COVID-19 Confirmed Cases Prediction as of March 23, 2020

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This report updates predictions for the number of COVID-19 confirmed cases at four time horizons (1-day, 5-day, 10-day and end of the outbreak) and for various countries/regions, based on a phenomenological approach detailed in [1], i.e., employing 3 versions of the generalized logistic growth equation to model the total confirmed cases. The prediction results are shown in Table 1. Note that for countries/regions at early growth stages, the predictions for long term horizon (10-day and end of the outbreak) are highly uncertain and will vary a lot as the situation changes.

A summary of the situation:

- Europe is at present the new epicenter of the COVID-19 outbreak, with 3.8 million population estimated to be the final confirmed cases in a medium scenario. The outbreak in Europe is still at an early stage with a slowly decaying growth rate of the confirmed cases.
- Italy and Spain are the most infected countries in Europe, while the inflection point is still not clear from the current trajectory, indicating the numbers will continue to grow with a fast rate.
- United States, Germany, Switzerland, United Kingdom, Netherlands, Austria, and Belgium are all in early exponential growth stages.
- As a result of the strong measures introduced by the French government, the growth rate in France is decaying, indicating that a possible inflection point could be reached in the near future. However, the uncertainty is still high and require a close monitoring.
- The first wave of outbreak in South Korea has closed to an end, while there seems to be a second round of transmission, which is beyond our model based scenarios.

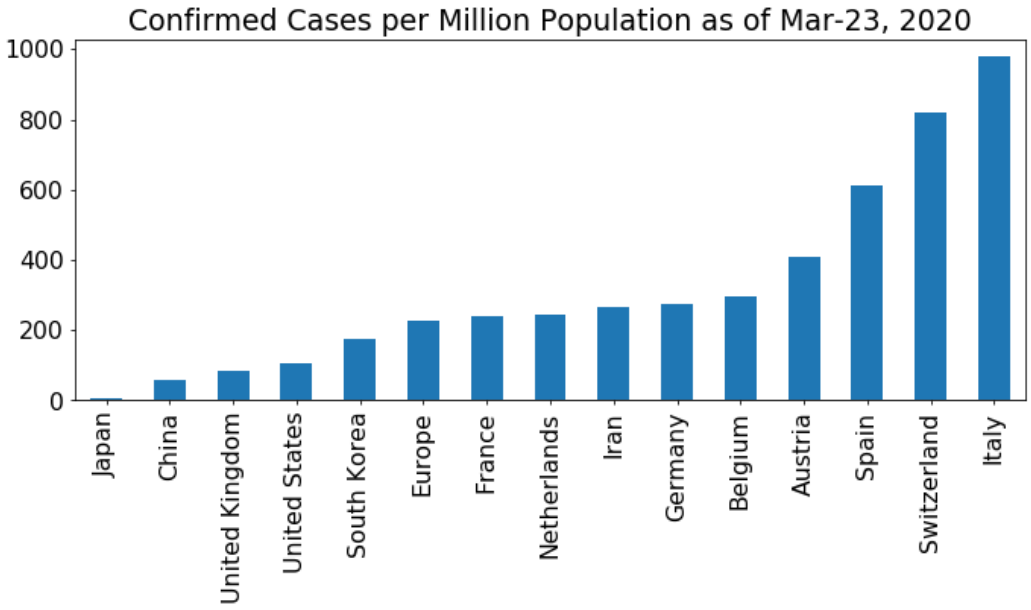


Figure 1. Confirmed cases per million population as of March 23, 2020

Table 1. Predictions for the number of confirmed cases at four time horizons (1-day, 5-day, 10-day and end of the outbreak) and for various countries/regions. All numbers are in thousands.

Country/Region	Scenario	24-Mar	28-Mar	2-Apr	Final Total Confirmed
Europe	**Positive**	182 (165, 196)	331 (257, 377)	606 (322, 815)	1370 (358, 2730)
	Medium	185 (173, 199)	319 (289, 353)	577 (487, 707)	3750 (1880, 7510)
	Negative	187 (173, 201)	323 (294, 356)	601 (518, 724)	Not Reliable
Italy	**Positive**	57.2 (50.4, 61.6)	100 (76.4, 115)	180 (97.3, 241)	444 (111, 887)
	Medium	62.7 (57.1, 67.9)	95 (87.3, 103)	149 (131, 170)	1120 (562, 2250)
	Negative	62.9 (58.4, 68.2)	96.2 (88.4, 106)	154 (137, 176)	Not Reliable
United States	**Positive**	40.5 (37.6, 43.3)	89.3 (62.9, 119)	129 (69.8, 229)	141 (70.6, 282)
	Medium	42.3 (38.8, 46.8)	118 (93.6, 137)	312 (190, 435)	634 (317, 1270)
	Negative	42.2 (38.4, 46.8)	129 (104, 147)	515 (316, 629)	Not Reliable
Spain	**Positive**	30.4 (26.5, 33.6)	56.5 (38.6, 71.3)	91.8 (44.1, 149)	129 (45.6, 257)

	Medium	31.8 (28.2, 35.9)	56.6 (48.5, 67.6)	103 (79.7, 150)	486 (243, 971)
	Negative	31.9 (27.3, 36.1)	58 (49.4, 70.5)	113 (86.5, 161)	Not Reliable
Germany	**Positive**	24.9 (21.8, 27.9)	43 (31.8, 52.9)	66 (36.7, 101)	90.7 (38.5, 181)
	Medium	24.7 (21.8, 27)	44.1 (36.9, 52.1)	75.9 (54, 109)	159 (79.4, 317)
	Negative	24.9 (22.3, 27.6)	47.1 (40.6, 54.7)	96.7 (74.5, 131)	Not Reliable
Iran	**Positive**	20.9 (18.5, 23)	22.4 (19.7, 24.7)	23.2 (20.2, 25.8)	23.6 (20.4, 26.2)
	Medium	24.1 (19.9, 28.6)	29.4 (24.1, 35.2)	36 (28.6, 44.8)	86.6 (43.3, 173)
	Negative	24.2 (19.4, 29.8)	30.2 (24.2, 37.7)	38.6 (30.2, 51.3)	Not Reliable
France	**Positive**	17.3 (15.9, 18.8)	23.8 (20.6, 28.1)	28.8 (23, 40.8)	32 (24, 60.6)
	Medium	17.5 (15.8, 19.2)	27.1 (24, 30.1)	42.7 (35.1, 52)	178 (88.8, 355)
	Negative	17.5 (15.6, 19.4)	27.7 (24.4, 31.5)	45.8 (38.6, 55.7)	Not Reliable
South Korea	**Positive**	8.94 (7.05, 10.8)	8.96 (7.05, 10.8)	8.96 (7.05, 10.8)	8.96 (7.05, 10.8)
	Medium	9.19 (4.21, 15.7)	10.3 (4.8, 17.7)	11.7 (5.39, 24.2)	71.7 (35.8, 143)
	Negative	8.88 (4.08, 14.9)	10 (4.72, 17.7)	11.5 (5.43, 28.3)	Not Reliable
Switzerland	**Positive**	8.08 (6.9, 9.24)	12.3 (9.2, 16.4)	15.6 (9.79, 26.2)	17.4 (9.89, 34.9)
	Medium	8.02 (6.87, 9.35)	12.5 (9.37, 15.7)	16.6 (10.7, 25.8)	20 (11, 40)
	Negative	8.27 (6.97, 9.66)	14.9 (12.2, 18.8)	28.5 (20.9, 48.1)	Not Reliable
United Kingdom	**Positive**	6.1 (5.29, 7.03)	9.04 (6.95, 12.3)	10.8 (7.43, 18.6)	11.4 (7.53, 22.7)
	Medium	6.35 (5.49, 7.4)	10.8 (8.32, 14)	16.4 (10.2, 26.5)	22.7 (11.4, 45.5)
	Negative	6.43 (5.46, 7.4)	12.2 (9.73, 15.9)	25.1 (17.5, 45.6)	Not Reliable
Netherlands	**Positive**	5.36 (4.73, 5.82)	9.85 (6.94, 11.9)	17.1 (8.17, 24.9)	29.4 (8.75, 58.9)

	Medium	4.59 (4.24, 4.88)	8.26 (7.53, 8.96)	15.1 (12.6, 17.9)	71.5 (35.7, 143)
	Negative	4.65 (4.31, 4.98)	8.52 (7.87, 9.14)	16.5 (14.6, 18.9)	Not Reliable
Japan	**Positive**	1.13 (1, 1.28)	1.32 (1.16, 1.5)	1.57 (1.31, 1.86)	3.26 (1.63, 6.52)
	Medium	1.32 (1.05, 1.54)	1.54 (1.23, 1.77)	1.87 (1.4, 2.2)	7.06 (1.76, 14.1)
	Negative	1.13 (0.977, 1.29)	1.35 (1.16, 1.55)	1.65 (1.4, 1.94)	Not Reliable

Note:

- Data source: European Centre for Disease Prevention and Control (ECDC), https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases.
- The positive and medium scenarios are based on the Generalized Logistic Model and the Logistic Model. The model with the lowest mean predicted final total confirmed number K is classified as the positive scenario, and the other one is classified as the medium scenario. The negative scenario is based on Generalized Growth model, which should only describe the early stage of the epidemic outbreak.
- The values in parentheses are 95% prediction intervals based on 500 simulations from the negative binomial error structure.

Limitations of using the statistics of reported confirmed number

It is important to understand what our prediction models show. The predictions are based on cases identified on the basis of testing and they therefore predict the numbers of future positive tests. Relating positive test results to real levels of infection is subject to a large number of biases. It is a fact that the real number of infections is far higher than those recorded in positive tests since only a tiny fraction of any population has been tested. It is also the case that, in most countries, testing is biased towards those who think they are infected. The first bias, therefore, will underestimate the real number of infections while the second bias will tend to overestimate since it is biased towards those who think they are ill.

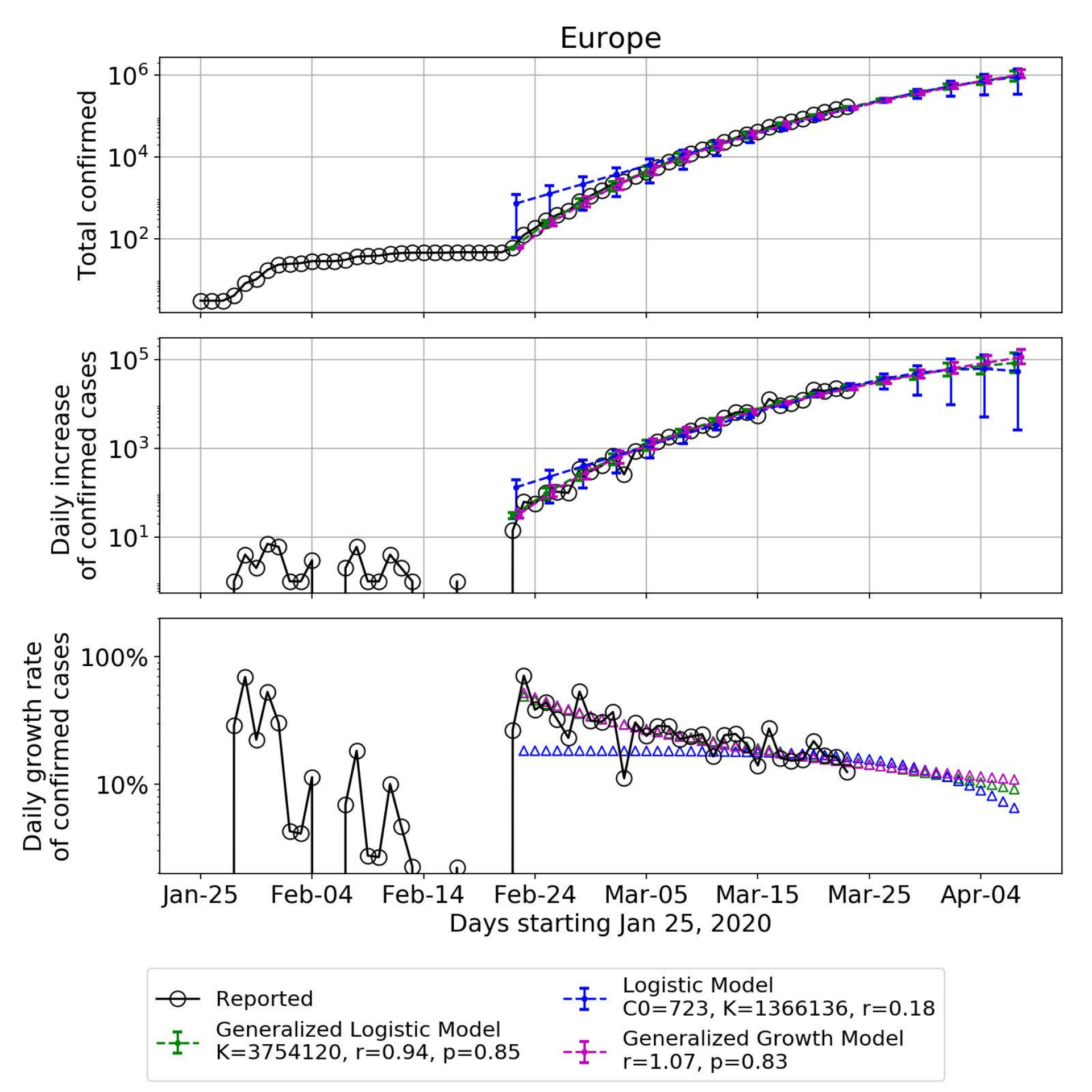
There are further complications. Depending on the testing protocols used, in some instances false positive results have been obtained. In other words, someone without the disease tested positive, probably because they were infected with some other coronavirus. And in other cases, false negative results were obtained, as was the case with the early testing deployed in the USA.

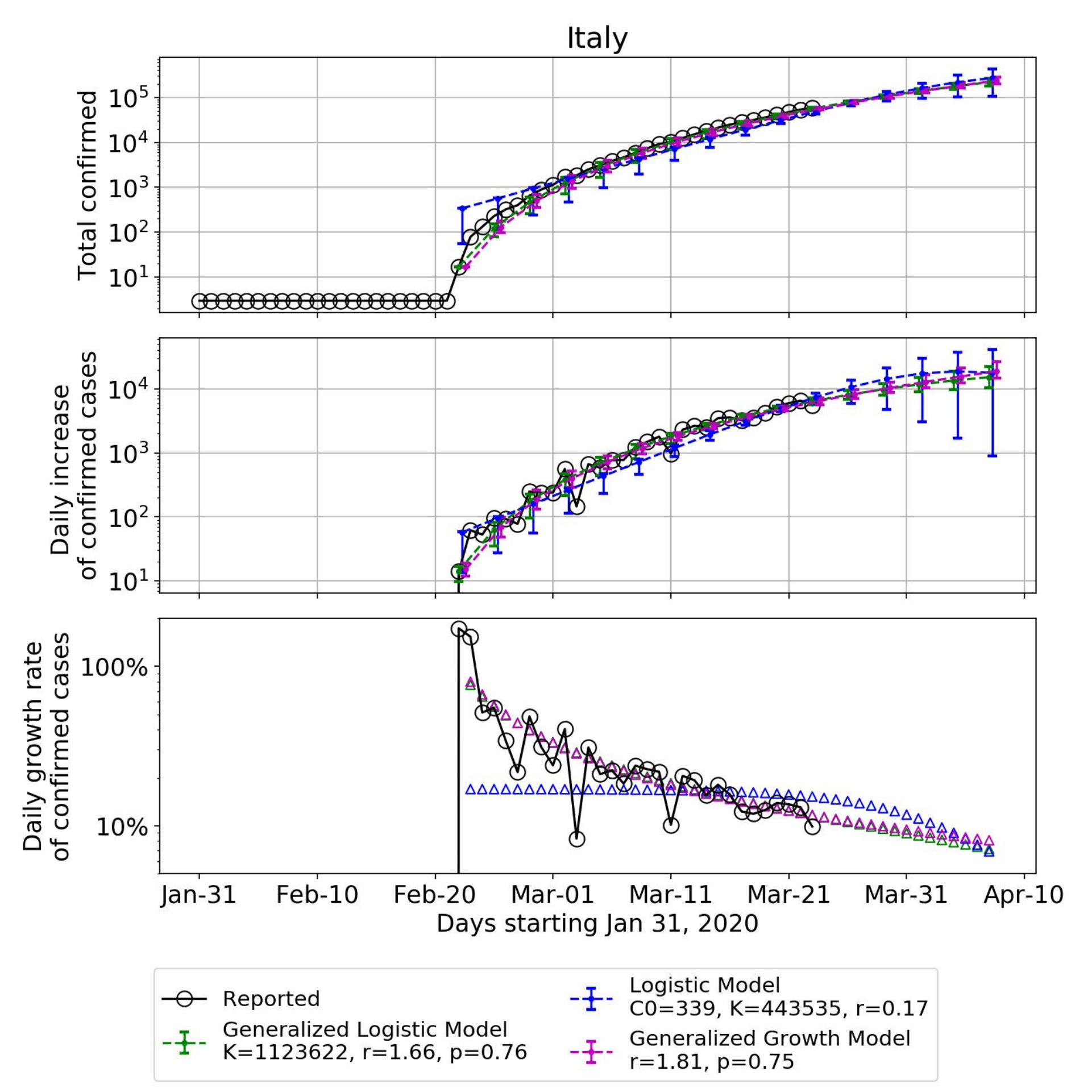
One final complication is the fact that tests are conducted sequentially over time. They do not represent a snapshot of a day in time. Many of those tested early, given a negative result, may today get a positive result. And many who tested positive early on, may today

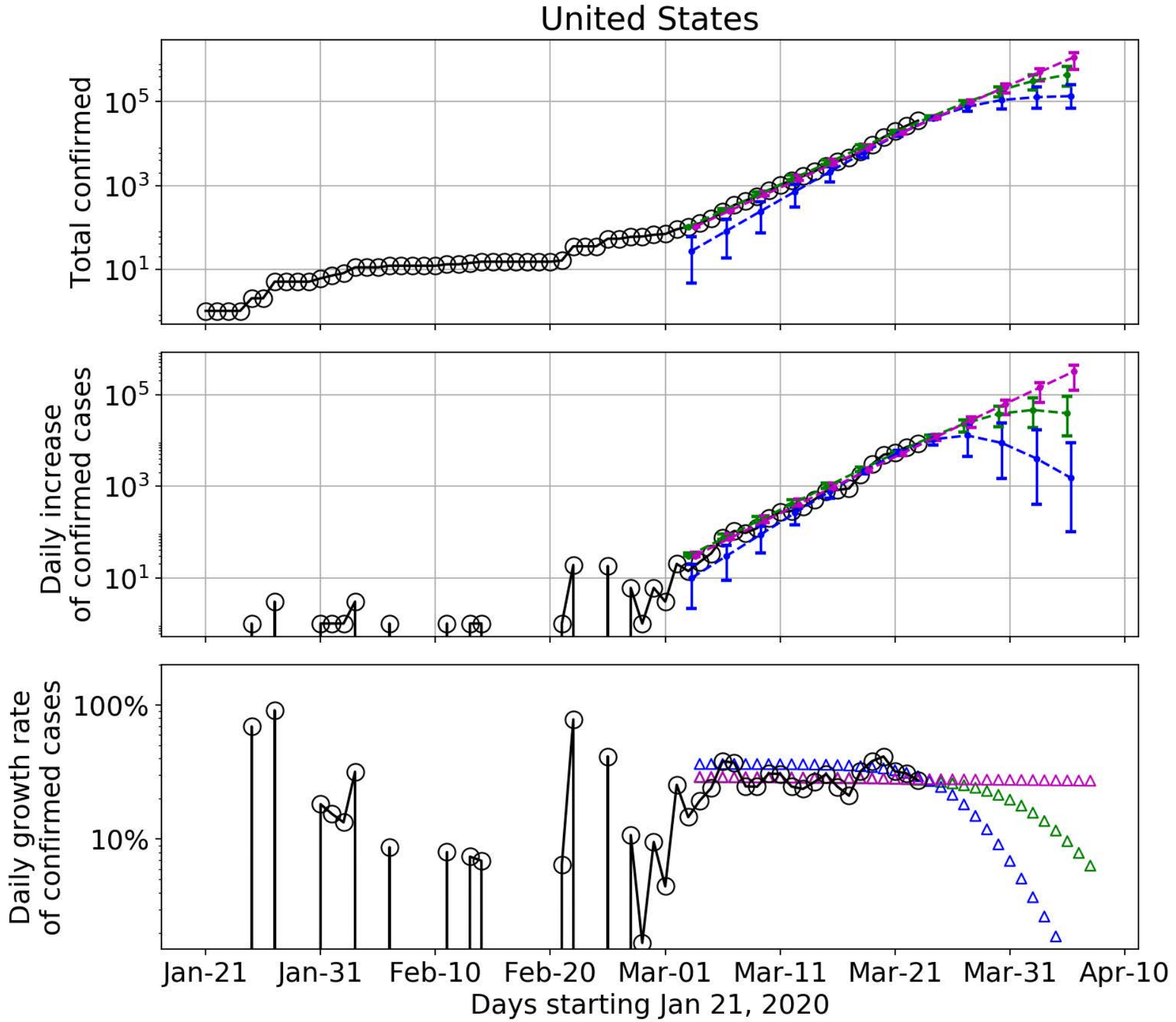
be cured.

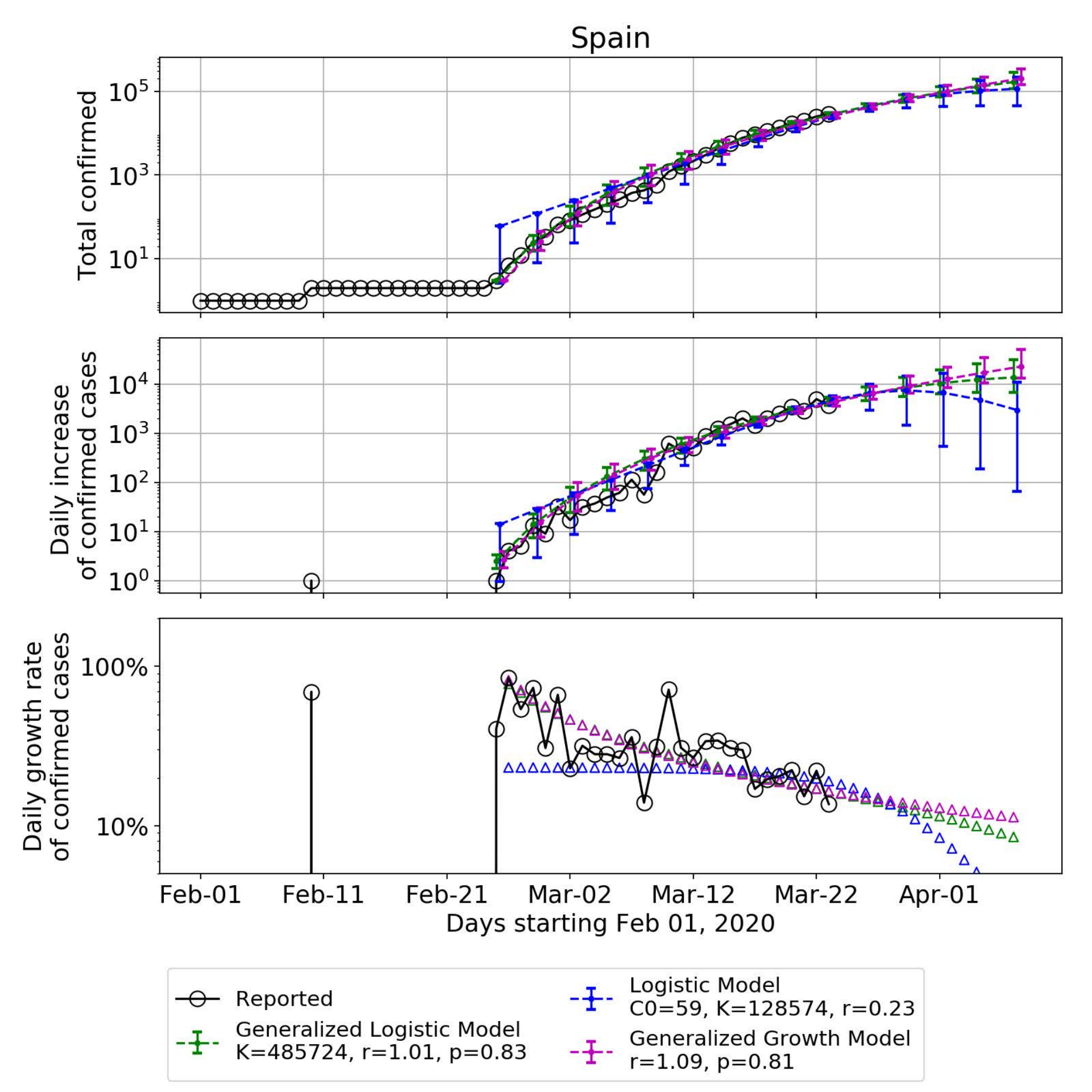
We anticipate that, over time, our methodology will improve and will provide a more accurate picture of the true levels of infection and where they are headed.

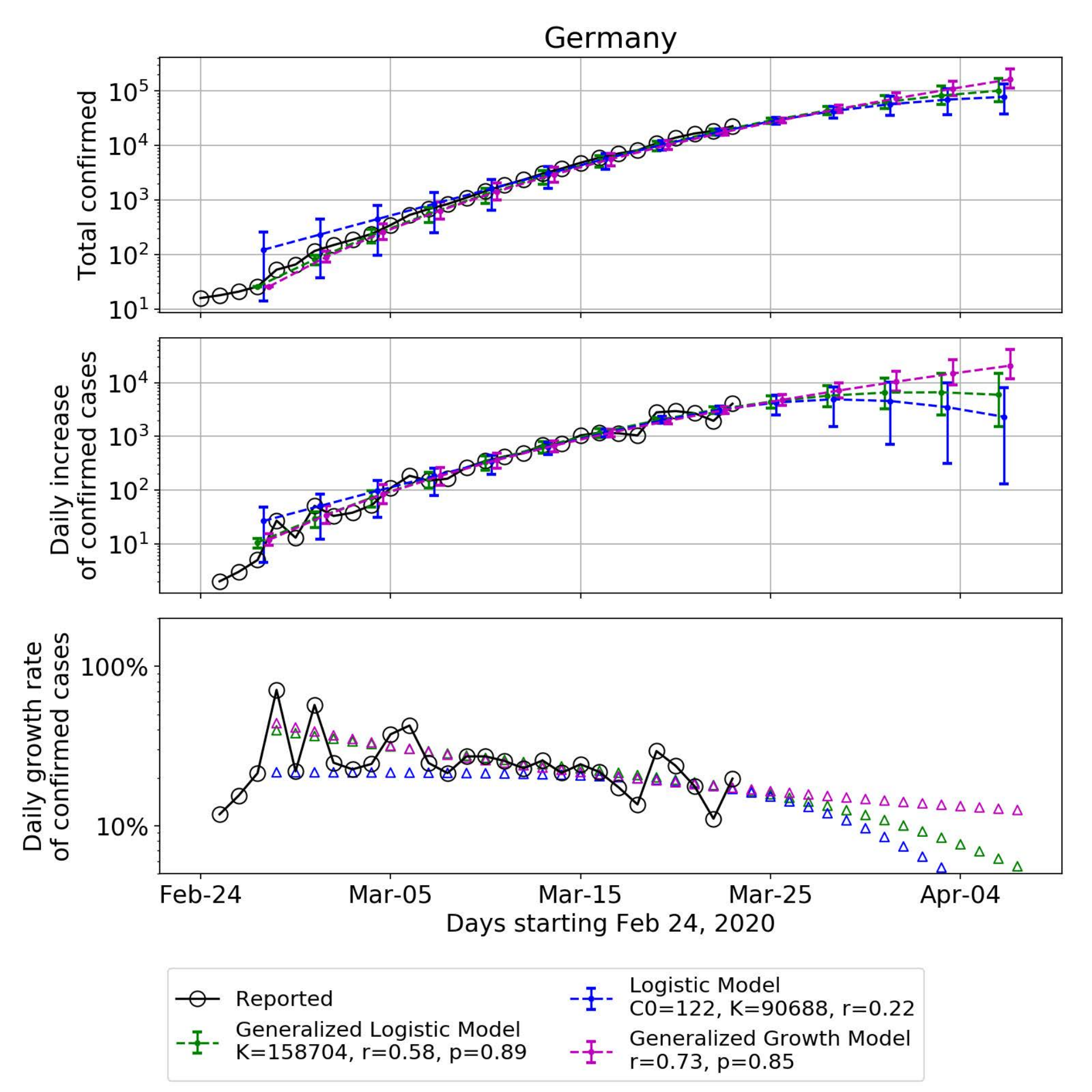
[1] Ke Wu, Didier Darcet, Qian Wang and Didier Sornette, Generalized logistic growth modeling of the COVID-19 outbreak in 29 provinces in China and in the rest of the world, preprint at http://arxiv.org/abs/2003.05681 and
medRxiv: https://medrxiv.org/cgi/content/short/2020.03.11.20034363v1

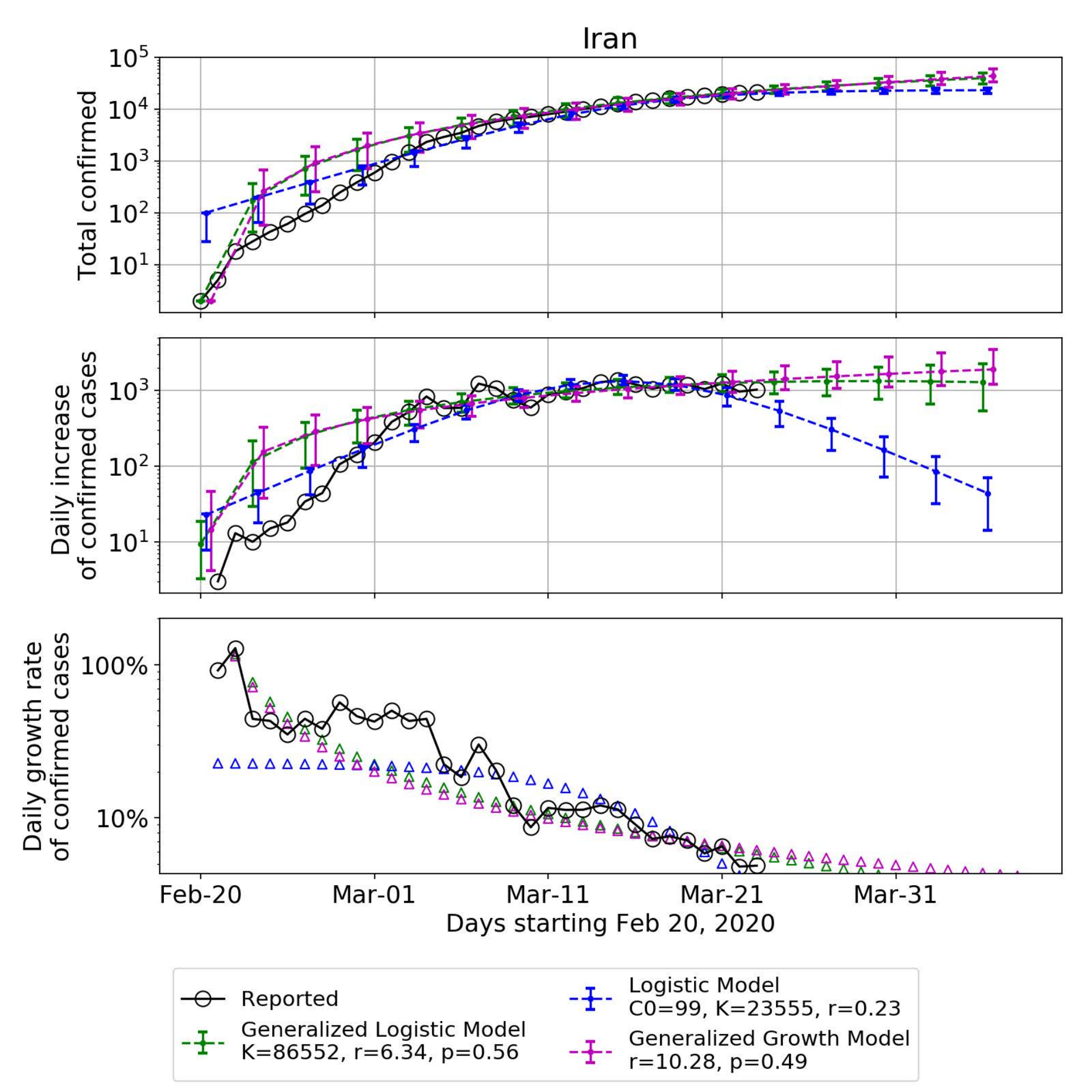

Europe
Total confirmed
10^6
10^4
10^2
Daily increase of confirmed cases
10^5
10^3
10^1
Daily growth rate of confirmed cases
100%
10%
Jan-25
Feb-04
Feb-14
Feb-24
Mar-05
Mar-15
Mar-25
Apr-04
Days starting Jan 25, 2020
Reported
Generalized Logistic Model
K=3754120, r=0.94, p=0.85
Logistic Model
C0=723, K=1366136, r=0.18
Generalized Growth Model
r=1.07, p=0.83

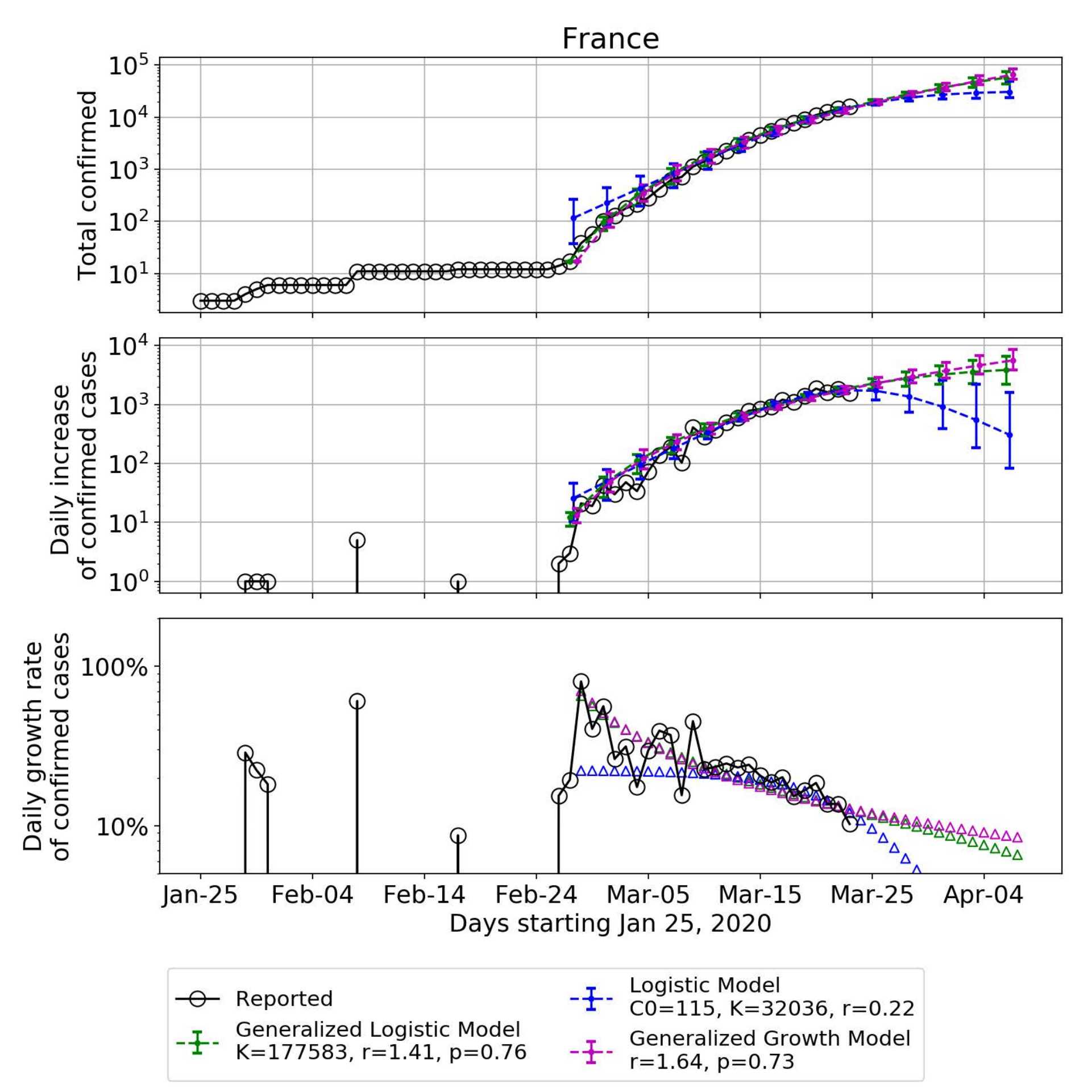

Italy
Total confirmed
10^5
10^4
10^3
10^2
10^1
Daily increase
of confirmed cases
10^4
10^3
10^2
10^1
Daily growth rate
of confirmed cases
100%
10%
Jan-31
Feb-10
Feb-20
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Days starting Jan 31, 2020
Reported
Generalized Logistic Model
K=1123622, r=1.66, p=0.76
Logistic Model
C0=339, K=443535, r=0.17
Generalized Growth Model
r=1.81, p=0.75

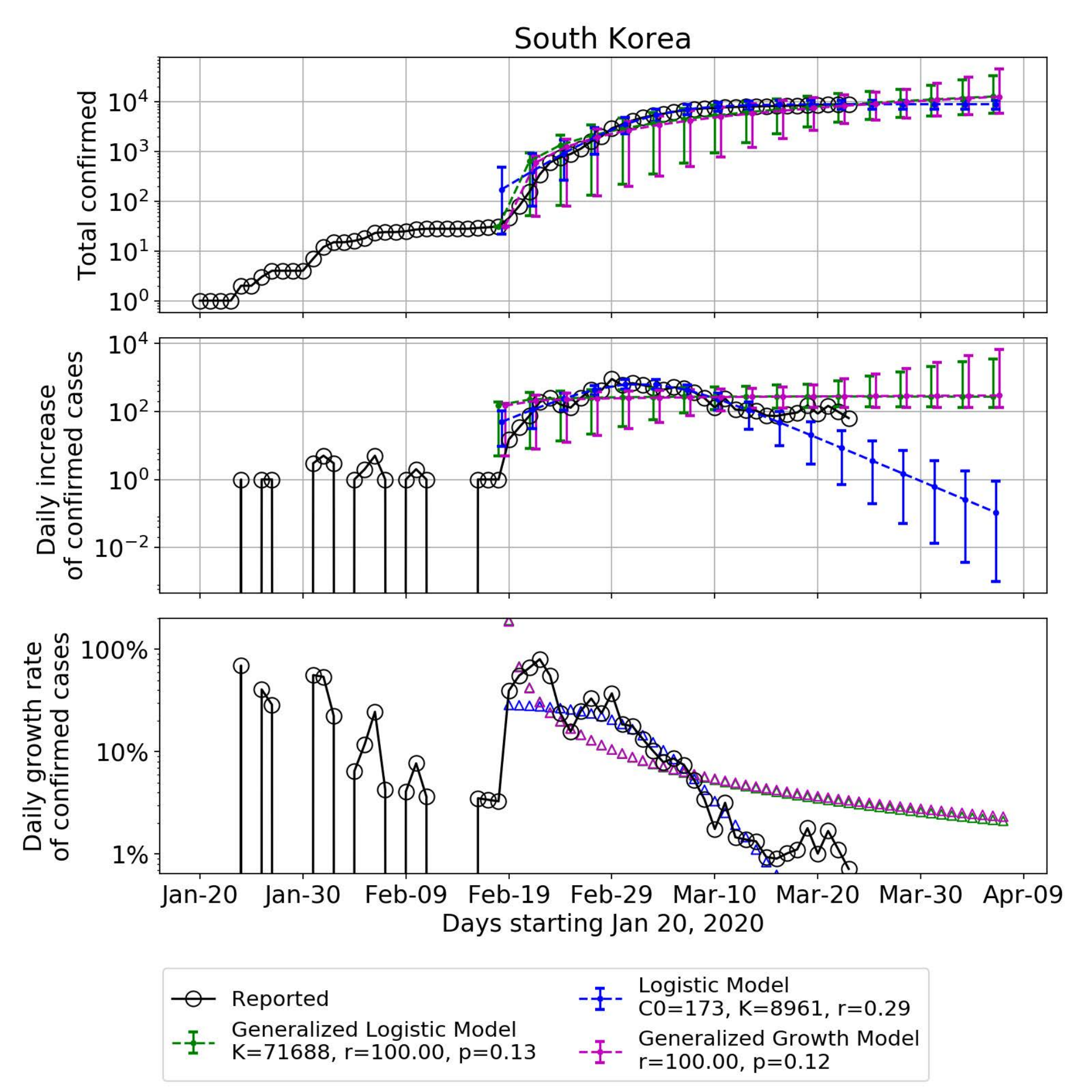

United States
Total confirmed
10^5
10^3
10^1
Daily increase
of confirmed cases
10^5
10^3
10^1
Daily growth rate
of confirmed cases
100%
10%
Jan-21
Jan-31
Feb-10
Feb-20
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Days starting Jan 21, 2020
Reported
Generalized Logistic Model
K=634362, r=0.29, p=1.00
Logistic Model
C0=27, K=140824, r=0.36
Generalized Growth Model
r=0.30, p=0.99

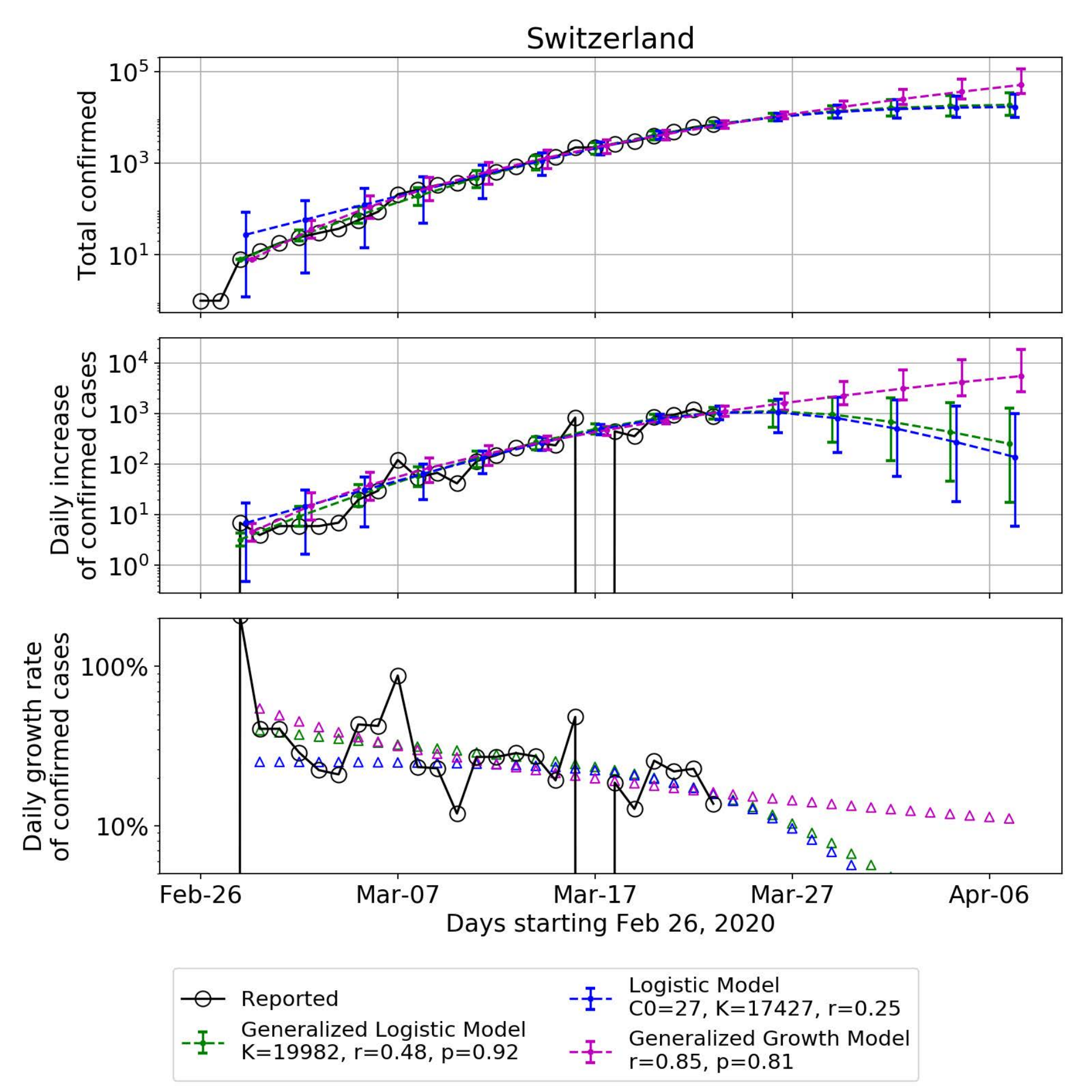

Spain
Total confirmed
10^5
10^3
10^1
Daily increase
of confirmed cases
10^4
10^3
10^2
10^1
10^0
Daily growth rate
of confirmed cases
100%
10%
Feb-01
Feb-11
Feb-21
Mar-02
Mar-12
Mar-22
Apr-01
Days starting Feb 01, 2020
Reported
Generalized Logistic Model
K=485724, r=1.01, p=0.83
Logistic Model
C0=59, K=128574, r=0.23
Generalized Growth Model
r=1.09, p=0.81

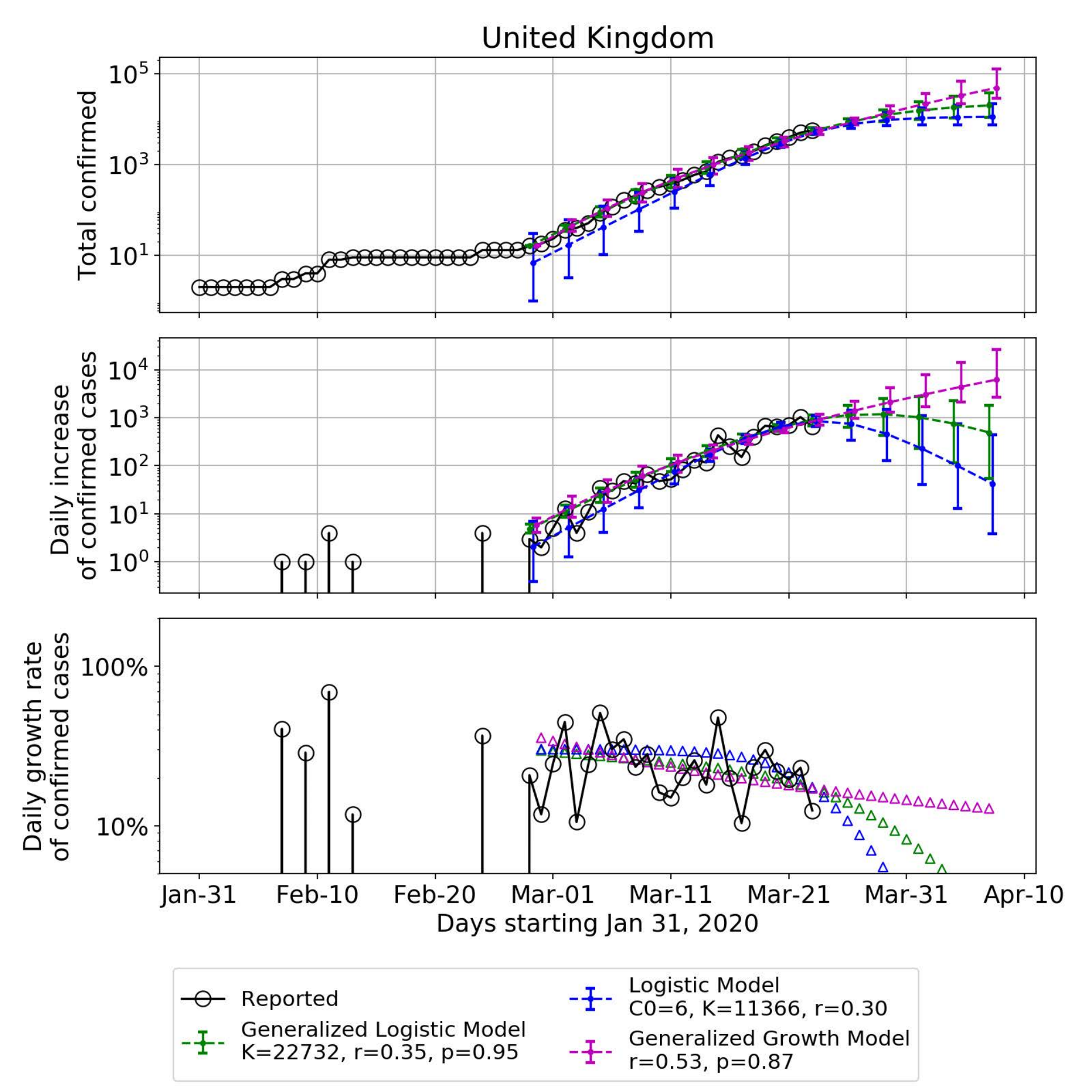

Germany
Total confirmed
10^5
10^4
10^3
10^2
10^1
Daily increase of confirmed cases
10^4
10^3
10^2
10^1
Daily growth rate of confirmed cases
100%
10%
Feb-24
Mar-05
Mar-15
Mar-25
Apr-04
Days starting Feb 24, 2020
Reported
Generalized Logistic Model
K=158704, r=0.58, p=0.89
Logistic Model
C0=122, K=90688, r=0.22
Generalized Growth Model
r=0.73, p=0.85

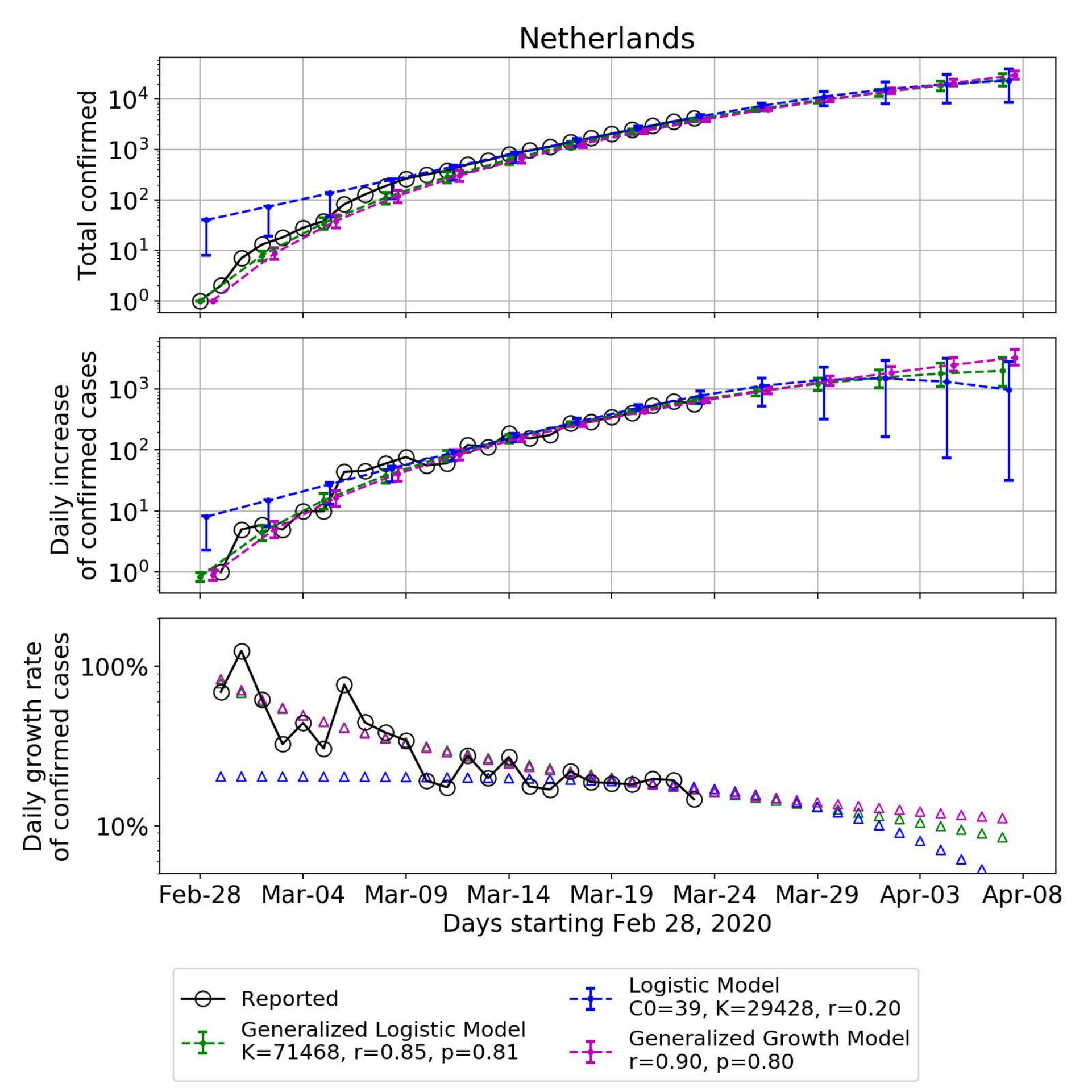

Iran
Total confirmed
Daily increase of confirmed cases
Daily growth rate of confirmed cases
100%
10%
Feb-20
Mar-01
Mar-11
Mar-21
Mar-31
Days starting Feb 20, 2020
Reported
Generalized Logistic Model
K=86552, r=6.34, p=0.56
Logistic Model
C0=99, K=23555, r=0.23
Generalized Growth Model
r=10.28, p=0.49

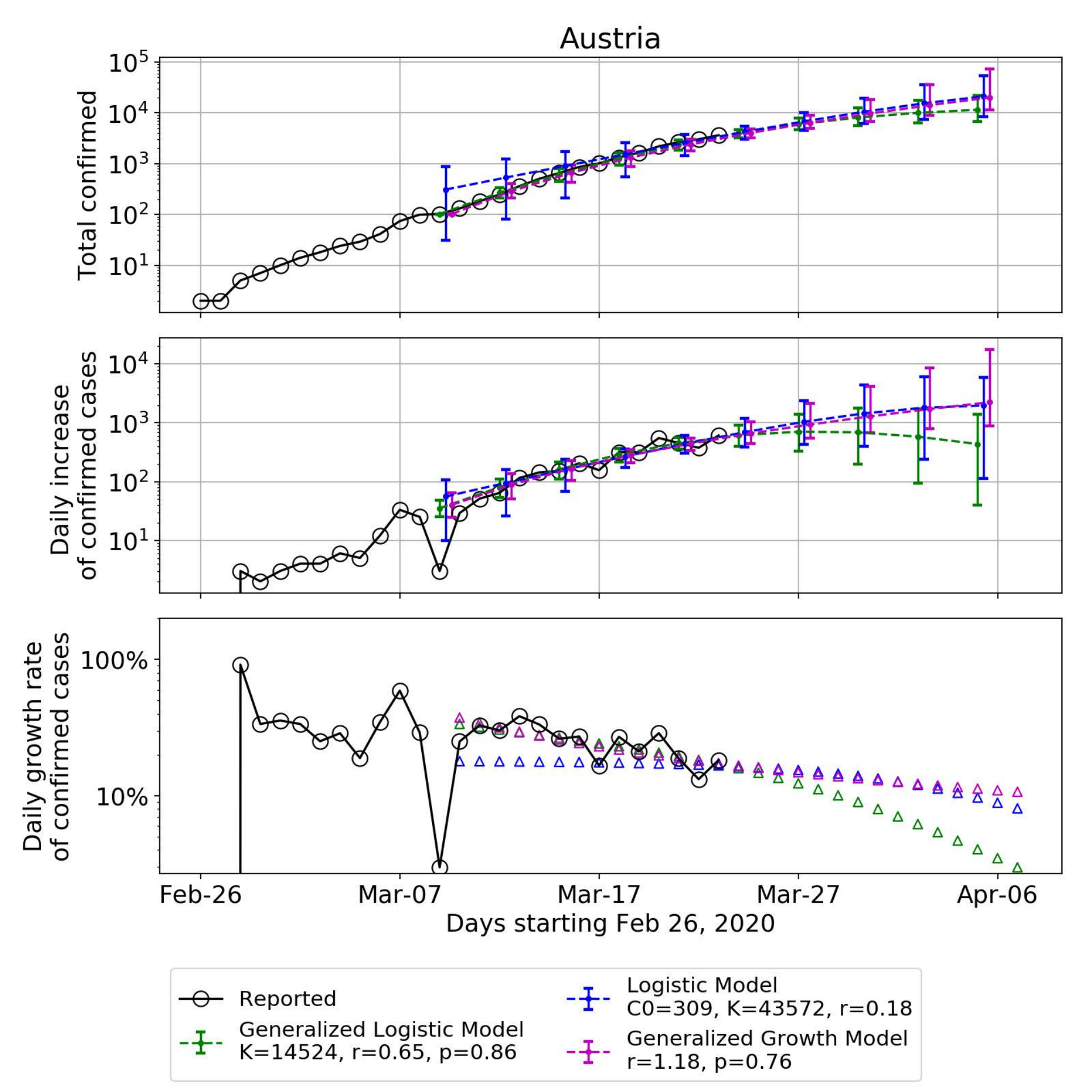

France
Total confirmed
Daily increase of confirmed cases
Daily growth rate of confirmed cases
100%
10%
Jan-25
Feb-04
Feb-14
Feb-24
Mar-05
Mar-15
Mar-25
Apr-04
Days starting Jan 25, 2020
Reported
Generalized Logistic Model
K=177583, r=1.41, p=0.76
Logistic Model
C0=115, K=32036, r=0.22
Generalized Growth Model
r=1.64, p=0.73

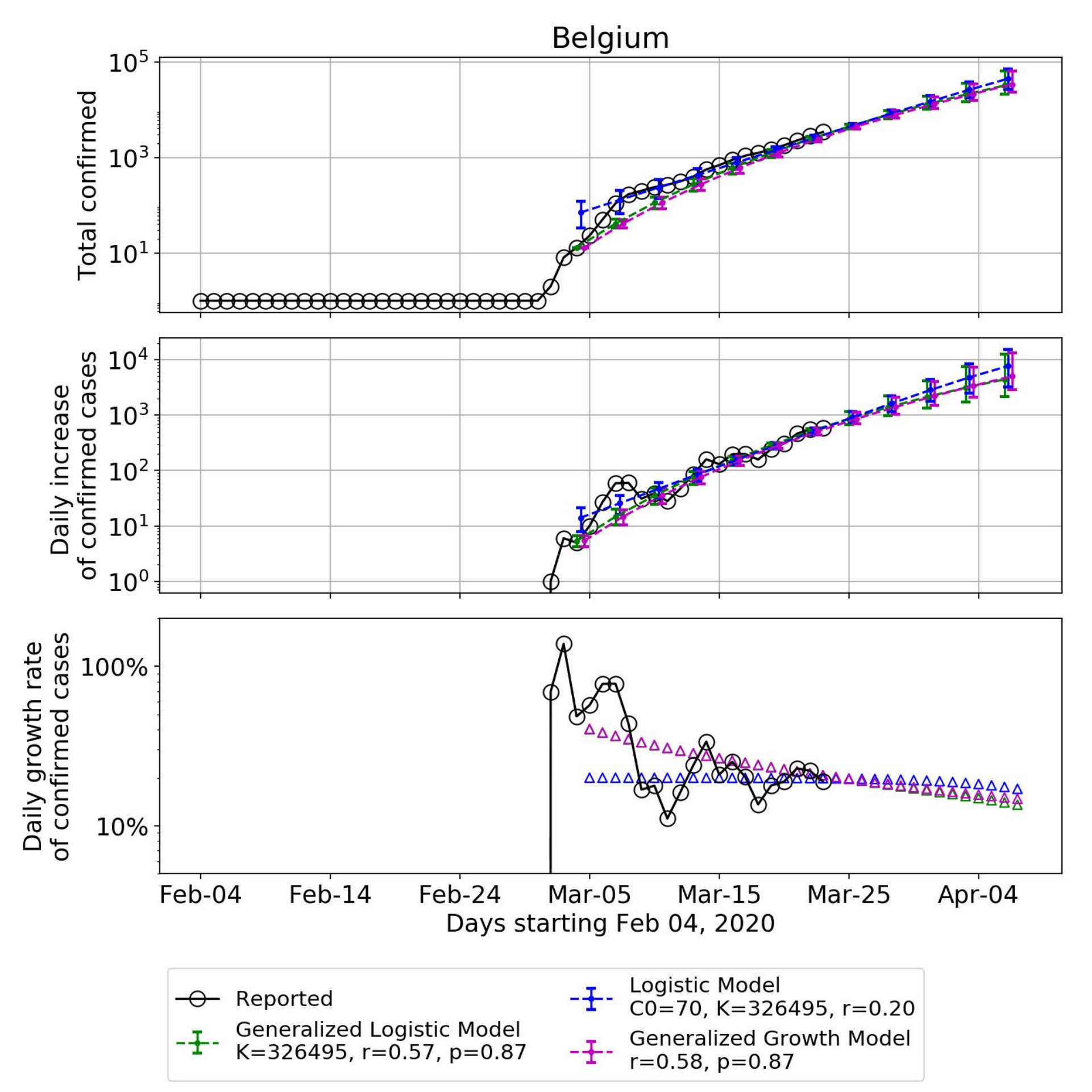

South Korea
Total confirmed
Daily increase of confirmed cases
Daily growth rate of confirmed cases
Jan-20
Jan-30
Feb-09
Feb-19
Feb-29
Mar-10
Mar-20
Mar-30
Apr-09
Days starting Jan 20, 2020
Reported
Generalized Logistic Model
K=71688, r=100.00, p=0.13
Logistic Model
C0=173, K=8961, r=0.29
Generalized Growth Model
r=100.00, p=0.12

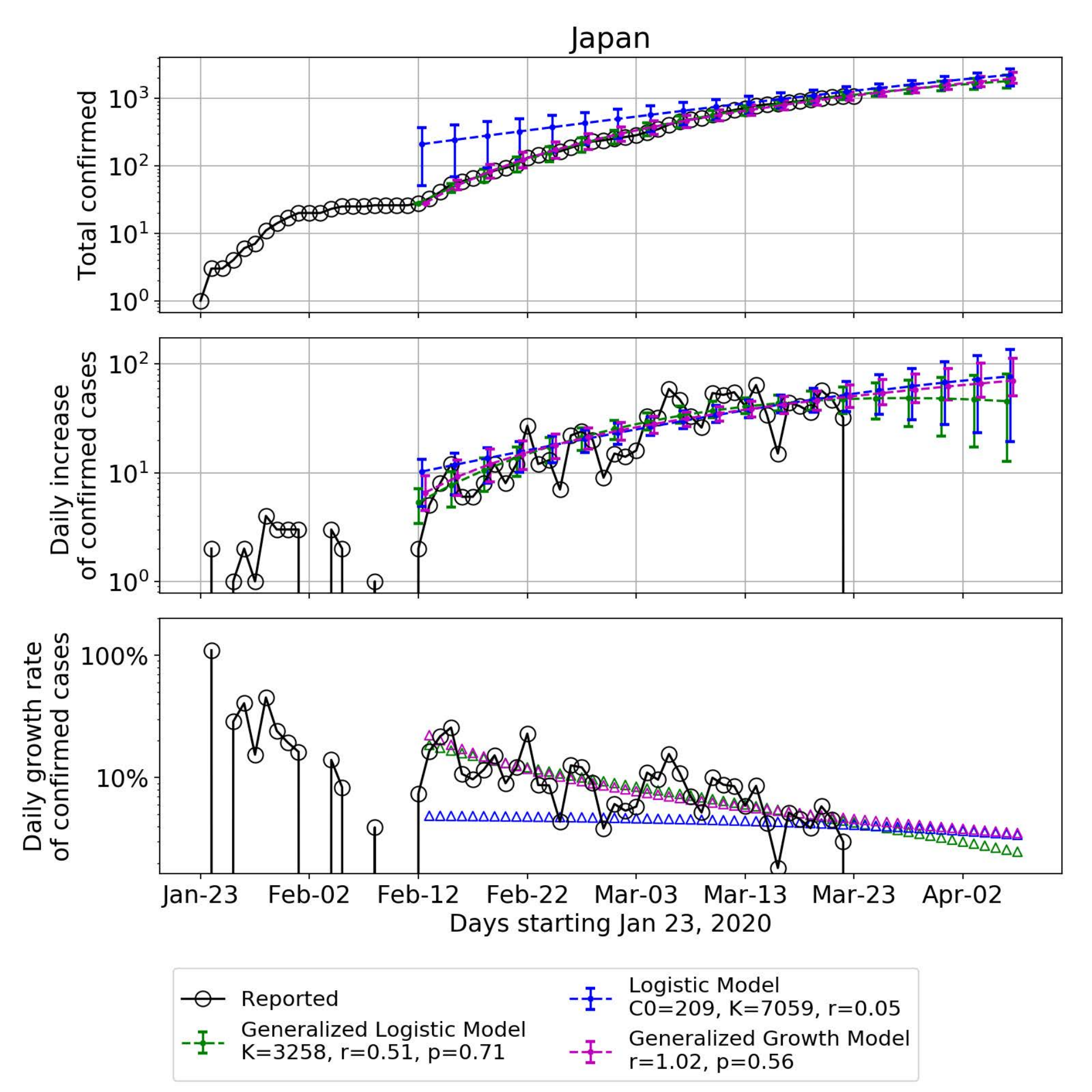

Switzerland
Total confirmed
10^5
10^3
10^1
Daily increase of confirmed cases
10^4
10^3
10^2
10^1
10^0
Daily growth rate of confirmed cases
100%
10%
Feb-26
Mar-07
Mar-17
Mar-27
Apr-06
Days starting Feb 26, 2020
Reported
Generalized Logistic Model
K=19982, r=0.48, p=0.92
Logistic Model
C0=27, K=17427, r=0.25
Generalized Growth Model
r=0.85, p=0.81


United Kingdom
Total confirmed
10^5
10^3
10^1
Daily increase of confirmed cases
10^4
10^3
10^2
10^1
10^0
Daily growth rate of confirmed cases
100%
10%
Jan-31
Feb-10
Feb-20
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Days starting Jan 31, 2020
Reported
Generalized Logistic Model
K=22732, r=0.35, p=0.95
Logistic Model
C0=6, K=11366, r=0.30
Generalized Growth Model
r=0.53, p=0.87


Netherlands
Total confirmed
10^4
10^3
10^2
10^1
10^0
Daily increase of confirmed cases
10^3
10^2
10^1
10^0
Daily growth rate of confirmed cases
100%
10%
Feb-28
Mar-04
Mar-09
Mar-14
Mar-19
Mar-24
Mar-29
Apr-03
Apr-08
Days starting Feb 28, 2020
Reported
Generalized Logistic Model
K=71468, r=0.85, p=0.81
Logistic Model
C0=39, K=29428, r=0.20
Generalized Growth Model
r=0.90, p=0.80


Austria
Total confirmed
Daily increase of confirmed cases
Daily growth rate of confirmed cases
100%
10%
Feb-26
Mar-07
Mar-17
Mar-27
Apr-06
Days starting Feb 26, 2020
Reported
Generalized Logistic Model
K=14524, r=0.65, p=0.86
Logistic Model
C0=309, K=43572, r=0.18
Generalized Growth Model
r=1.18, p=0.76


Belgium
Total confirmed
Daily increase of confirmed cases
Daily growth rate of confirmed cases
100%
10%
Feb-04
Feb-14
Feb-24
Mar-05
Mar-15
Mar-25
Apr-04
Days starting Feb 04, 2020
Reported
Generalized Logistic Model
K=326495, r=0.57, p=0.87
Logistic Model
C0=70, K=326495, r=0.20
Generalized Growth Model
r=0.58, p=0.87


Japan
Total confirmed
Daily increase of confirmed cases
Daily growth rate of confirmed cases
100%
10%
Jan-23
Feb-02
Feb-12
Feb-22
Mar-03
Mar-13
Mar-23
Apr-02
Days starting Jan 23, 2020
Reported
Generalized Logistic Model
K=3258, r=0.51, p=0.71
Logistic Model
C0=209, K=7059, r=0.05
Generalized Growth Model
r=1.02, p=0.56