北京大学
PEKING UNIVERSITY

Time: 21:00 p.m. (Beijing Time), March 4, 2020

Daily Brief on International Epidemic Situation of COVID-19

Data: Based on the outbreak data up to March 3.

Countries concerned: Iran, Italy, Spain, France, Germany, South Korea, Japan, Singapore, Malaysia, Thailand and Vietnam. Diamond Princess was analyzed separately. We expect to start US analysis in coming data.

Method: Apply the vSIR model developed by our team to calculate the effective reproduction number R for each country. See medRxiv posting for its application on China's: https://www.medrxiv.org/content/10.1101/2020.02.17.20024257v1
See also www.songxichen.com for COVID-19 project.

A special term: the effective reproduction number (R) is the average number of infections made by an infected while being infectious. Only when R is less than 1, the outbreak begins to slow down and gradually comes to an end. R is the most determining factor for the internal dynamic of an outbreak. Our early study on COVID-19 in 30 provinces of China shows that R is an effective leading index and has good forecasting power for COVID-19 outbreak in China under the vSIR model framework.

Results: (i) The effective reproduction number R at 10.5 and 14 days infectious duration (Fig1)，the infection loading statistics in the past 7 days and Risk Rating for each country (Table 1).

(ii) Time series plots of the 14-day R of Korea, Japan, Iran and Italy along with four China's provinces (including Hubei) to gain information on the epidemic stages of Korea, Japan, Iran and Italy relative to the provinces of China. See Fig 2.

(iii) Future projection of infected subpopulation size for Korea and Japan. See Fig 3.

Key Finding: For the first time, Japan's 14-day R declined to lower than 1 on Mar 2. Although it is not statistically significantly less than 1, it is a good sign showing a slowing down of the epidemic there. Our prediction now is that the outbreak in Japan would be gone by the end of June and Tokyo Olympics would not be affected based with 95% prediction confidence. We hope that the Korea's epidemic would end sooner (now projected over a time interval from June to August) by reduction of the R more

substantially. Our prediction is that China's epidemic would end in June with the provinces other than Hubei clearing up the infected stocks by the end of April.

Other Findings

1. Iran's 14-day reproduction number R is 7.57 with 1,824 confirmed cases increasing exponentially. Iran's risk level is F, which is the highest rating in our report.

2. The 14-day R in Italy is 3.79 with 2,263 confirmed cases and the risk rating is E, one level lower than Iran. The trends in the dynamics of Iran and Italy's reproduction number (R) are similar to that of Hubei province (Wuhan is the capital city of the province) in late January to early February.

3. Korea's R is currently at 2.13, with up to 5,255 confirmed cases and is rated as E risk category. Korea's 14-day R has declined and leveled around 3.5 since it went over 9 on February 14 and further declined to 2.13 on Mar 3. It is evident that the contagious force as results of the collective infections of the church group has been released. The pattern of its infection dynamic is similar to that of China's Zhejiang province in early February. Under the removal (including recover and death) rate being 0.1, we predict that Korea's number of infected cases will reach its peak between March 4 and March 19, afterwards it would decline to zero between June 1 and August 20. The estimated number of cumulative infected persons will be between 7,077 and 38,247 as shown in Figure 3.1.

4. The 14-day R in Japan (excluding Diamond Princess) is 0.94 but it is not significantly less than 1 at the 5% statistical significance. We have downgraded the risk level of Japan to C from D. Japan's 14-day R was higher than 3 in the mid-February and then declined with some fluctuations. The number of new and cumulative confirmed cases in Japan in the past 7 days has gradually declined and the number of existing infections is about to decline in few days. The epidemic in Japan is very similar to the dynamics in Shanghai in early February and the risk is relatively low. Under the scenario of 0.1 removal rate, we predict that the number of infected cases in Japan would be zero between April 27 and July 3, 2020, and the estimated number of cumulative infected persons would be between 307 and 755 as shown in Figure 3.2. Therefore, it is most likely that the Olympics would not be affected as far as the epidemic of Japan is concerned. We hope that Korea's epidemic would end sooner, which would provide a better surrounding to the event. Our prediction is China's

epidemic would be gone by the end of June with provinces other than Hubei clearing of the infection by the end of April.

5. Effective reproduction numbers of Spain, France, and Germany are 5.07, 4.23 and 3.38 respectively, all significantly greater than 1, suggesting these countries are in the early exponential growth phase. However, as these three countries are still in their early stage of the epidemic, the R numbers may be over-estimated, in particular, as many of the confirmed cases are the imported cases from Italy.

6. The 14-day R in Malaysia is 3.77 with a recurrent outbreak. There's been no new cases occurred between February 15 to 26 while 14 new confirmed cases since February 27. The overall epidemic situation is relatively not severe with a risk rating of B. The 14-day period R in Singapore is also greater than 1, but it is not significantly greater than 1 at 5%. With 36 existing confirmed cases in total, the risk rating of Singapore is B, indicating the overall epidemic situation is relatively moderate.

7. The risk rating for Thailand and Diamond Princess is B. All Diamond Princess personnel have disembarked on March 3 and the number of existing confirmed cases is 700. In Vietnam, there have been no new cases emerging since Feb 25 with a risk rating of A, the best in these countries.

8. As the international epidemic is gaining momentum, there is an increasing risk of "back-flow" epidemic to China. There have been cumulatively 13 foreign imported cases from Italy, Iran and England in China since February 29 to March 4. Among them, there are 8 in Zhejiang, 2 in Ningxia, 2 in Beijing and 1 in Shenzhen.

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Table 1: Effective Reproduction Number (R) up to March 3, 2020 and Statistics of Confirmed Cases. The calculation of R is based on the assumptions that the infection duration is one and a half weeks (10.5 days) and two weeks (14 days). ++ indicates that R is greater than 1 at the at the 5% statistical significance. -- indicates that R is significantly less than 1 at 5%. [x] represents the number of consecutive days for which R has been significantly less than 1 at 5%. Data in () is the number of confirmed cases or risk level up to the previous day. The risk level of the epidemic in each region is derived from the value of R and the number of new cases, ordering from A to F with increasing severity.

Rank	Country	R (10.5 days)	R (14 days)	Number of Existing Cases up to March 3	Number of New Confirmed Cases in the Past 7 Days	Number of New Existing Cases in the Past 7 Days	Risk Level
1	Iran	5.68++	7.57++	1824(1260)	2241(1440)	1745(1211)	F
2	Italy	2.84++	3.79++	2263(1835)	2179(1807)	1952(1614)	E
3	Korea	1.6++	2.13++	5255(4753)	4182(3919)	4143(3886)	E
4	Spain	3.8++	5.07++	162(121)	158(120)	157(120)	D
5	France	3.17++	4.23++	196(116)	198(118)	194(109)	D
6	Germany	2.54++	3.38++	182(116)	178(114)	178(114)	D
7	Japan	0.71--[2]	0.94	242(227)	124(115)	95(91)	C(D)
8	Singapore	0.94	1.25	36(32)	19(16)	3(-5)	C
9	Malaysia	2.83++	3.77++	14(11)	14(7)	10(7)	C
10	Thailand	0.4--[3]	0.54--[3]	11(11)	6(8)	-4(-3)	B
11	Diamond Princess	0--[11]	0.01--[11]	700(700)	11(11)	8(8)	B
12	Vietnam	End	End	0(0)	0(0)	0(-2)	A

T**he turning point of an outbreak**: due to the random fluctuations and reporting errors in the data, we suggest that the turning point of an outbreak in a region is confirmed only when the timespan for which R has been significantly lower than 1 is equal to or larger than the average duration from the infection date to the clinical confirmation date (we suggest using 7 days based on Chinese data for COVID-19). That is, if the R based on the 14-day infectious duration has been significantly (at 5% level) lower than 1 for 7 consecutive days, it may be declared that the turning point has been reached.

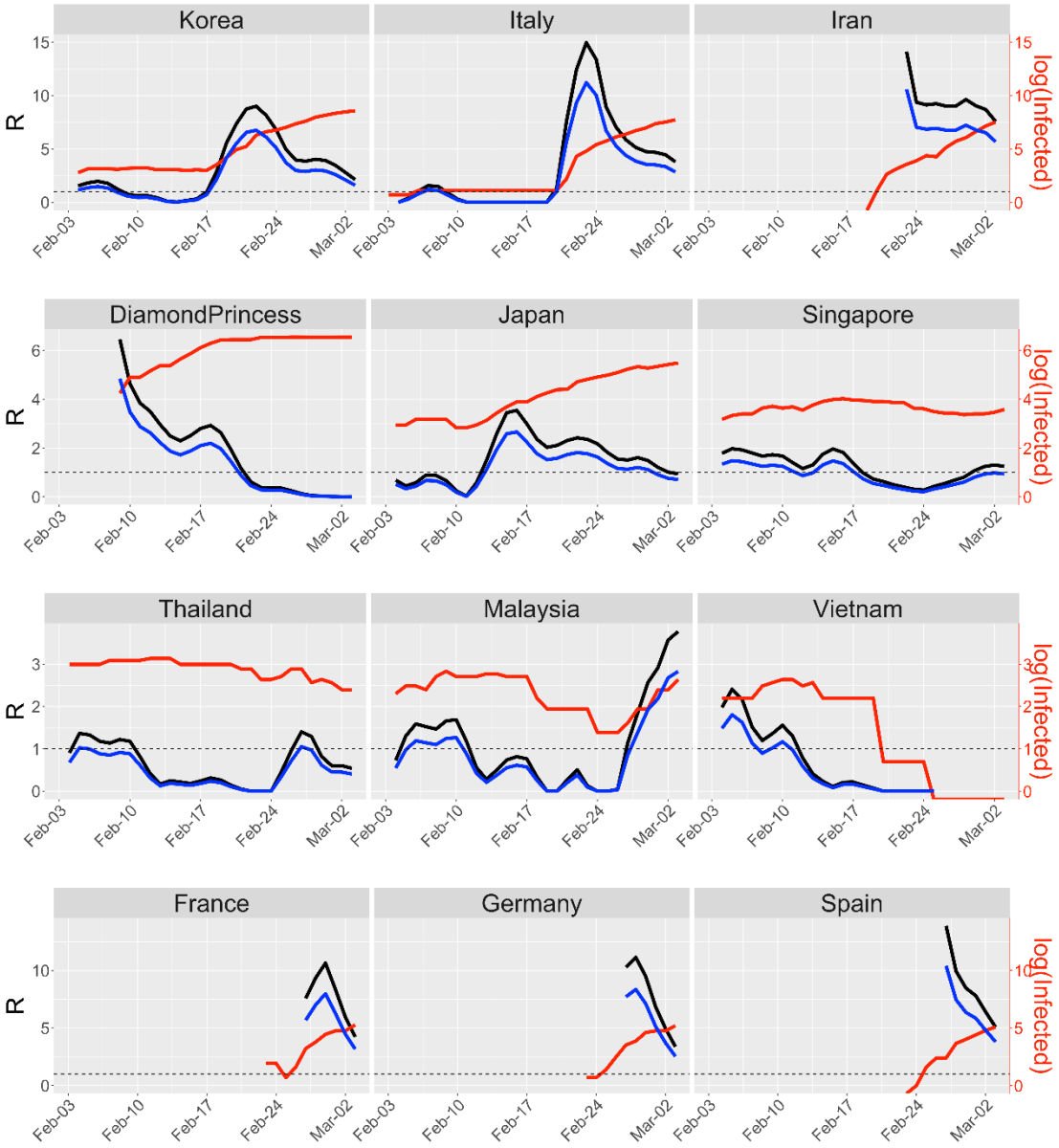

Figure 1. Time series plots of estimated effective reproduction numbers R and the logarithm of infected cases (red) up to March 2, 2020. Two Rs are given based on 10.5-day infectious duration (blue) and **14-day duration (black)**. The critical threshold level R=1 is the horizontal dashed line.

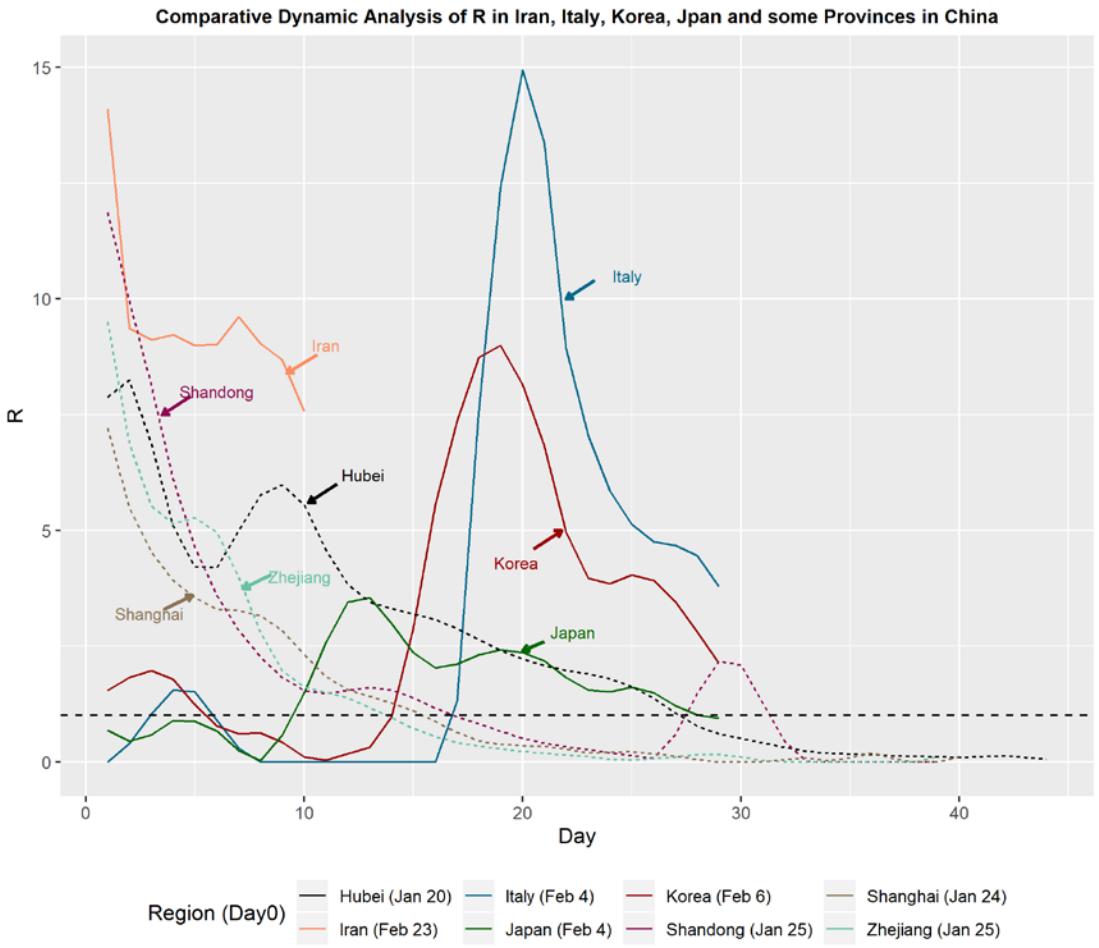

Figure 2. Effective Reproduction Number (R) in Iran, Italy, South Korea, Japan, and some comparative provinces in China Up to March 2, 2020, Based on a 14-day Infectious duration. Time 0 is the fifth day of the outbreak which are given in the legend. Dashed line refers to provinces within China while solid line refers to countries worldwide. The critical threshold R=1 is marked by the horizontal dashed line. Only when R is less than 1, the outbreak begin to decline and gradually come to an end.

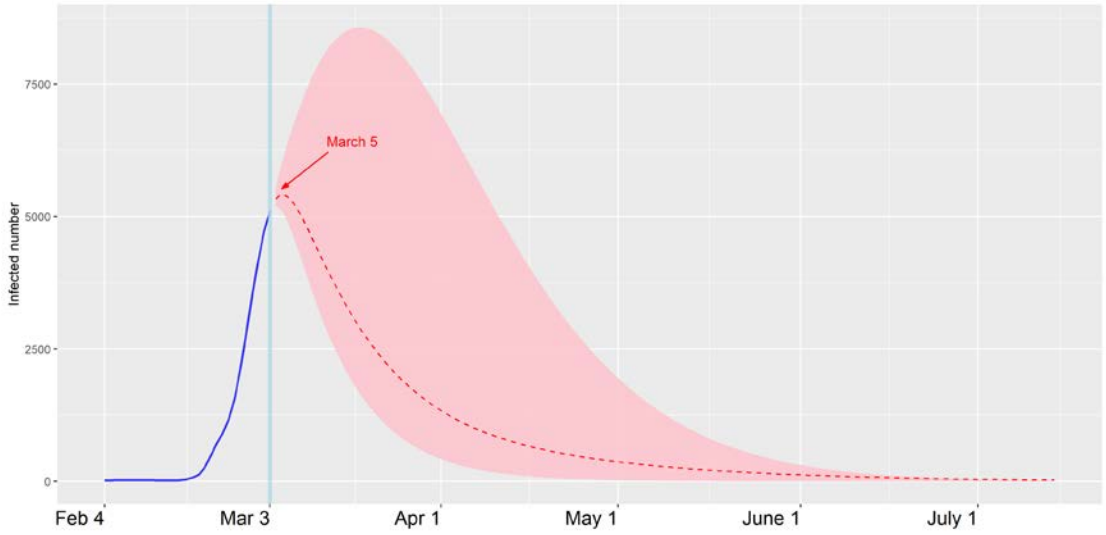

Figure 3.1. Forecast of Number of Confirmed Cases in South Korea. Observed number of infected persons (left blue solid line) and predicted number of existing infected persons (right red dashed line). 95% confidence interval (pink region). Date with the most recent data (vertical cyan line), which is March 3, 2020. Under the assumption of removal rate (γ) equal to 0.1, we predict that the number of existing cases will reach the peak between March 4 and March 19, and further decrease to zero between June 1 and August 20. The number of cumulative infected persons is estimated to be between 7,077 to 38,247.

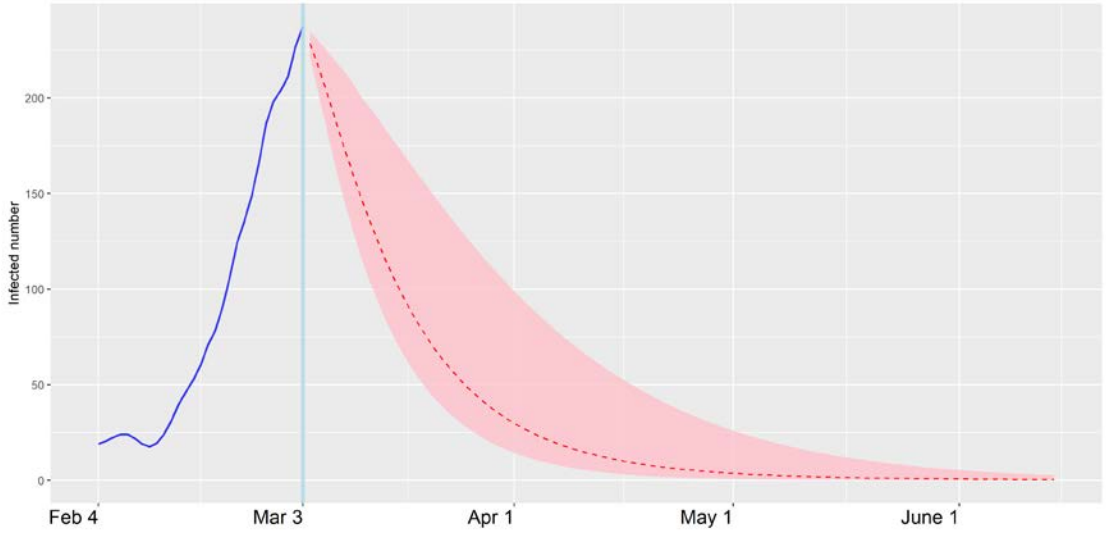

Figure 3.2. Forecast of Number of Confirmed Cases in Japan. Observed number of infected persons (left blue solid line) and predicted number of existing infected persons (right red dashed line). 95% confidence interval (pink region). Date with the most recent data (vertical cyan line), which is March 3, 2020. Under the assumption of removal rate(γ) equal to 0.1, we predict that the number of existing cases will reach the peak on March 3, and further decline zero between April 27 and July 3. The number of cumulative infected persons is estimated to be between 307 and 755.