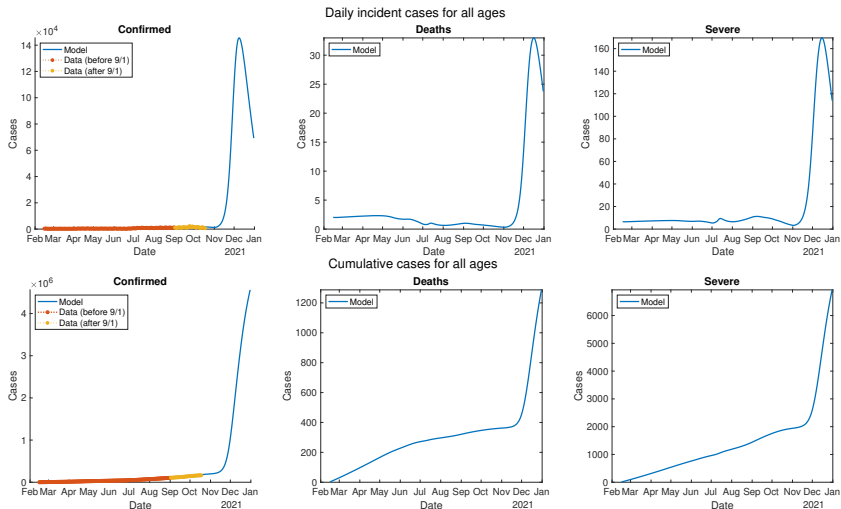


Figure 41: The model prediction and data for daily confirmed cases (top) and cumulative confirmed cases (bottom).

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 max단계

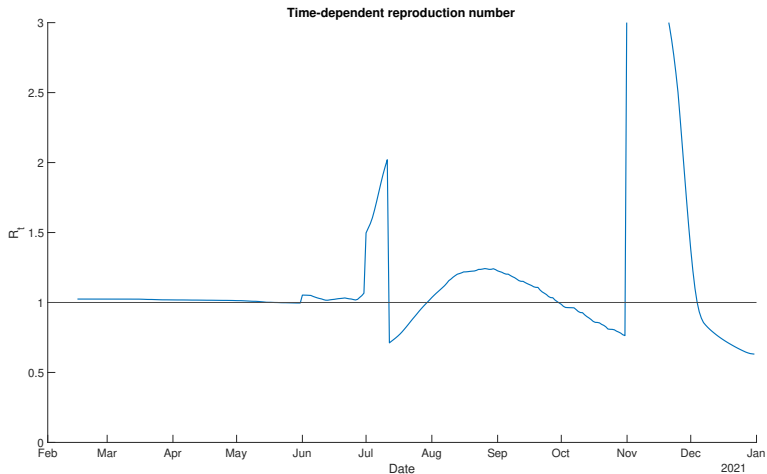


Figure 42: The estimated reproduction number from 2021/02/15 to 2021/12/31.

현 4단계 (구 3단계): 11월 이후 사회적 거리두기 완화 수준 2단계, 등교 완화 수준 max단계

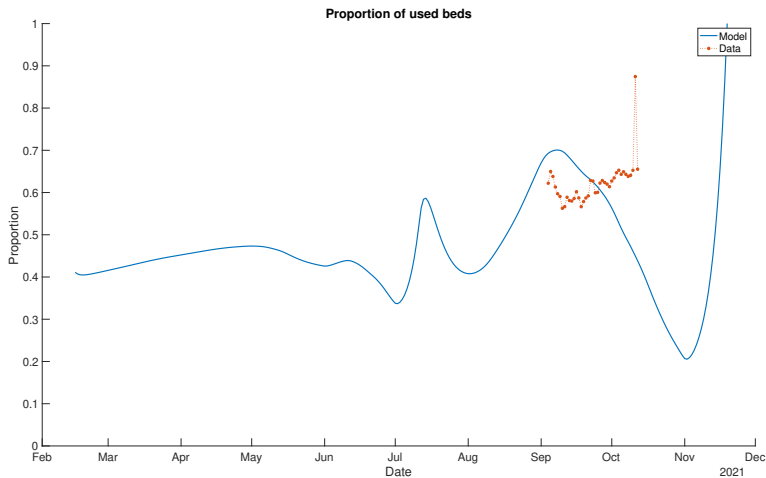


Figure 43: The estimated proportion of beds usage from 2021/02/15 to 2021/12/31.