



Time: 12 p.m. (Beijing Time), March 21, 2020

Daily Brief on International Epidemic Situation of COVID-19

Data: Based on the outbreak data up to March 19

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 varying coefficient 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 dynamics 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 the COVID-19 outbreak in China.

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 value in Korea has been significantly lower than 1 for 11 consecutive days, and the number of existing confirmed cases has been declining for 6 consecutive days. The prevention and control of the pandemic came to the second half-section, with the epidemic risk rating downgraded from E to D. The situation in Singapore and Malaysia remains deadlocked with no clear trend.

(ii) Europe: The epidemic in Europe is still increasing exponentially. The 14-day R of Italy decreases to 2.02, comparable to that of Hubei in mid-February. The value of R in

Spain, Germany, France, and the UK is between 2.5 and 3 which is still significantly larger than 1 at 5% level, close to that of Hubei in early February.

(iii) North America: The 14-day R of the US rebounds to 4.49, indicating the epidemic is at the stage of exponential increase, rated at F. Canada's R value fell to 3.23 with over 850 infections in 10 provinces, rated at C.

Other Findings:

1. The 14-day R value in the United States increased from 4.03 to 4.59. The number of existing cases is 13,921, increasing by nearly 5,000 in a single day. Based on our calculations, nearly 35,000 potential cases in the US have not yet been confirmed, and the total number of infected cases has exceeded 50,000, with the rating upgraded to the highest level F. After the R value fell to 3.05, it rebounds significantly, indicating the epidemic is in the stage of rapid development. The US epidemic continues to spread, with more than 5,000 confirmed cases in New York state and more than 1,000 in Washington and California. Canada's 14-day R value fell briefly to 3.23, while still significantly greater than 1. The number of existing cases is 850, with a single-day increase of 142. The epidemic rating is raised to C.
2. The 14-day R of Italy decreased to 2.02, which is close to that of Hubei in mid-February, implying it comes to a crucial period to curb the spread of the epidemic. The R value of Italy leveled around 3 from March 11 to March 14 and then gradually declined to 2.02 on March 19. There're 3,190 infections and the daily increase is over 5,000 for the first time. There're also nearly 35,000 potential cases, bringing the number of infections to over 70,000 in total which is expected to exceed that of China as the situation in Italy further worsens. The number of the recovered increased to 4,440, while there're 3,405 deaths which are more than that of China. Therefore, the risk level of Italy maintained at F. The epidemic situation in northern Italy has worsened with nearly 20,000 diagnoses and over 2,000 deaths.
3. Iran's 14-day R is 1.64 and the risk level is downgraded from F to E. After a great drop at the beginning of March, the 14-day R maintained around 2.5 from March 9 to March 15, and then gradually drops to 1.64 on March 19. Iran's R value is similar to that of Hubei in mid-February to late-February. On March 19, there're 11,466 confirmed cases with 9,569 new cases in the past week. There're a total of 6,745 cured and 1,433 dead, next to China and Italy.
4. South Korea's 14-day R is 0.19, which has been significantly lower than 1 for 11 consecutive days. The number of existing confirmed cases has been decreasing for

6 consecutive days, indicating that the spread of the epidemic is under control, with the epidemic risk rating downgraded from E to D.

5. Japan's 14-day R gradually declined to 0.75 after increasing to 1.25, rated as C, with 778 existing cases and an increase of 30 cases in a single day. Japan's PCR detection capacity is less than 7,000 per day, far behind that of South Korea, which is more than 20,000, inferring a larger number of potential cases. Whether the Olympic Games can be held as scheduled remains to be seen.
6. Spain, France, and Germany are in the stage of exponential increase, with the 14-day R decreased to around 3, rated at E. The epidemic in Spain is quite severe with 17,390 infections and 1,002 deaths, the R value of which declined to 3.17 from over 5 in 6 days. The 14-day R of Germany declined to 2.96 from 4.24 in 6 days with 15,260 infections and 44 deaths. The 14-day R of France declined to 2.5 from 3.3 in 6 days with 372 deaths. The value of R in those countries is quite close to that of Hubei in early February and that of Italy in mid-March, indicating the possibility of a further outbreak.
7. The 14-day R value in the UK is 3.15 with 2,457 infections, the daily increase of which has been over 6,000 for 2 consecutive days, rated as D. The 14-day R came to a stalemate after a bounce. The value of R bounced to 3.95 on March 14 and then declined quickly to 3.18 on March 17 and leveled around 3.1 ever since. There are 3,846 existing confirmed cases in Switzerland and over 2,000 in Austria, Belgium, and Holland. The R value of those countries falls gradually between 2.5 to 3. The R value of Norway and Denmark decreased rapidly to 1.4 and 1.09 separately with over 1,000 infections.
8. The situation in Singapore and Malaysia remains uncertain. Malaysia is in the early stage of the outbreak whose number of confirmed patients is nearly log-linear in figure 1, the R value of which is 2.22 on March 19 fluctuating around 4. As for Singapore, the R value fluctuated around 2 and increases to 2.85 on March 19. Singapore is still facing a very high risk of imported cases. The import population is mainly domestic residents and workers in Singapore. The government has once again raised the level of prevention and control. However, its effectiveness needs further observation.
9. Thailand's 14-day R have again rose to 3.74 recently, implying a slightly recurrent outbreak. The risk level rose from B to C. The same happened in Vietnam. There

are 71 new cases from March 7 to March 19 after the infected cases were cleared on Feb 25.

Summary: The epidemic in the US has got worse recently, disclosing an outbreak. With infected cases confirmed in one day around 5,000, America's risk level is upgraded to F. The circuit breaker has been triggered four times in the stock market, indicating social and economic unrest is picking up steam. The 14-day R in Europe is decreasing steadily, while the epidemic is still on the rise. Italy has the highest number of deaths in the world. The epidemic in Asia gradually comes under control, with risk ratings being downgraded. China still needs to strengthen the countermeasures to prevent imported cases, mainly focusing on the negative impact of the social problems caused by the worsening of the epidemic in the United States and other countries.

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

Table 1: Effective Reproduction Number (R) up to March 19, 2020, and Statistics of Confirmed Cases. The calculation of R is based on the assumption 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 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 19	Number of New Confirmed Cases in the Past 7 Days	Number of New Existing Cases in the Past 7 Days	Risk Level
1	Italy	1.52++	2.02++	33190(28710)	25922(23251)	20351(18120)	F
2	US	3.44++	4.59++	13921(9086)	12791(8341)	12511(8123)	F(E)
3	Spain	2.38++	3.17++	17390(12037)	16832(11534)	14515(10085)	E
4	Germany	2.22++	2.96++	15260(11810)	12685(10406)	12525(10260)	E
5	France	1.88++	2.5++	9323(8268)	8119(6853)	6520(6047)	E
6	Iran	1.23++	1.64++	11466(11144)	9569(8332)	5096(4774)	E(F)
7	Korea	0.14--[14]	0.19--[11]	6319(6527)	673(696)	-1078(-993)	D(E)
8	UK	2.36++	3.15++	3046(2457)	2679(2166)	2470(2011)	D
9	Belgium	2.22++	2.96++	2219(1780)	1858(1528)	1824(1517)	D
11	Austria	2.19++	2.92++	2000(1633)	1652(1400)	1644(1389)	D
12	Switzerland	2.12++	2.83++	3846(3004)	3073(2552)	3037(2534)	D
10	Holland	1.89++	2.53++	2402(1993)	1846(1548)	1793(1495)	D
13	Norway	1.05++	1.4++	1751(1556)	1055(1073)	1048(1067)	D
14	Denmark	0.82--[4]	1.09	1219(1052)	441(543)	435(539)	D
15	Sweden ⁽¹⁾	0.77--[2]	1.03	1411(1268)	740(779)	736(776)	D
16	Thailand	2.81++	3.74++	278(229)	247(202)	238(194)	C(B)
17	Canada	2.42++	3.23++	850(708)	724(620)	706(606)	C(B)
18	Malaysia	2.22++	2.97++	941(838)	872(771)	815(732)	C
19	Singapore	2.14++	2.85++	261(196)	198(147)	156(112)	C
20	Japan	0.57--[5]	0.75--[3]	778(748)	279(316)	209(244)	C

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. (i) Sweden decided to stop testing mild and susceptible cases, implying the situation might be underestimated.

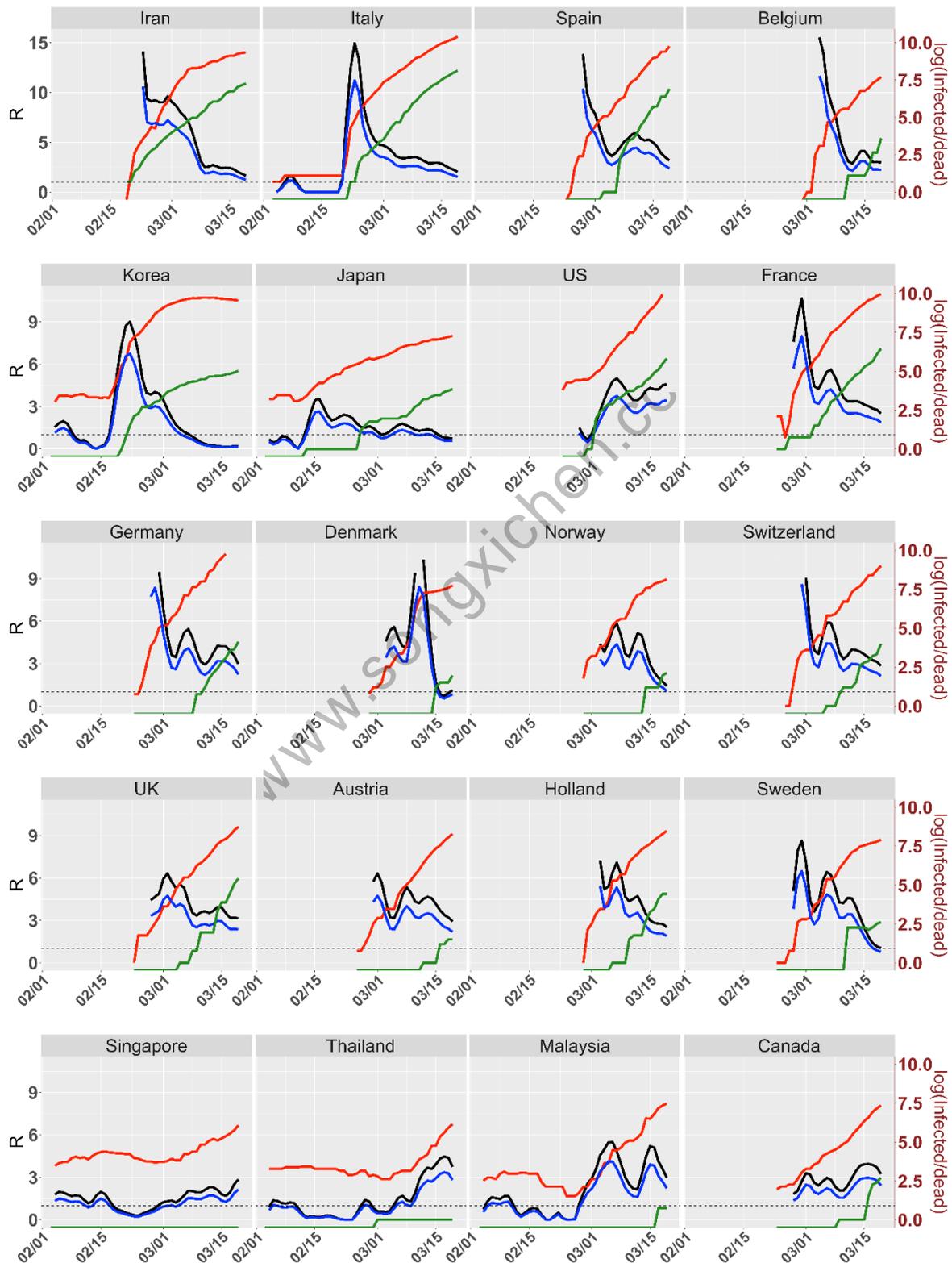


Figure 1. Time series plots of estimated effective reproduction numbers R , the **logarithm of infected cases** (red) and the **logarithm of dead cases** (green) up to March 19, 2020. Two R s are given based on **10.5-day infectious duration** (blue) and **14-day duration** (black). The critical threshold 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

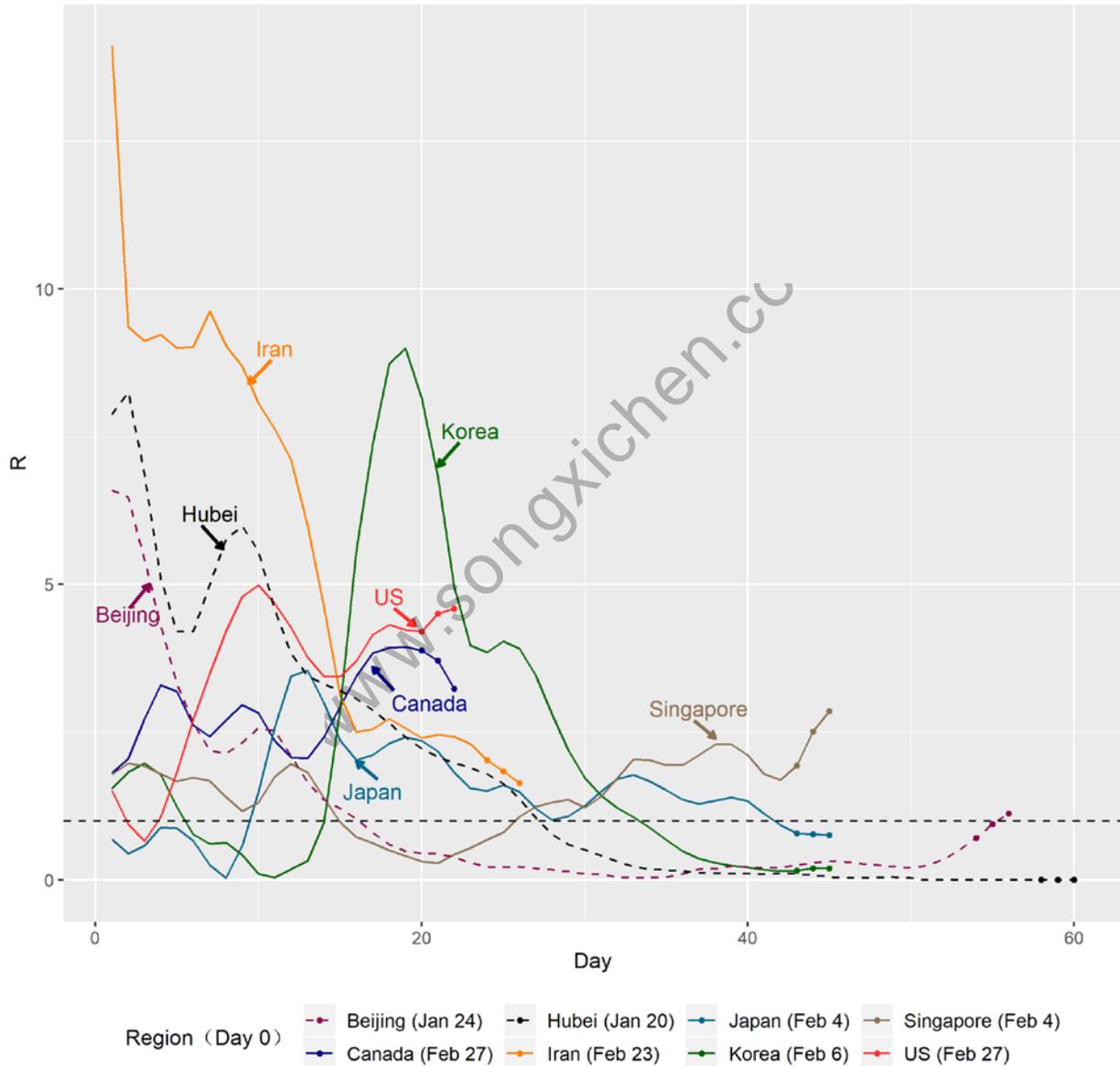


Figure 2.1. Effective Reproduction Number (R) in Canada, Iran, US, Korea, Japan, Singapore and some Comparative Provinces in China up to March 19, 2020, based on a 14-day Infectious Duration. Day 0 is the fifth day since the outbreak as given in the legend. Points at the end of the line refer to the 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.

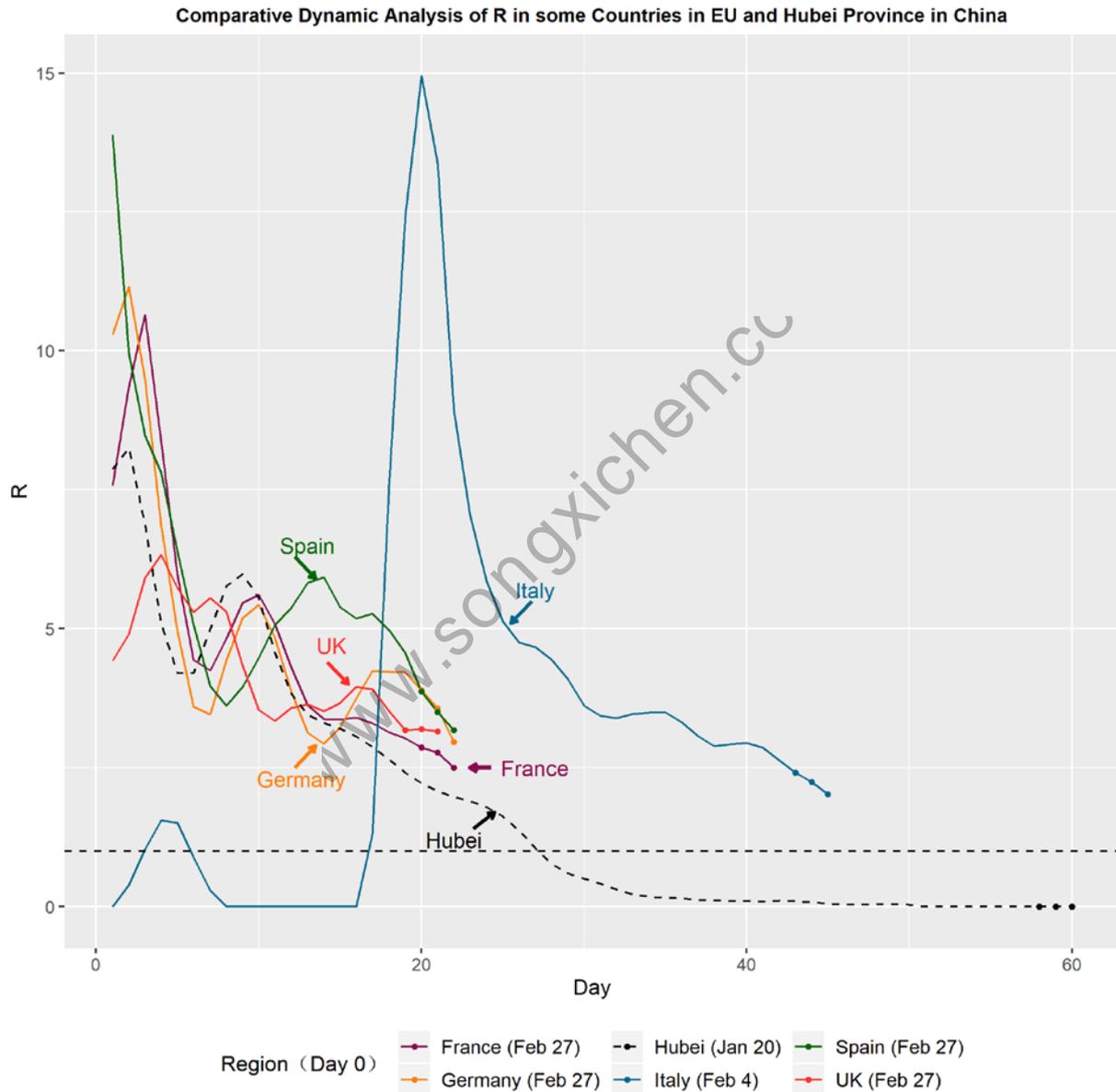


Figure 2.2. Effective Reproduction Number (R) in EU and Hubei Province in China up to March 19, 2020, based on a 14-day Infectious Duration. Day 0 is the fifth day since the outbreak as given in the legend. Points at the end of the line refer to the value of R of the recent 3 days. The critical threshold $R=1$ 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.