

Time: 21:00 p.m. (Beijing Time), March 13, 2020

Daily Brief on International Epidemic Situation of COVID-19

Data: Based on the outbreak data up to March 12

21 Countries concerned: (1) Asia: Iran, South Korea, Japan (excluding Diamond Princess), Malaysia, Singapore, Thailand and Vietnam; (2) Europe: Italy, Spain, France, Germany, UK, Holland, Switzerland, Belgium, Austria, Denmark, Norway and Sweden; (3) North America: US and Canada.

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: <https://www.medrxiv.org/content/10.1101/2020.02.17.20024257v1>

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 (Figure1), 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 international areas along with Hubei and Beijing in China to gain information on the epidemic stages (Figure 2-1 and 2-2).

Key Finding: (i) Asia: **The 14-day R of Korea has been significantly lower than 1 at 5% level for 4 days with the number of infections declining for the first time, implying the turning point might be achieved in 3 days.** The epidemic in Japan, Singapore and Malaysia came to a state of stalemate resulting from passive countermeasures adopted.

(ii) Europe: Italy's 14-day R further declined to 2.68 while the outbreak hasn't been under control yet with the highest risk rating of F. The 14-day R of Spain has declined for the first time to 5 after climbing for one week, while that of France and Germany declined to 3.1 from 5 in the last week, rated at E. The number of infections in Denmark

rocketed in last 3 days with R value of 10.35. The 14-day R of the UK has been around 4 with some fluctuations since March 7 rated at D.

(iii) North America: The 14-day R of the US has been dropping for 4 days to 3.05 with over 1,000 infections, indicating the epidemic is still at an early stage of exponential increasing, therefore the risk level is upgraded to E from D.

Other Findings:

1. The 14-day R of South Korea dropped to 0.27, which has been significantly less than 1 for 4 consecutive days, fallen by 81% in the past week, and **the turning point is expected to be confirmed in the near future**. Due to the slowing spread of the virus and the increasing number of cures, the number of existing infections in South Korea saw an initial decline. But because of the absolute number of infections is high, the risk is still high rated at E.
2. In the United States, the 14-day R was 3.05, with 1,410 existing confirmed cases. The number of single-day increased cases was 447, exceeding 300 for the first time, with the risk rated raised from D to E. **The R value in the U.S. declined for four consecutive days, but the rate of decline slowed down significantly and the value was significantly greater than 1, signaling the epidemic still in a rapid development stage**. Outbreaks have been reported in 48 states and Washington, D.C., and 18 states have entered a state of emergency, with more than 200 confirmed cases in Washington, New York, and California. The 14-day R in Canada is 2.64. The number of existing cases was 144, increasing to 42 in single day, rated B. Both Ontario and British Columbia have more than 50 confirmed cases, with seven confirmed provinces altogether.
3. In Italy, the 14-day R is 2.68 with 12,839 infections, rated as F which is the highest level in our report. There have been more than 1,000 positive diagnoses per day for 6 consecutive days, indicating the epidemic is still spreading. The 14-day R leveled around 3.5 since for 6 days until March 10 and then declined slightly to 2.68 on Mar 13, **which is similar with that of Hubei (Wuhan is the capital city of the province) in early February**. The epidemic situation in northern Italy has worsened with 6,896 infections in Lombardy, 1,759 in Emilia Romagna and 1,759 in Veneto.
4. Since March, Iran's 14-day R has dropped rapidly from above 9 to 2.36. With 6,370 confirmed cases, Iran is still in an exponential growth stage, rated as F which is the highest level in our report. Iran has confirmed 5,328 new cases in the past seven days, with a total of 3,276 cured as of March 12. Iran's R value is similar to that of

Hubei in mid-February. The epidemic situation may be underestimated in Iran due to testing conditions.

5. Japan's 14-day R was 1.25, which was the first climb after a week of continuous declining, still significantly greater than 1. **The Japanese epidemic is at a stalemate**, with 569 existing cases and an increase of 65 in a single day. The risk rating for the epidemic remains C. Japan's PCR detection capacity is less than 7,000 per day, far lower than that of South Korea, which is more than 20,000, inferring a larger number of actual confirmed cases. Whether the Olympic Games can be held as scheduled remains to be seen, and Chairman Xi's visit will also be affected.
6. Spain, France, and Germany are in the early stage of outbreak, with nearly 3,000 existing confirmed cases increasing exponentially, and the risk rating upgraded to E from D. The 14-day R in Spain turned down to 5 after climbing from 3.62 to 5.92 in a week since March 5. The dynamics of R in Spain is comparable with that of Hubei in late January and the value of R is close to that of Italy at the end of February, indicating the possibility of further outbreak. The dynamics of R in France and Germany are quite similar, gradually falling from over 5 on March 7 to 3.1 on March 12, which is comparable to that of Hubei in early February and that of Italy in early March.
7. The 14-day R value in the UK is 3.21, which has fluctuated around 4 since March 7 with 576 existing confirmed cases, rated at D. There're over 100 infections in London which makes it the epidemic center. The number of infections in Denmark has rocketed to 261 on March 12 from 58 on March 9, with a 14-day R value of 10.35 and a risk level of D, Denmark became the second country after Italy to enforce a lockdown, where schooling and gatherings have been suspended since March 12. The R values of Switzerland, Sweden, Austria, the Netherlands, and Norway fell between 3 to 5 in fluctuations, and the R value of Belgium declined rapidly to 2.51. These countries are in the early stage of exponential growth rated at D.
8. Singapore has recently rebounded due to the clustered cases, with a 14-day R of 2.18. Singapore also has a serious import risk. Nine of the 13 new cases on March 12 were imported cases. After the outbreak in Malaysia around March 5, the spread of the epidemic has slowed recently, and the R continues to decrease to 1.9. However, it is still significantly greater than 1 at the 5% level, indicating that the epidemic has not been effectively controlled.

9. Thailand's 14-day R continued to rise to 3.21 from March 3, which means that the epidemic has become worse. Its risk level is B. The same happened to Vietnam. 31 new cases were confirmed during March 7 to March 12 after the infected cases cleared to be 0 in Feb 25.

Summary: Most countries are still in the stage of exponential growth, among which the most severe ones such as South Korea and Iran, have shown a significant decline in growth rate. The epidemic situation in Japan and Italy came to a state of stalemate while the epidemic in the US is spreading rapidly. It's worth mentioning that the changes in the epidemic may further lead to chain reactions in economic, political and social areas. The governments not only need to pay more attention to the global epidemic and prevent imported cases, but also keep an eye on relevant social issues and beware of the potential negative impact.

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See also www.songxichen.com for COVID-19 project.

Table 1: Effective Reproduction Number (R) up to March 12, 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 12	Number of New Confirmed Cases in the Past 7 Days	Number of New Existing Cases in the Past 7 Days	Risk Level
1	Italy	2.01++	2.68++	12839(10590)	11255(9373)	9364(7884)	F
2	Iran	1.77++	2.36++	6370(6370)	5328(7153)	2660(4092)	F
3	Spain	3.75++	5++	2875(1952)	2919(2017)	2649(1790)	E
4	France	2.34++	3.11++	2803(2221)	2453(2024)	2399(1980)	E
5	Germany	2.33++	3.1++	2735(1550)	2405(1327)	2400(1324)	E
6	US	2.29++	3.05++	1410(963)	1227(851)	1195(824)	E(D)
7	Korea	0.21--[7]	0.27--[4]	7397(7520)	1695(2103)	1196(1831)	E
8	Denmark	7.76++	10.35++	784(513)	770(504)	769(503)	D
9	Norway	3.81++	5.08++	703(489)	647(455)	647(455)	D
11	Holland	3.34++	4.46++	609(498)	576(479)	571(474)	D
12	Sweden	3.33++	4.43++	675(492)	631(465)	623(457)	D
10	Austria	3.12++	4.16++	356(244)	337(222)	332(220)	D
13	Switzerland	2.82++	3.76++	809(470)	749(410)	745(406)	D
14	UK	2.41++	3.21++	576(446)	474(375)	469(369)	D
15	Belgium	1.88++	2.51++	395(263)	376(244)	373(241)	D
16	Singapore	1.64++	2.18++	105(84)	75(54)	72(51)	C
17	Malaysia	1.43++	1.91++	126(106)	108(79)	98(78)	C
18	Japan	0.94	1.25	569(504)	330(289)	261(225)	C
19	Thailand	2.41++	3.21++	40(35)	28(27)	25(24)	B
20	Canada	1.98++	2.64++	144(102)	102(74)	101(73)	B

The 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.

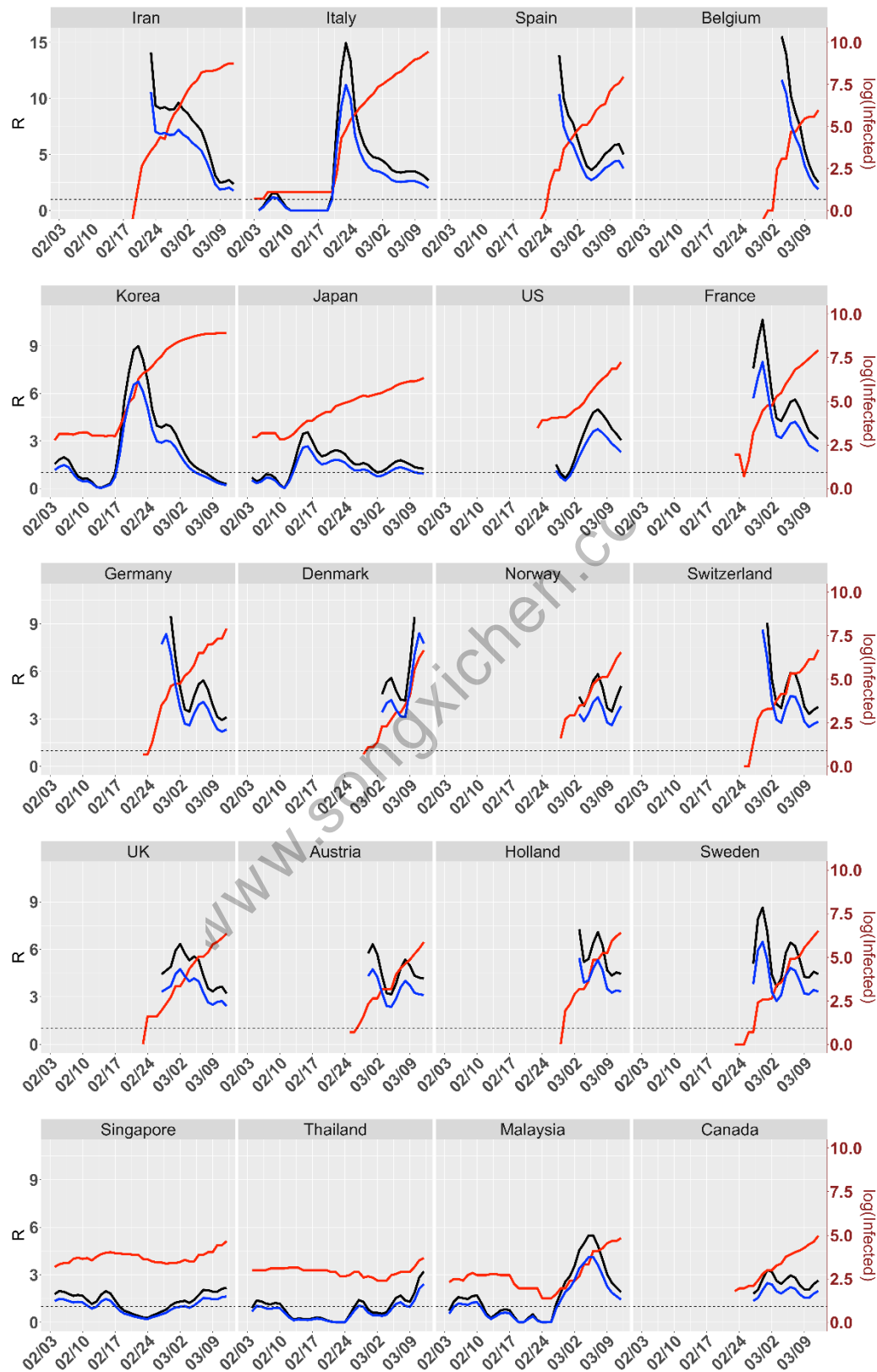


Figure 1. Time series plots of estimated effective reproduction numbers R and the **logarithm of infected cases (red)** up to March 12, 2020. Two R s are given based on **10.5-day infectious duration (blue)** and **14-day duration (black)**. The critical threshold level $R=1$ is the horizontal dashed line.

Comparative Dynamic Analysis of R in Iran, US, Canada, Korea, Japan, Singapore and some Provinces in China

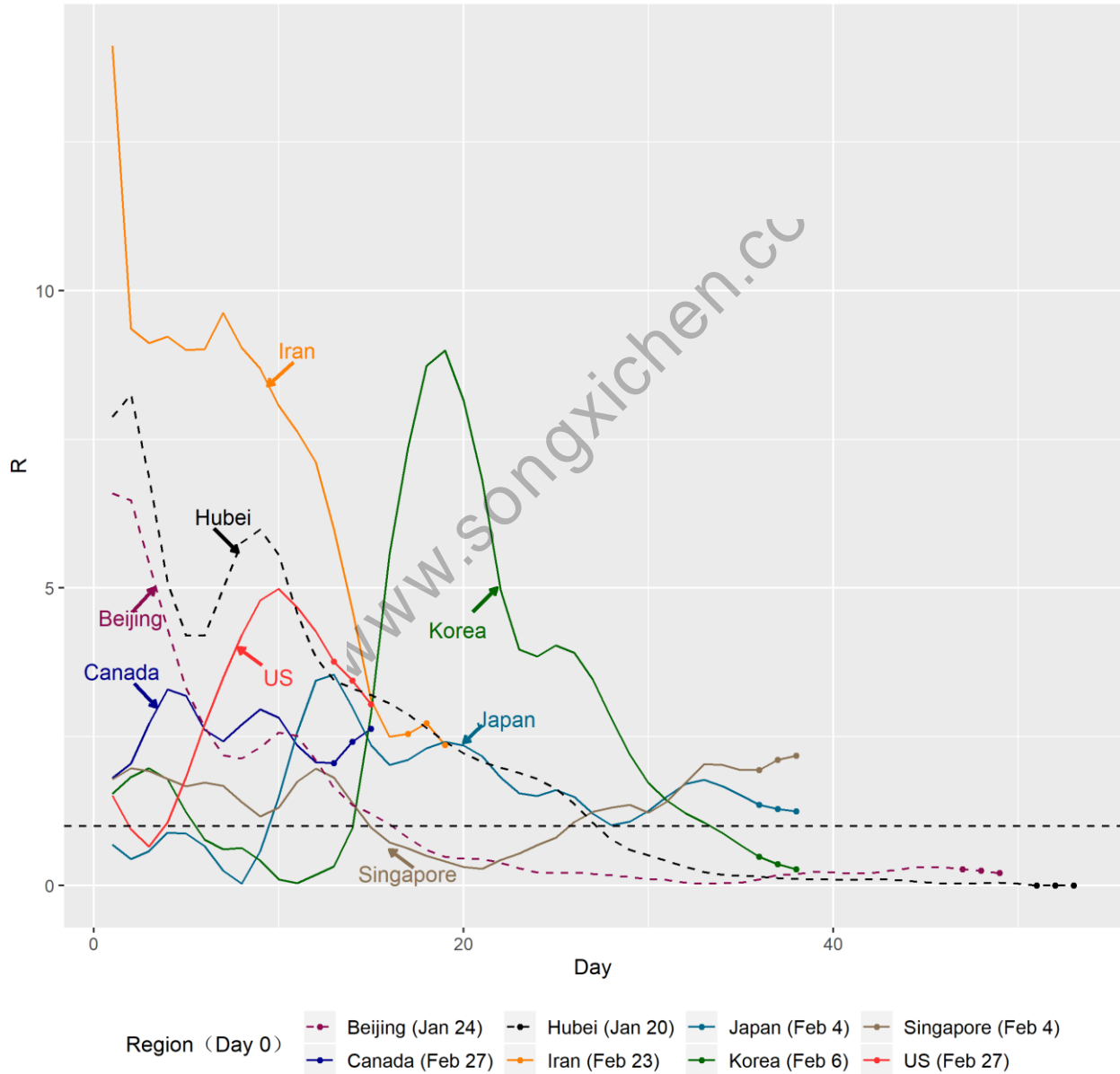


Figure 2.1. Effective Reproduction Number (R) in Canada, Iran, US, Korea, Japan, Singapore and some Comparative Provinces in China up to March 12, 2020, based on a 14-day Infectious Duration. Day 0 is the fifth day since the outbreak which are given in the legend. Points at the end of the line refer to the value of R of recent 3 days. The critical threshold $R=1$ is marked by the horizontal dashed line. Only when R is less than 1, the outbreak begins to decline and gradually come to an end.

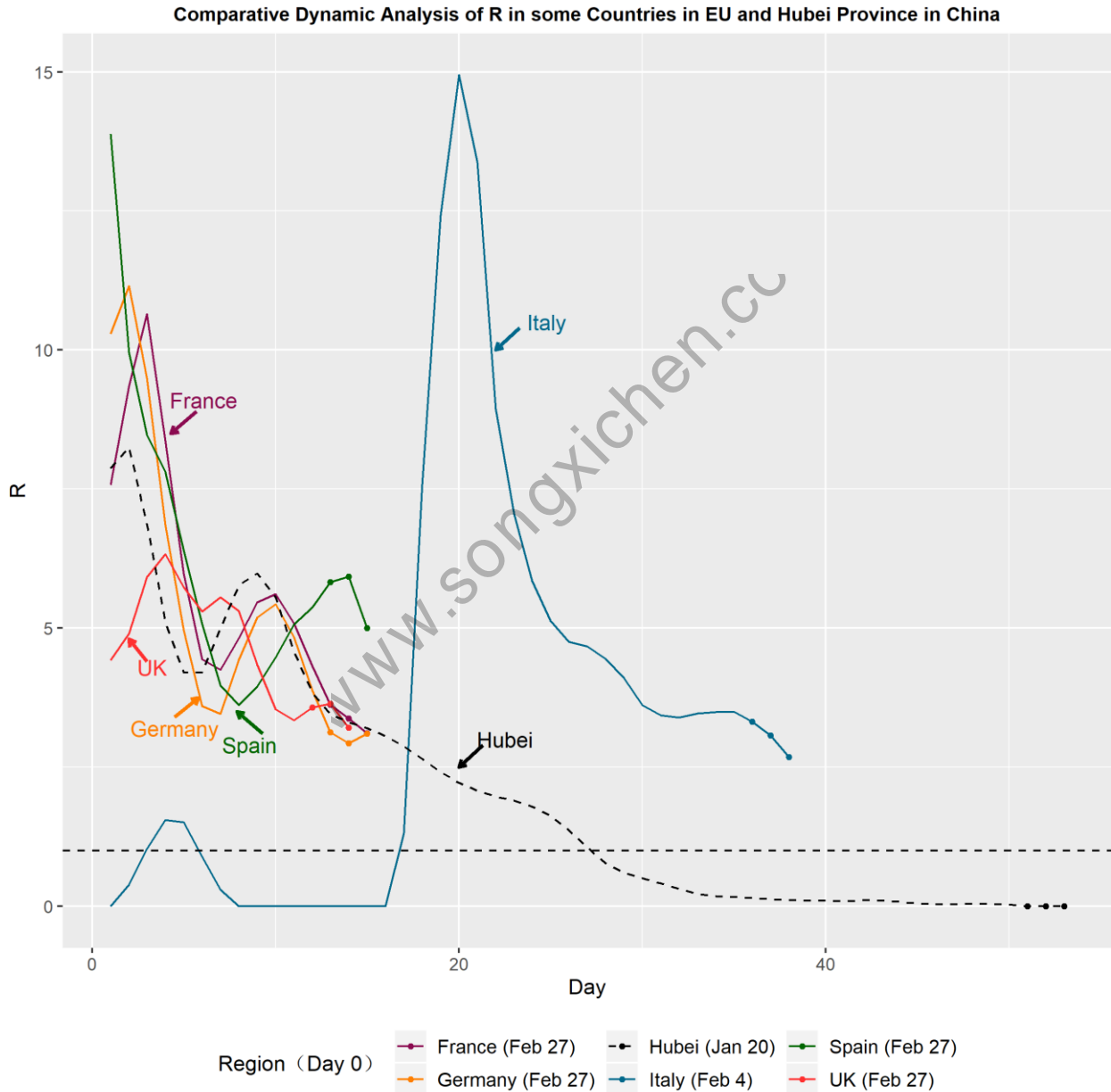


Figure 2.2. Effective Reproduction Number (R) in EU and Hubei Province in China up to March 12, 2020, based on a 14-day Infectious Duration. Day 0 is the fifth day since the outbreak which are given in the legend. Points at the end of the line refer to the value of R of recent 3 days. The critical threshold $R=1$ is marked by the horizontal dashed line. Only when R is less than 1, the outbreak begins to decline and gradually come to an end.