# COVID-19 Confirmed Cases and Cumulative Mortality Predictions as of April 23, 2020

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**Summary of the situation:**

- Europe reached 1.23 million confirmed cases today with a 2.7% growth rate, compared with 2.8% yesterday. The decay of the after-peak trajectory continues slowly, as shown from the small estimated parameter "a" (=0.23) in the generalized Richards model. It is also important to understand that confirmed infections undershoot actual infections by a very large margin (see Supplements to COVID-19 Confirmed Cases Prediction This version: April 15, 2020[1]). Figure 1 allows us to suggest that the distributions of final confirmed numbers in all rich cool north countries are converging, while hot north and S hemisphere countries are not. However, the distributions of final deaths have not converged in most countries, as the number of deaths is lagging behind confirmed cases.

- The US reached 843K total confirmed cases today, with a 2.1% growth rate, compared with 4.7% yesterday. The epidemic in the USA seems to be maturing and reaching an inflection point[2], although the daily mortality curve has not reached the inflection point. Similar to Europe, the decay of after-peak trajectory is expected to be slow, likely linked to large numbers on patients on ventilators that continue to die for several weeks. See [1] for further analysis on US test numbers and confirmed case numbers.

- Austria, Switzerland, Spain, Italy, Ireland, Germany, France and Portugal are the countries with most mature outbreaks with strong signs that inflection points have been passed. They all have an outbreak progress larger than 80% in medium scenario. The mortality numbers in these countries also supports an after-peak trajectory. Austria and Switzerland, identified as the two most mature countries, have been the first countries to publish the lift of the lockdown measures[3].

- Belgium, Netherlands, UK and Turkey are less matured with outbreak progress in the range 60-80% in medium scenario. They may continue to follow the generalized exponential model, resulting in high uncertainties. Apart from Turkey, the other three countries have their distributions of final confirmed cases and deaths converged.

- Russia, Brazil, Sweden, Turkey and Japan continue their previous exponential growth, indicating highly uncertain future projections, as shown by their non-converged or highly dispersed ensemble distributions of final confirmed cases (Figure 1). The transmission in Japan seems to slow down. The sudden jump in today's death is because deaths that are pending to be confirmed cases are included in the statistics. In terms of per capita deaths, Russia, Brazil and Japan do not yet have real epidemics compared to West European countries.

- Our predictions for confirmed cases yesterday are correct in all countries except, again, an undershot in Russia (see figure 2).

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[1] https://ethz.ch/content/dam/ethz/special-interest/mtec/chair-of-entrepreneurial-risks-dam/documents/Covid-19/Covid_Supplements_15April2020.pdf

[2] On a logistic curve, the inflection point indicates where the curvature changes its sign. As we model the total number of confirmed cases, it is equal to the peak of the daily increase curve, after which the daily number of cases is decreasing. If the inflection point has been passed, the worst of the outbreak is over.

[3] Switzerland has announced on April 16 its three-phase plan to rollback coronavirus lockdown: phase 1=April 17, phase 2= May 11, phase 3=June 8. Austria started reopening non-essential stores since April 13. (https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-78818.html) (https://www.theguardian.com/world/2020/apr/14/austria-reopens-small-shops-and-parks-as-coronavirus-lockdown-is-relaxed)

Method:

This report updates predictions for the number of COVID-19 confirmed cases and deaths 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]. We employ 4 versions of the generalized logistic growth equation to model the total number of confirmed cases and deaths, resulting in a positive, medium and negative scenario for the final expected number of cases/deaths as explained in the last page. 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. The predicted ranges overlap and, as time passes, we anticipate our methodology to zero in on more reliable numbers. As mortality data, also from ECDC, is much noisier in many countries than the infection numbers, since today we use 7 days moving average for the fitting and simulations to account for weekly seasonality, instead of 3 days moving average. The data is neither normalized by population nor time-shifted for the calibrations.

Data source: European Centre for Disease Prevention and Control (ECDC) [2] updated every day at 1pm CET, reflecting data collected up to 6:00 and 10:00 CET. Thus the daily data in some countries is one day delayed compared to other online live sources.

Key Figures & Tables:

-In Table 1, we report the latest confirmed cases per million population and the estimated outbreak progress in the positive and medium scenario (today's confirmed cases divided by the estimated total final confirmed case in positive and now additionally in medium scenarios).

-In Table 2 and Table 3, we report the prediction results of confirmed cases (Table 2) and deaths (Table 3) in each selected country/region at four time horizons (1-day, 5-day, 10-day and end of the outbreak) in three scenarios. The detailed fitting results for each country/region are plotted in the figures at the end of this report.

-In Figure 1, we present a distribution of the estimated final total confirmed cases and deaths per million population based on the positive and medium scenario.

-In Figure 2, we show the 1-day prediction error of yesterday's report.

- At the end of this report, we present two figures for each country, where the total number of confirmed cases/deaths are in the upper panel (log scale), the daily confirmed cases / deaths in the middle panel, and the daily growth rate of confirmed cases / deaths in the lower panel (log scale), respectively. The empirical data is marked by the empty circles. The blue, red, purple and green lines in the upper, middle and lower left panels show the fits with the Logistic Growth Model, Generalized Richards Model (GRM), Generalized Growth Model (GGM) and Generalized Logistic Model (GLM) respectively.

Comment: We need to emphasize that reported confirmed cases are a leading indicator that is subject to a large number of extraneous variables such as sampling rate[4], sample targeting and reliability of testing. See note at end of this report. The real number of cases in the population is likely to be many multiples higher than those computed from confirmed tests.

[4] For instance, The UK is experiencing issues with raising the testing rate linked to a global shortage of certain key reagents and swabs. From April 1st, all testing is to be targeted at health sector staff and this will obviously bias future data compared with past data.

**Table 1.** Current confirmed cases per million population and estimated outbreak progress in positive and medium scenarios (today's confirmed cases divided by the estimated total final confirmed cases in positive and medium scenario). **The ranking is in terms of outbreak progress in medium scenario (fourth column from left).** Numbers in brackets are 80% confidence intervals. As positive scenarios predict a smaller final number of total infected cases, the outbreak progress is thus larger in the positive scenario. Note that the estimated final confirmed numbers tend to underestimate the final results, thus the estimated outbreak progress serves both as a lower bound for future developments and as a guide of the dynamics of the evolution of the epidemics[5]. The number of tests per million population and confirmed cases per test are presented in the last two columns based on the information from Wikipedia [3].

| | Confirmed per Million Population (Apr-23) | Outbreak Progress in Positive Scenario | Outbreak Progress in Medium Scenario | Tests per Million Population (update date in brackets) | Confirmed Cases per Test (update date in brackets) |
|---|---|---|---|---|---|
| Austria | 1687 | 100% (93.6%, 100%) | 99.7% (94.4%, 100%) | 23121 (Apr 23) | 7.3% (Apr 23) |
| Switzerland | 3310 | 93.3% (88.1%, 98.9%) | 92.4% (88.5%, 97.0%) | 26948 (Apr 22) | 12.1% (Apr 22) |
| Germany | 1785 | 91.9% (87.5%, 97.1%) | 90.8% (86.7%, 94.8%) | 24927 (Apr 21) | 6.9% (Apr 21) |
| France | 1779 | 90.2% (82.7%, 98.2%) | 89.6% (81.8%, 98.1%) | 5455 (Apr 12) | 25.7% (Apr 12) |
| Spain | 4460 | 89.7% (84.0%, 95.4%) | 87.9% (83.4%, 92.2%) | 19905 (Apr 13) | 17.8% (Apr 13) |
| Italy | 3100 | 86.4% (82.4%, 90.5%) | 84.1% (80.4%, 88.2%) | 24025 (Apr 21) | 12.5% (Apr 21) |
| Ireland | 3435 | 86.5% (77.4%, 95.3%) | 83.0% (74.7%, 90.5%) | 23433 (Apr 20) | 13.7% (Apr 20) |
| Portugal | 2138 | 80.3% (71.8%, 89.2%) | 79.6% (68.6%, 90.3%) | 22953 (Apr 23) | 7.3% (Apr 23) |
| Belgium | 3667 | 74.4% (63.7%, 82.7%) | 71.6% (59.0%, 84.7%) | 14059 (Apr 20) | 23.8% (Apr 20) |
| Netherlands | 2022 | 73.7% (68.1%, 78.5%) | 68.9% (62.2%, 77.4%) | 9470 (Apr 20) | 19.8% (Apr 20) |
| Europe | 1649 | 72.8% (67.6%, 77.2%) | 68.6% (63.6%, 73.4%) | NA | NA |
| United States | 2576 | 72.5% (65.3%, 79.9%) | 68.3% (62.0%, 77.1%) | 13620 (Apr 22) | 18.5% (Apr 22) |
| United Kingdom | 2008 | 71.1% (64.8%, 77.1%) | 67.6% (59.4%, 76.3%) | 8639 (Apr 23) | 22.9% (Apr 23) |
| Turkey | 1199 | 68.0% (55.0%, 78.9%) | 66.2% (60.5%, 71.6%) | 9031 (Apr 22) | 12.7% (Apr 22) |
| Japan | 94 | 82.1% (77.1%, 86.9%) | 56.6% (43.0%, 64.0%) | 1035 (Apr 22) | 8.8% (Apr 22) |
| Sweden | 1572 | 56.8% (30.5%, 83.5%) | 54.8% (37.7%, 66.3%) | 9150 (Apr 21) | 15.6% (Apr 21) |
| Russia | 401 | 49.7% (41.4%, 57.0%) | 45.9% (33.2%, 51.0%) | 16366 (Apr 22) | 2.2% (Apr 22) |
| Brazil | 218 | 52.4% (36.2%, 64.6%) | 39.9% (1.6%, 58.5%) | 2266 (Apr 16) | 5.9% (Apr 16) |
| Iran | 1051 | Not reliable | Not reliable | 4397 (Apr 21) | 22.8% (Apr 21) |
| South Korea | 207 | Not reliable | Not reliable | 11293 (Apr 23) | 1.8% (Apr 23) |

[5]One uncertainty with Italy (and other countries) is whether the main outbreak that is focused on the North may spread through other parts of the country. In other words, does the dynamics aggregated over a whole country represent correctly the dynamics in different parts?

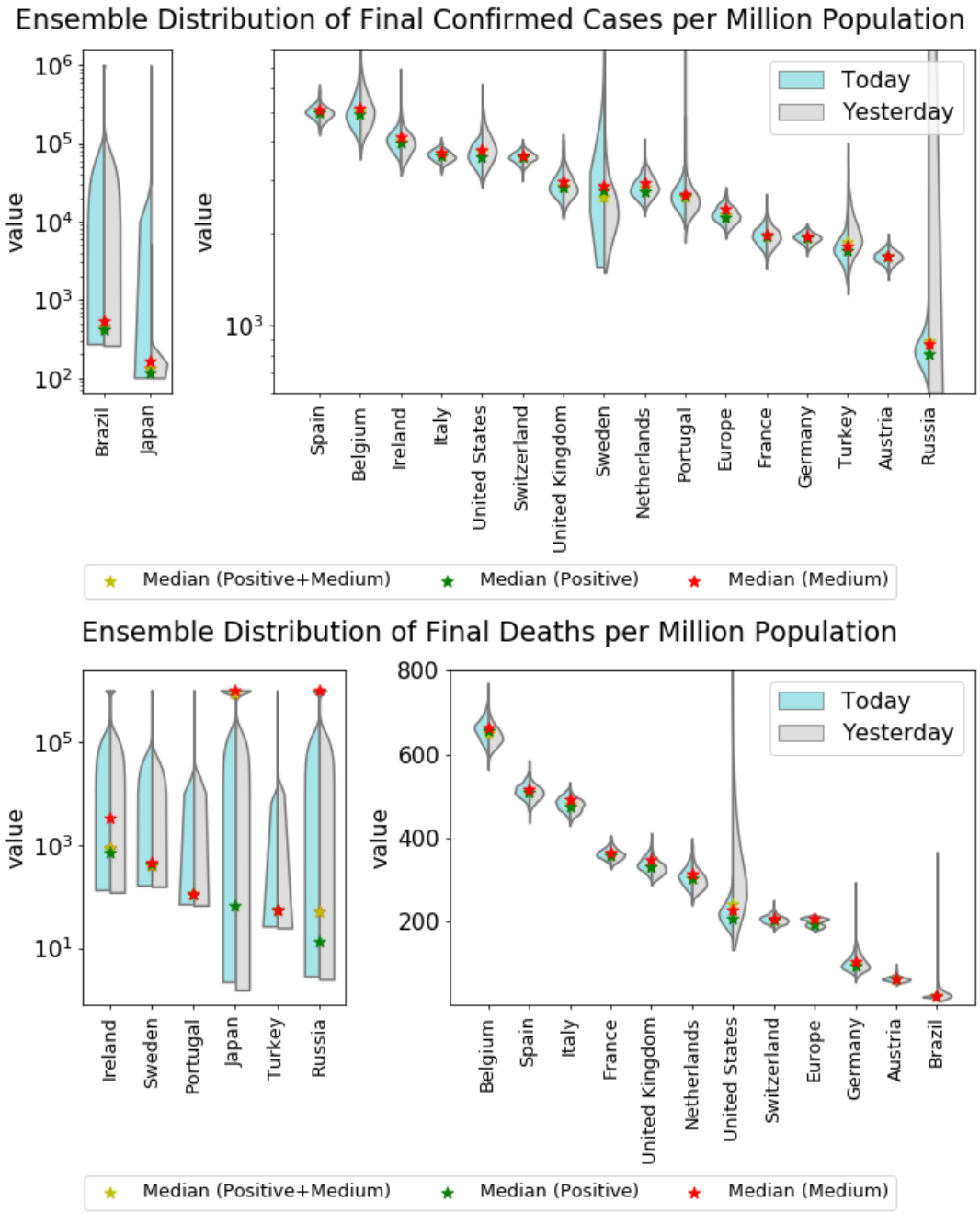


**Figure 1.** Violin plot of the distributions of the final total number of confirmed cases (upper panel) and deaths (lower panel) per million derived by combining the distributions of the positive and medium scenarios. The left side of each violin in cyan is today's distribution, while the right side of each violin in grey is yesterday's distribution. The model setup in the negative scenario does not incorporate a maximum saturation number and thus cannot be used. The yellow star indicates the median prediction for the combined distribution, while the green and red stars indicate the median of the positive and of the medium scenarios respectively. Note that, where we have >1 million infections or deaths per 1 million of population, the results are deemed to be unreliable (Table 2 & 3).

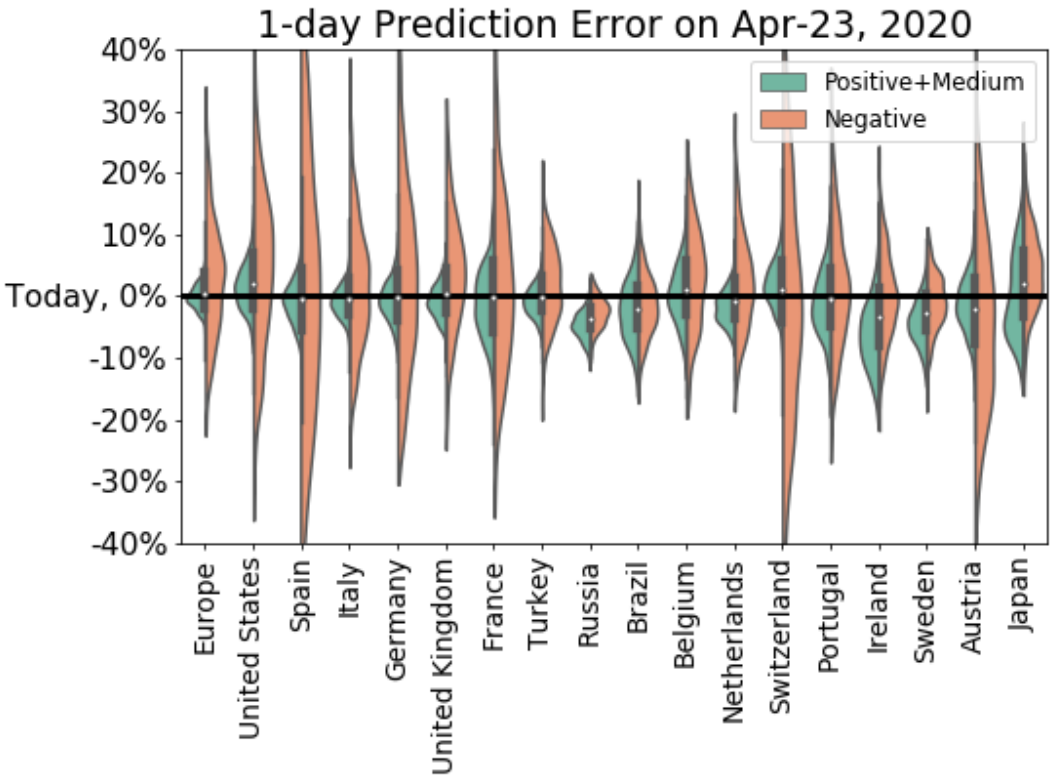


**Figure 2.** One-day prediction error of the forecast performed yesterday (April 21) for the total number of confirmed cases for the 13 countries/regions. The horizontal line corresponds to today's empirical data. We show the full distribution of errors for each of the two scenarios.

**Table 2.** 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. The values in parentheses are 80% prediction intervals based on 500 simulations using a negative binomial error structure. In Today's validation column, today's empirical data is presented below yesterday's 1-day predictive interval. "Not reliable" is declared if more than 10% of the simulations produce extreme numbers (larger than total population). All numbers are in thousands.

| Country | Scenario* | Today's validation | 24-Apr | 28-Apr | 3-May | Final Total Confirmed |
|---|---|---|---|---|---|---|
| Europe | Positive | (1190, 1270)<br>1230 | 1270<br>(1230, 1300) | 1360<br>(1310, 1400) | 1460<br>(1400, 1510) | 1690<br>(1590, 1820) |
| | Medium | (1200, 1260)<br>1230 | 1260<br>(1230, 1290) | 1360<br>(1320, 1390) | 1460<br>(1420, 1510) | 1790<br>(1680, 1930) |
| | Negative | (1120, 1420)<br>1230 | 1290<br>(1140, 1460) | 1470<br>(1300, 1660) | 1720<br>(1520, 1950) | Not Reliable |
| United States | Positive | (812, 904)<br>843 | 871<br>(827, 914) | 951<br>(901, 1000) | 1020<br>(961, 1090) | 1160<br>(1050, 1290) |
| | Medium | (821, 888)<br>843 | 866<br>(837, 899) | 949<br>(913, 987) | 1030<br>(979, 1080) | 1230<br>(1090, 1360) |
| | Negative | (722, 1020)<br>843 | 884<br>(733, 1050) | 1040<br>(869, 1250) | 1260<br>(1050, 1540) | Not Reliable |
| Spain | Positive | (196, 218)<br>208 | 211<br>(200, 224) | 219<br>(207, 231) | 224<br>(211, 238) | 232<br>(219, 248) |
| | Medium | (198, 214)<br>208 | 210<br>(203, 219) | 218<br>(210, 227) | 225<br>(216, 235) | 237<br>(226, 250) |
| | Negative | (153, 277)<br>208 | 214<br>(153, 281) | 243<br>(180, 326) | 283<br>(208, 389) | Not Reliable |
| Italy | Positive | (180, 193)<br>187 | 190<br>(183, 197) | 197<br>(189, 204) | 203<br>(195, 211) | 217<br>(207, 227) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Medium | (180, 191)<br>187 | 189<br>(183, 194) | 196<br>(190, 202) | 203<br>(196, 210) | 223<br>(212, 233) |
| | Negative | (166, 215)<br>187 | 193<br>(165, 219) | 213<br>(183, 242) | 239<br>(204, 271) | Not Reliable |
| Germany | Positive | (141, 154)<br>148 | 150<br>(143, 156) | 154<br>(146, 161) | 157<br>(149, 164) | 161<br>(152, 169) |
| | Medium | (142, 152)<br>148 | 149<br>(143, 155) | 154<br>(148, 160) | 158<br>(151, 164) | 163<br>(156, 171) |
| | Negative | (124, 181)<br>148 | 153<br>(124, 186) | 173<br>(141, 209) | 197<br>(161, 239) | Not Reliable |
| United Kingdom | Positive | (128, 139)<br>133 | 138<br>(132, 143) | 152<br>(146, 158) | 165<br>(157, 174) | 188<br>(173, 206) |
| | Medium | (128, 136)<br>133 | 136<br>(132, 141) | 152<br>(146, 157) | 166<br>(158, 174) | 198<br>(175, 225) |
| | Negative | (122, 154)<br>133 | 143<br>(125, 160) | 171<br>(150, 191) | 211<br>(181, 241) | Not Reliable |
| France | Positive | (109, 127)<br>119 | 120<br>(111, 129) | 124<br>(115, 134) | 127<br>(118, 138) | 132<br>(121, 144) |
| | Medium | (109, 126)<br>119 | 119<br>(111, 128) | 123<br>(115, 133) | 127<br>(118, 137) | 133<br>(121, 146) |
| | Negative | (100, 144)<br>119 | 122<br>(102, 147) | 138<br>(114, 165) | 159<br>(130, 191) | Not Reliable |
| Turkey | Positive | (94.5, 101)<br>98.7 | 101<br>(97.7, 104) | 113<br>(109, 118) | 125<br>(117, 133) | 145<br>(125, 180) |
| | Medium | (95.2, 101)<br>98.7 | 100<br>(97.7, 104) | 113<br>(110, 118) | 126<br>(120, 132) | 149<br>(138, 163) |
| | Negative | (92.9, 109)<br>98.7 | 104<br>(94.9, 113) | 126<br>(114, 137) | 157<br>(141, 173) | Not Reliable |
| Russia | Positive | (53.5, 56.8)<br>58 | 59.9<br>(57.9, 61.7) | 80.6<br>(76.5, 85) | 99.1<br>(91, 110) | 117<br>(102, 140) |
| | Medium | (53.3, 57)<br>58 | 60.7<br>(58.9, 62.6) | 82.8<br>(79.3, 87.2) | 104<br>(97.1, 118) | 126<br>(114, 175) |
| | Negative | (54.7, 58.4)<br>58 | 62.2<br>(60, 64.6) | 93.6<br>(89.8, 97.8) | 150<br>(140, 161) | Not Reliable |
| Brazil | Positive | (42.5, 48.4)<br>45.8 | 48<br>(45.3, 51.6) | 57.5<br>(53.5, 62.9) | 67.9<br>(60.6, 77.6) | 87.3<br>(70.8, 126) |
| | Medium | (41.3, 46.9)<br>45.8 | 46.7<br>(44, 49.7) | 57.1<br>(53.2, 61.5) | 69.6<br>(62.1, 79.1) | 115<br>(78.2, 2910) |
| | Negative | (42.1, 48.1)<br>45.8 | 47.3<br>(44.4, 50.5) | 59.8<br>(55.9, 63.7) | 78.1<br>(72.7, 84.3) | Not Reliable |
| Belgium | Positive | (39.5, 44.8)<br>41.9 | 42.9<br>(40.1, 45.6) | 46.3<br>(43.1, 49.4) | 49.5<br>(45.9, 53.7) | 56.3<br>(50.7, 65.8) |
| | Medium | (39.3, 44.5)<br>41.9 | 42.7<br>(40.3, 45.6) | 46.2<br>(43.5, 49.6) | 49.6<br>(46.1, 54) | 58.5<br>(49.5, 71.1) |
| | Negative | (38.5, 47.7)<br>41.9 | 43.8<br>(39.2, 48.5) | 50.7<br>(45.2, 56.1) | 59.6<br>(52.6, 66.6) | Not Reliable |
| Netherlands | Positive | (34.1, 36.7)<br>34.8 | 36<br>(34.7, 37.3) | 38.5<br>(37.2, 40.1) | 41.1<br>(39.5, 42.9) | 47.3<br>(44.4, 51.1) |
| | Medium | (33.5, 35.8)<br>34.8 | 35.4<br>(34.3, 36.6) | 38.2<br>(36.9, 39.6) | 41.1<br>(39.4, 42.9) | 50.6<br>(45, 56) |
| | Negative | (33.3, 40.7)<br>34.8 | 37.7<br>(33.5, 42) | 43.1<br>(37.9, 48.3) | 50.2<br>(43.7, 56.4) | Not Reliable |
| Switzerland | Positive | (27.4, 30.5)<br>28.2 | 29.1<br>(27.5, 30.7) | 29.5<br>(27.9, 31.1) | 29.8<br>(28.2, 31.5) | 30.2<br>(28.5, 32) |
| | Medium | (27.5, 30.1)<br>28.2 | 29<br>(27.7, 30.3) | 29.5<br>(28.3, 30.8) | 29.9<br>(28.6, 31.3) | 30.5<br>(29.1, 31.9) |
| | Negative | (21.4, 36.5)<br>28.2 | 28.5<br>(21.2, 37.3) | 31.9<br>(23.6, 42.1) | 36.4<br>(26.8, 49.1) | Not Reliable |
| Portugal | Positive | (20.3, 23.1)<br>22 | 22.5<br>(21, 24.1) | 23.9<br>(22.2, 25.6) | 25.1<br>(23.2, 26.9) | 27.4<br>(24.6, 30.6) |
| | Medium | (20.4, 23.4)<br>22 | 22.3<br>(20.8, 23.8) | 23.6<br>(22.1, 25.4) | 24.9<br>(23.1, 26.9) | 27.6<br>(24.3, 32) |

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|---|---|---|---|---|---|---|
| | Negative | (19.5, 25.2)<br>22 | 22.8<br>(20.3, 25.6) | 26.1<br>(23.1, 29.1) | 30.3<br>(26.5, 34) | Not Reliable |
| Ireland | Positive | (14.2, 16.5)<br>16.7 | 16.1<br>(15, 17.3) | 17.5<br>(16.2, 19) | 18.5<br>(17, 20.2) | 19.3<br>(17.5, 21.5) |
| | Medium | (14.7, 17.1)<br>16.7 | 16.4<br>(15.3, 17.5) | 18<br>(16.7, 19.2) | 19.1<br>(17.6, 20.5) | 20.1<br>(18.4, 22.3) |
| | Negative | (15.2, 18.3)<br>16.7 | 17.4<br>(16.1, 18.8) | 20.8<br>(19.2, 22.5) | 25.5<br>(23.4, 27.9) | Not Reliable |
| Sweden | Positive | (14.6, 16.1)<br>16 | 16.1<br>(15.3, 16.9) | 18<br>(16.9, 19.1) | 20.2<br>(18.3, 22) | 28.2<br>(19.2, 52.6) |
| | Medium | (14.5, 16.1)<br>16 | 16.1<br>(15.2, 16.9) | 18.1<br>(17, 19.2) | 20.5<br>(19, 22) | 29.2<br>(24.2, 42.5) |
| | Negative | (14.9, 16.7)<br>16 | 16.6<br>(15.6, 17.6) | 19.4<br>(18.2, 20.5) | 23.2<br>(21.6, 24.7) | Not Reliable |
| Austria | Positive | (13.9, 15.5)<br>14.9 | 14.8<br>(13.9, 15.9) | 14.9<br>(13.9, 15.9) | 14.9<br>(13.9, 15.9) | 14.9<br>(14, 16) |
| | Medium | (13.8, 15.7)<br>14.9 | 14.8<br>(14.1, 15.7) | 14.9<br>(14.1, 15.7) | 14.9<br>(14.2, 15.8) | 15<br>(14.2, 15.8) |
| | Negative | (11.6, 17.4)<br>14.9 | 14.2<br>(11.7, 17.2) | 15.8<br>(12.9, 19.2) | 17.7<br>(14.4, 21.7) | Not Reliable |
| Japan | Positive | (10.8, 11.9)<br>11.9 | 11.6<br>(11.2, 12.2) | 12.8<br>(12.2, 13.4) | 13.7<br>(13, 14.4) | 14.5<br>(13.7, 15.5) |
| | Medium | (11.7, 13.4)<br>11.9 | 13<br>(12.2, 13.8) | 14.8<br>(13.9, 15.9) | 16.7<br>(15.6, 18.4) | 21<br>(18.6, 27.7) |
| | Negative | (11.5, 13.5)<br>11.9 | 12.8<br>(11.9, 13.9) | 15.6<br>(14.4, 17) | 19.7<br>(18, 21.8) | Not Reliable |
| Iran | Positive | (80.7, 87.7)<br>86 | 85.4<br>(81.8, 88.6) | 87.9<br>(83.9, 91.1) | 89.8<br>(85.7, 93.3) | 92.4<br>(87.2, 96.9) |
| | Medium | (77.8, 86.2)<br>86 | 83.3<br>(79.2, 87.4) | 86.7<br>(82.2, 91) | 89.6<br>(84.8, 94.5) | 95.4<br>(88.9, 102) |
| | Negative | (78.3, 101)<br>86 | 90.9<br>(79.4, 104) | 100<br>(87.6, 115) | 112<br>(98.6, 129) | Not Reliable |

**Table 3.** Predictions for the number of total deaths at four time horizons (1-day, 5-day, 10-day and end of the outbreak) and for various countries/regions, based on the Generalised Richards model [1]. The values in parentheses are 80% prediction intervals based on 500 simulations using a negative binomial error structure. "Not reliable" is declared if more than 10% of the simulations produce extreme numbers (larger than total population). All numbers are in thousands. Note that it is emerging that there can be a large variation in reporting standard between countries. In the UK, it is made clear that reported deaths are for hospital deaths only and do not include deaths in the community. Similarly, data for Belgium is allegedly being revised to account for community deaths.

| Country | Scenario* | Today's validation | 24-Apr | 28-Apr | 3-May | Final Total Confirmed |
|---|---|---|---|---|---|---|
| Europe | Positive | (101, 105)<br>113 | 106<br>(105, 108) | 117<br>(115, 119) | 127<br>(124, 130) | 144<br>(139, 150) |
| | Medium | (102, 103)<br>113 | 106<br>(105, 106) | 117<br>(116, 118) | 129<br>(128, 130) | 156<br>(152, 160) |
| | Negative | (92.2, 121)<br>113 | 111<br>(96.4, 126) | 132<br>(115, 151) | 161<br>(140, 188) | Not Reliable |
| United States | Positive | (39.1, 41.7)<br>46.8 | 42.7<br>(40.5, 45) | 51.4<br>(48.1, 55) | 59<br>(53.6, 65.5) | 67.6<br>(58.7, 81.8) |
| | Medium | (39.3, 41.3)<br>46.8 | 42.4<br>(41.1, 43.5) | 51.8<br>(49.9, 53.8) | 60.8<br>(57.5, 64.8) | 75.2<br>(67.3, 88.2) |
| | Negative | (38.7, 44.6)<br>46.8 | 43.7<br>(40.6, 47.7) | 57.8<br>(53.9, 63.3) | 79.7<br>(72.8, 88.9) | Not Reliable |
| Spain | Positive | (19.7, 21.3)<br>21.7 | 21<br>(20.3, 21.8) | 22<br>(21.2, 22.9) | 22.8<br>(22, 23.7) | 23.8<br>(22.8, 25) |
| | Medium | (20, 21.1)<br>21.7 | 21<br>(20.4, 21.6) | 22<br>(21.5, 22.7) | 22.9<br>(22.3, 23.7) | 24.2<br>(23.4, 25.2) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Negative | (18.4, 23.7)<br>21.7 | 21.3<br>(18.7, 24.2) | 24.5<br>(21.4, 28) | 28.6<br>(24.8, 33.1) | Not Reliable |
| Italy | Positive | (23, 24.5)<br>25.1 | 24.2<br>(23.5, 24.9) | 25.4<br>(24.7, 26.3) | 26.6<br>(25.7, 27.5) | 28.7<br>(27.6, 30.2) |
| | Medium | (23.2, 24.1)<br>25.1 | 24.2<br>(23.7, 24.6) | 25.5<br>(25, 26) | 26.8<br>(26.2, 27.3) | 29.7<br>(28.6, 30.9) |
| | Negative | (21.4, 27.3)<br>25.1 | 24.7<br>(21.9, 27.8) | 27.8<br>(24.6, 31.4) | 31.8<br>(27.9, 36) | Not Reliable |
| Germany | Positive | (4.31, 4.58)<br>5.09 | 4.66<br>(4.53, 4.79) | 5.44<br>(5.27, 5.65) | 6.25<br>(5.96, 6.59) | 7.97<br>(7.06, 9.45) |
| | Medium | (4.34, 4.57)<br>5.09 | 4.67<br>(4.56, 4.78) | 5.48<br>(5.29, 5.63) | 6.33<br>(5.96, 6.67) | 8.64<br>(6.78, 11) |
| | Negative | (4.25, 4.81)<br>5.09 | 4.75<br>(4.44, 5.1) | 5.91<br>(5.54, 6.33) | 7.56<br>(7.02, 8.17) | Not Reliable |
| United Kingdom | Positive | (15.4, 16.1)<br>18.1 | 16.5<br>(16.2, 17) | 18.6<br>(18.1, 19.2) | 20.3<br>(19.6, 21) | 22.1<br>(21, 23.3) |
| | Medium | (15.5, 16)<br>18.1 | 16.5<br>(16.2, 16.8) | 18.7<br>(18.3, 19.1) | 20.6<br>(19.9, 21.3) | 23.1<br>(21.6, 24.7) |
| | Negative | (15, 18.2)<br>18.1 | 17.2<br>(15.4, 18.8) | 21.6<br>(19.4, 23.7) | 27.9<br>(24.8, 31.3) | Not Reliable |
| France | Positive | (19.1, 20.1)<br>21.3 | 20.2<br>(19.7, 20.7) | 21.8<br>(21.2, 22.4) | 23<br>(22.3, 23.6) | 24.1<br>(23.2, 25) |
| | Medium | (19.2, 20)<br>21.3 | 20.2<br>(19.8, 20.6) | 21.9<br>(21.4, 22.4) | 23.2<br>(22.6, 23.9) | 24.6<br>(23.7, 25.7) |
| | Negative | (17.9, 23.5)<br>21.3 | 21.1<br>(18.3, 24.3) | 25.6<br>(22.4, 29.3) | 31.9<br>(27.4, 37.1) | Not Reliable |
| Turkey | Positive | (1.96, 2.07)<br>2.38 | 2.13<br>(2.07, 2.21) | 2.6<br>(2.5, 2.71) | 3.12<br>(2.91, 3.39) | 4.46<br>(3.6, 7.29) |
| | Medium | (1.95, 2.08)<br>2.38 | 2.14<br>(2.08, 2.2) | 2.58<br>(2.43, 2.7) | 3.09<br>(2.6, 3.36) | 4.55<br>(2.63, 7.87) |
| | Negative | (1.93, 2.13)<br>2.38 | 2.16<br>(2.06, 2.25) | 2.76<br>(2.61, 2.89) | 3.62<br>(3.4, 3.83) | Not Reliable |
| Russia | Positive | (0.353, 0.401)<br>0.513 | 0.426<br>(0.4, 0.452) | 0.628<br>(0.457, 0.73) | nan<br>(nan, nan) | 1.92<br>(0.458, 8.89) |
| | Medium | (0.356, 0.406)<br>0.513 | 0.426<br>(0.401, 0.453) | 0.674<br>(0.607, 0.742) | 1.19<br>(0.904, 1.38) | Not Reliable |
| | Negative | (0.356, 0.403)<br>0.513 | 0.429<br>(0.401, 0.453) | 0.686<br>(0.623, 0.746) | 1.24<br>(1.02, 1.4) | Not Reliable |
| Brazil | Positive | (2.35, 2.48)<br>2.91 | 2.58<br>(2.51, 2.65) | 3.21<br>(3.1, 3.35) | 3.81<br>(3.59, 4.09) | 4.55<br>(4.09, 5.2) |
| | Medium | (2.35, 2.48)<br>2.91 | 2.58<br>(2.51, 2.64) | 3.23<br>(3.11, 3.37) | 3.87<br>(3.63, 4.2) | 4.77<br>(4.22, 5.89) |
| | Negative | (2.36, 2.54)<br>2.91 | 2.63<br>(2.54, 2.73) | 3.57<br>(3.42, 3.73) | 5.04<br>(4.75, 5.34) | Not Reliable |
| Belgium | Positive | (5.41, 5.66)<br>6.26 | 5.74<br>(5.63, 5.83) | 6.47<br>(6.34, 6.61) | 6.99<br>(6.77, 7.23) | 7.49<br>(7.05, 7.98) |
| | Medium | (5.37, 5.56)<br>6.26 | 5.73<br>(5.63, 5.83) | 6.49<br>(6.35, 6.63) | 7.05<br>(6.86, 7.26) | 7.6<br>(7.31, 7.93) |
| | Negative | (5.3, 6.13)<br>6.26 | 6.01<br>(5.5, 6.47) | 7.55<br>(6.9, 8.2) | 9.83<br>(8.82, 10.8) | Not Reliable |
| Netherlands | Positive | (3.55, 3.81)<br>4.05 | 3.82<br>(3.68, 3.95) | 4.21<br>(4.04, 4.35) | 4.57<br>(4.35, 4.75) | 5.26<br>(4.82, 5.72) |
| | Medium | (3.58, 3.77)<br>4.05 | 3.81<br>(3.69, 3.91) | 4.2<br>(4.06, 4.33) | 4.57<br>(4.39, 4.74) | 5.43<br>(4.93, 5.97) |
| | Negative | (3.38, 4.12)<br>4.05 | 3.88<br>(3.47, 4.31) | 4.58<br>(4.11, 5.12) | 5.55<br>(4.91, 6.24) | Not Reliable |
| Switzerland | Positive | (1.39, 1.49)<br>1.53 | 1.48<br>(1.43, 1.53) | 1.57<br>(1.51, 1.63) | 1.65<br>(1.58, 1.72) | 1.75<br>(1.66, 1.85) |
| | Medium | (1.39, 1.49)<br>1.53 | 1.48<br>(1.43, 1.53) | 1.57<br>(1.52, 1.63) | 1.65<br>(1.59, 1.73) | 1.78<br>(1.67, 1.9) |
| | Negative | (1.32, 1.66)<br>1.53 | 1.49<br>(1.33, 1.68) | 1.72<br>(1.54, 1.95) | 2.05<br>(1.8, 2.32) | Not Reliable |

| | | | | | | |
|---|---|---|---|---|---|---|
| Portugal | Positive | (0.694, 0.759) 0.785 | 0.75 (0.715, 0.789) | 0.843 (0.792, 0.893) | 0.934 (0.84, 1.02) | 1.13 (0.861, 1.66) |
| | Medium | (0.692, 0.758) 0.785 | 0.753 (0.713, 0.786) | 0.85 (0.8, 0.899) | 0.947 (0.883, 1.03) | 1.18 (0.995, 1.64) |
| | Negative | (0.697, 0.762) 0.785 | 0.757 (0.723, 0.792) | 0.898 (0.857, 0.942) | 1.09 (1.03, 1.15) | Not Reliable |
| Ireland | Positive | (0.577, 0.645) 0.769 | 0.658 (0.624, 0.69) | 0.848 (0.726, 0.918) | 1.12 (0.741, 1.29) | 3.44 (0.741, 6.17) |
| | Medium | (0.578, 0.641) 0.769 | 0.654 (0.621, 0.692) | 0.862 (0.804, 0.919) | 1.17 (1.03, 1.28) | Not Reliable |
| | Negative | (0.58, 0.645) 0.769 | 0.657 (0.627, 0.695) | 0.875 (0.831, 0.927) | 1.21 (1.13, 1.3) | Not Reliable |
| Sweden | Positive | (1.5, 1.62) 1.94 | 1.67 (1.61, 1.73) | 2.04 (1.86, 2.16) | 2.49 (1.91, 2.78) | Not Reliable |
| | Medium | (1.5, 1.62) 1.94 | 1.66 (1.6, 1.73) | 2.06 (1.95, 2.17) | 2.56 (2.31, 2.85) | Not Reliable |
| | Negative | (1.5, 1.66) 1.94 | 1.68 (1.59, 1.77) | 2.16 (2.03, 2.28) | 2.87 (2.67, 3.04) | Not Reliable |
| Austria | Positive | (0.433, 0.495) 0.494 | 0.482 (0.451, 0.513) | 0.515 (0.477, 0.549) | 0.539 (0.498, 0.578) | 0.563 (0.514, 0.615) |
| | Medium | (0.42, 0.475) 0.494 | 0.462 (0.435, 0.488) | 0.5 (0.468, 0.532) | 0.531 (0.495, 0.572) | 0.574 (0.522, 0.648) |
| | Negative | (0.42, 0.492) 0.494 | 0.47 (0.43, 0.511) | 0.552 (0.501, 0.598) | 0.66 (0.595, 0.716) | Not Reliable |
| Japan | Positive | (0.142, 0.177) 0.287 | 0.166 (0.149, 0.186) | 0.24 (0.209, 0.271) | 0.368 (0.282, 0.464) | Not Reliable |
| | Medium | (0.149, 0.184) 0.287 | 0.2 (0.181, 0.219) | 0.259 (0.231, 0.283) | 0.356 (0.307, 0.398) | Not Reliable |
| | Negative | (0.15, 0.183) 0.287 | 0.199 (0.181, 0.218) | 0.258 (0.233, 0.287) | 0.359 (0.312, 0.407) | Not Reliable |
| Iran | Positive | (4.99, 5.37) 5.39 | 5.29 (5.1, 5.48) | 5.56 (5.36, 5.78) | 5.82 (5.59, 6.06) | 6.47 (6.09, 6.88) |
| | Medium | (5.04, 5.34) 5.39 | 5.29 (5.13, 5.43) | 5.57 (5.41, 5.72) | 5.84 (5.66, 6.01) | 6.63 (6.22, 7.06) |
| | Negative | (4.75, 5.75) 5.39 | 5.31 (4.78, 5.88) | 5.9 (5.3, 6.53) | 6.67 (5.99, 7.4) | Not Reliable |

* Note:

-The scenarios are based on the final total confirmed numbers. On April 11, 2020, we introduced the Generalized Richards Model in addition to our existing three models: Generalized Logistic Model, Logistic Model and Generalized Growth model (see [1] for their presentation). We remove the lowest mean predicted final total confirmed number K among the four models (which is classical statistical method ensuring robustness). Then, the model with the second lowest mean predicted final total confirmed number K is classified as the positive scenario, and the third lowest one is classified as the medium scenario. The negative scenario is based on the Generalized Growth model, which should only describe the early stage of the epidemic outbreak and is therefore least reliable for countries in the more mature stage.

-Trajectories from Iran have largely deviated from a typical logistic type growth (S curve), and can't be properly described by our models. Although we still report its calibration results in Table 1, they should not be taken as reliable in all scenarios and time horizons. This is probably a result of unreliable reported data from Iran.

## Limitations of using the statistics of reported confirmed number

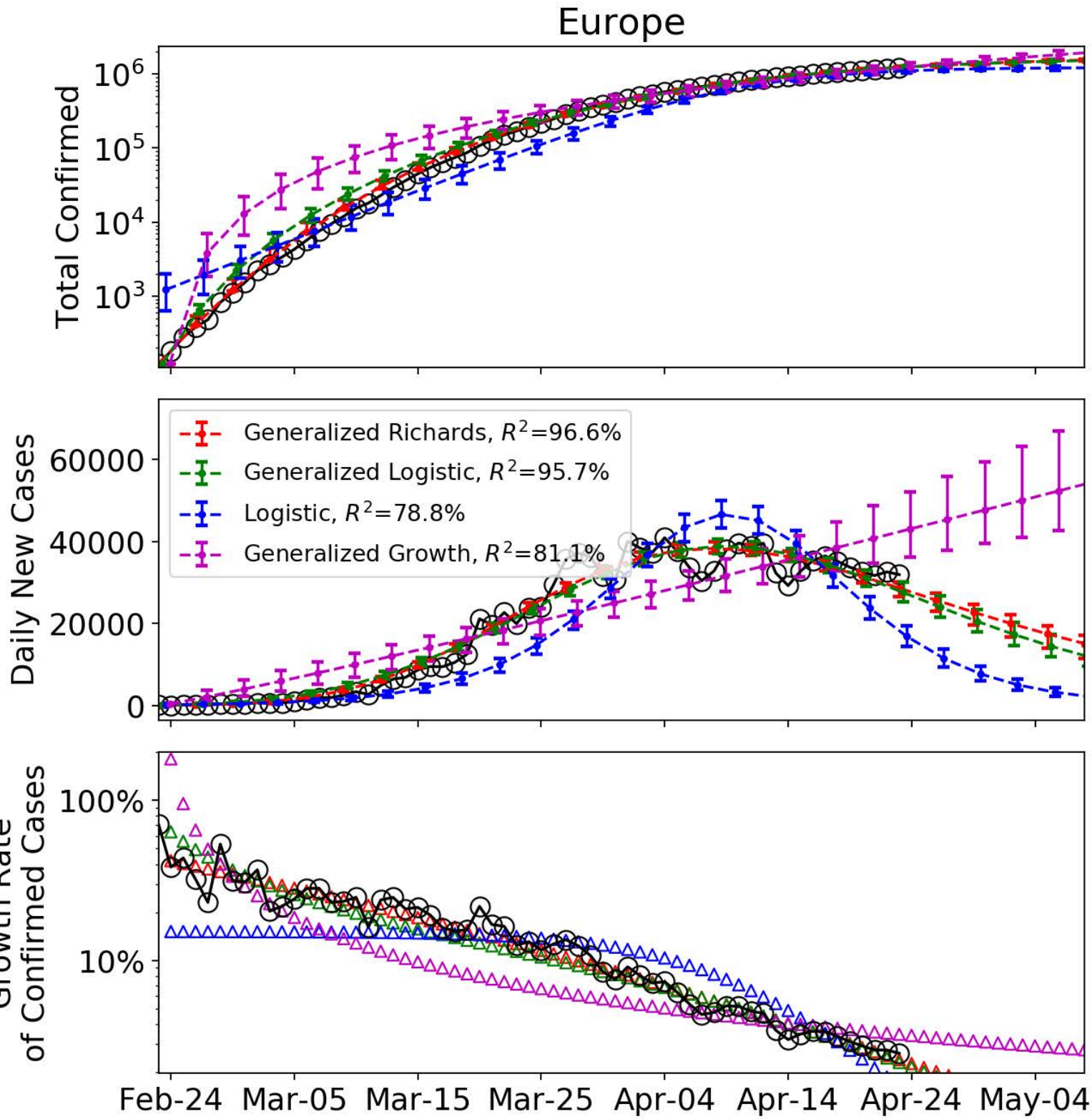
It is important to understand what our prediction models show. The predictions are based on cases identified on the basis of testing and they therefore predict the numbers of future positive tests. Relating positive test results to real levels of infection is subject to a large number of biases. It is 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, giving 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

[2] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

[3] https://en.wikipedia.org/wiki/COVID-19_testing



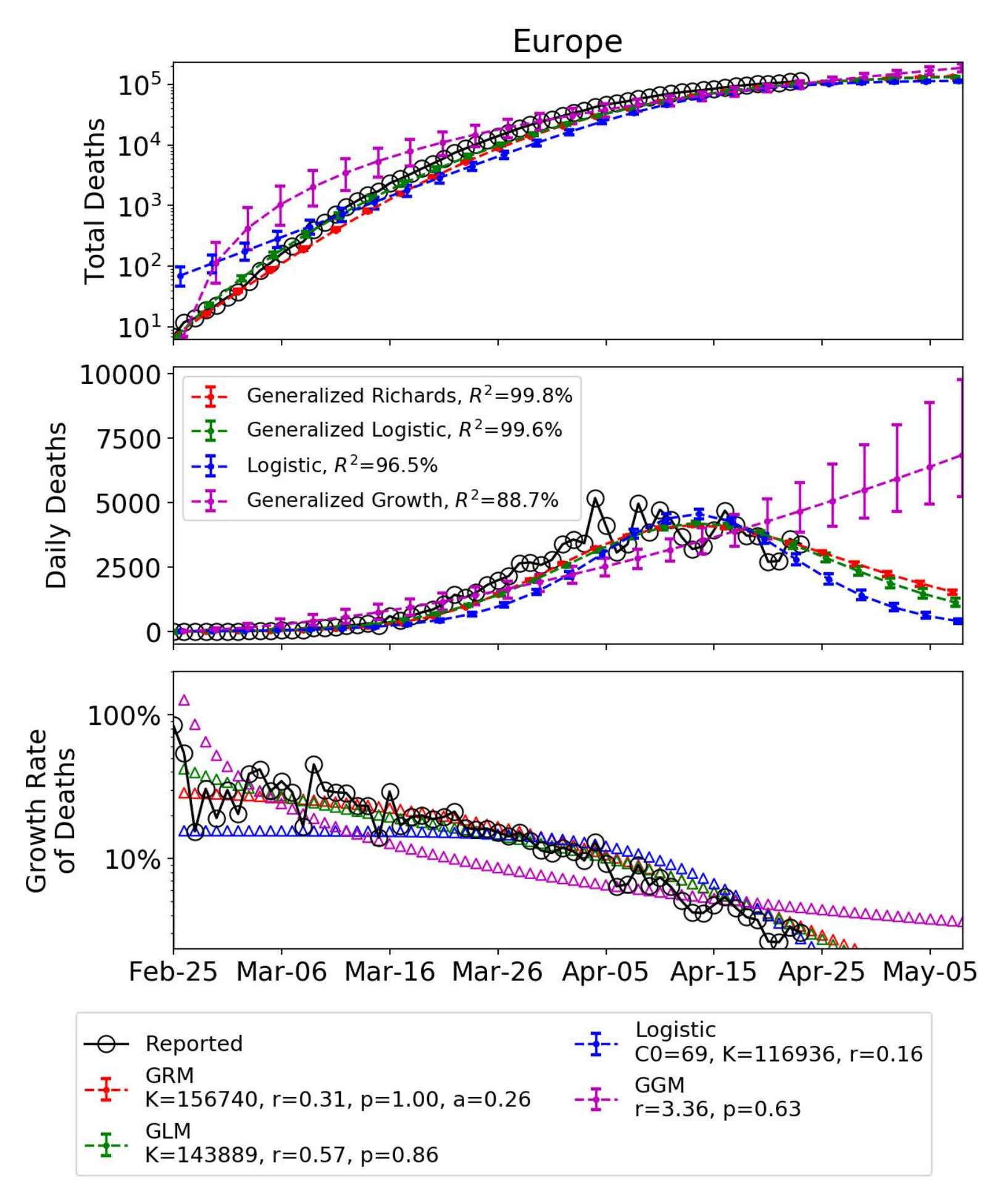

Reported

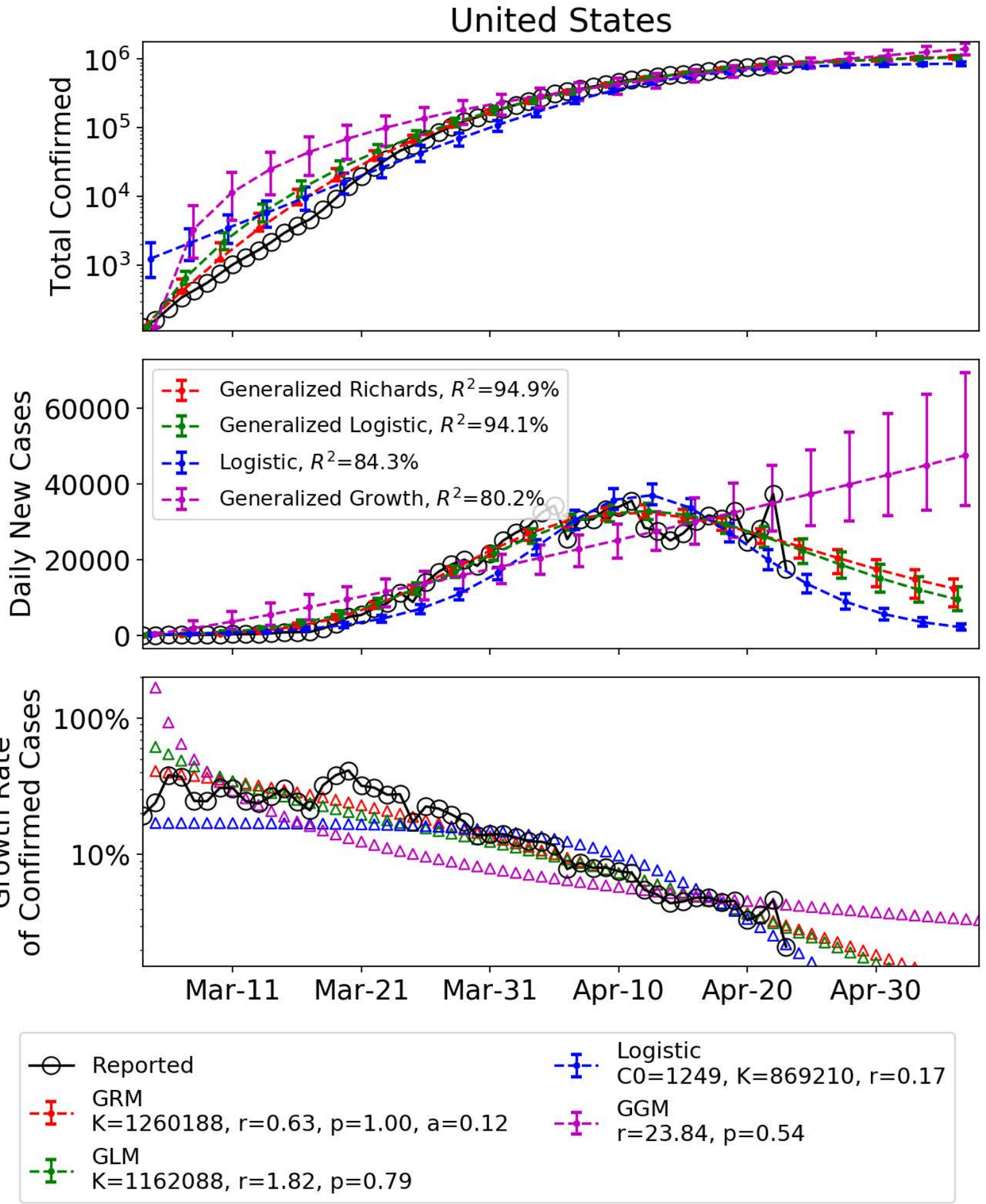
GRM
K=1827251, r=0.65, p=0.94, a=0.23

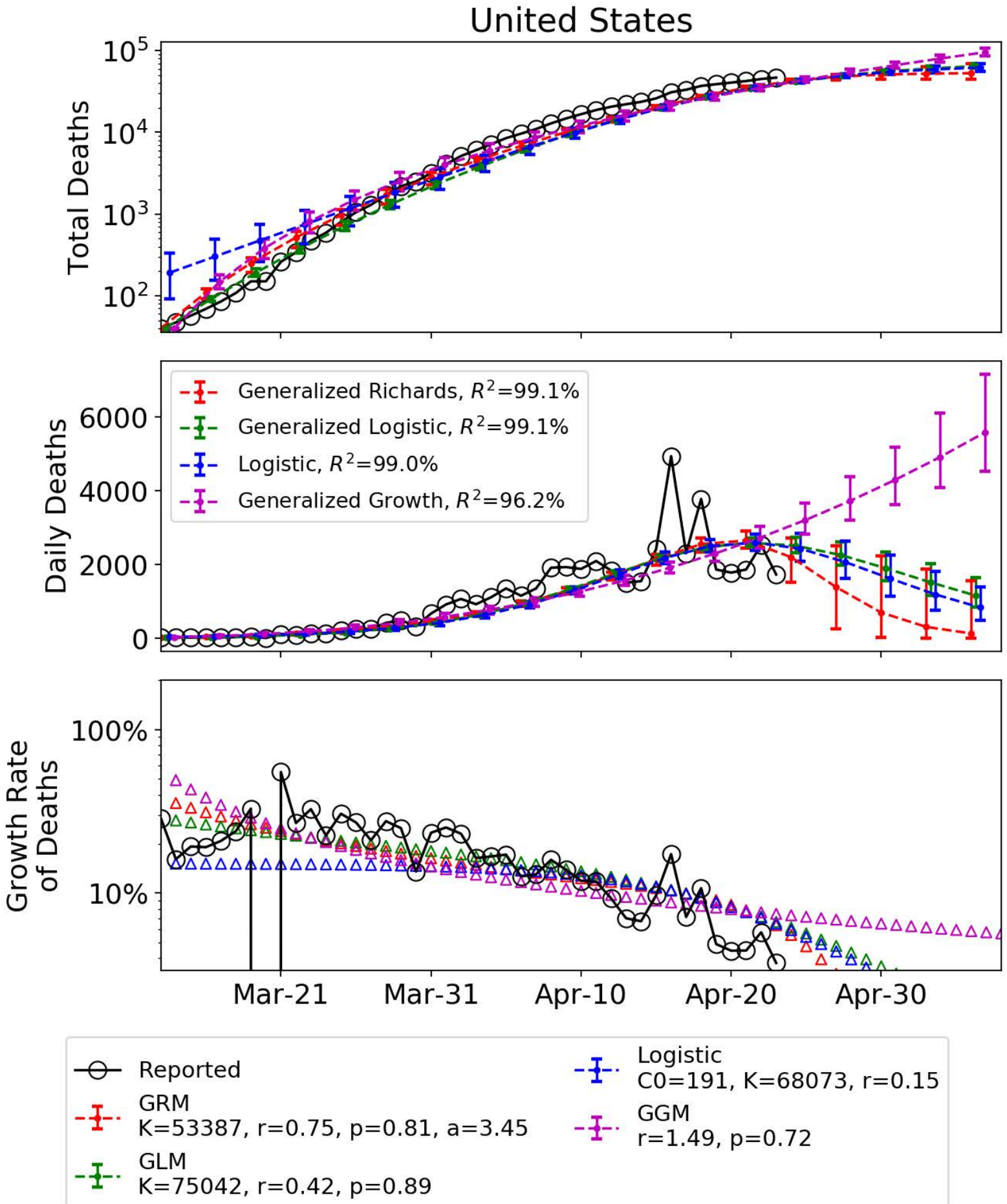
GLM
K=1694485, r=2.06, p=0.77

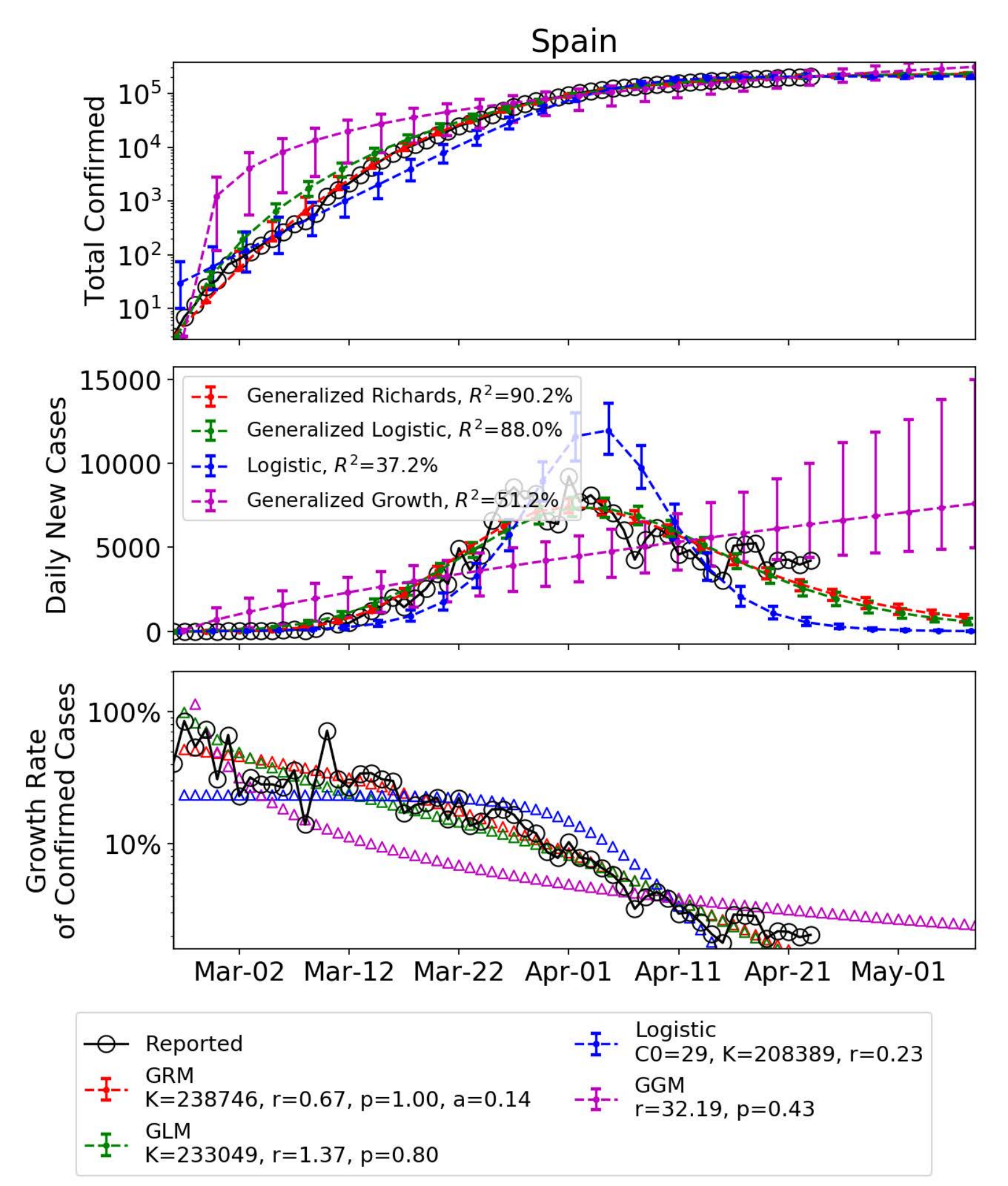
Logistic
C0=1219, K=1230628, r=0.15

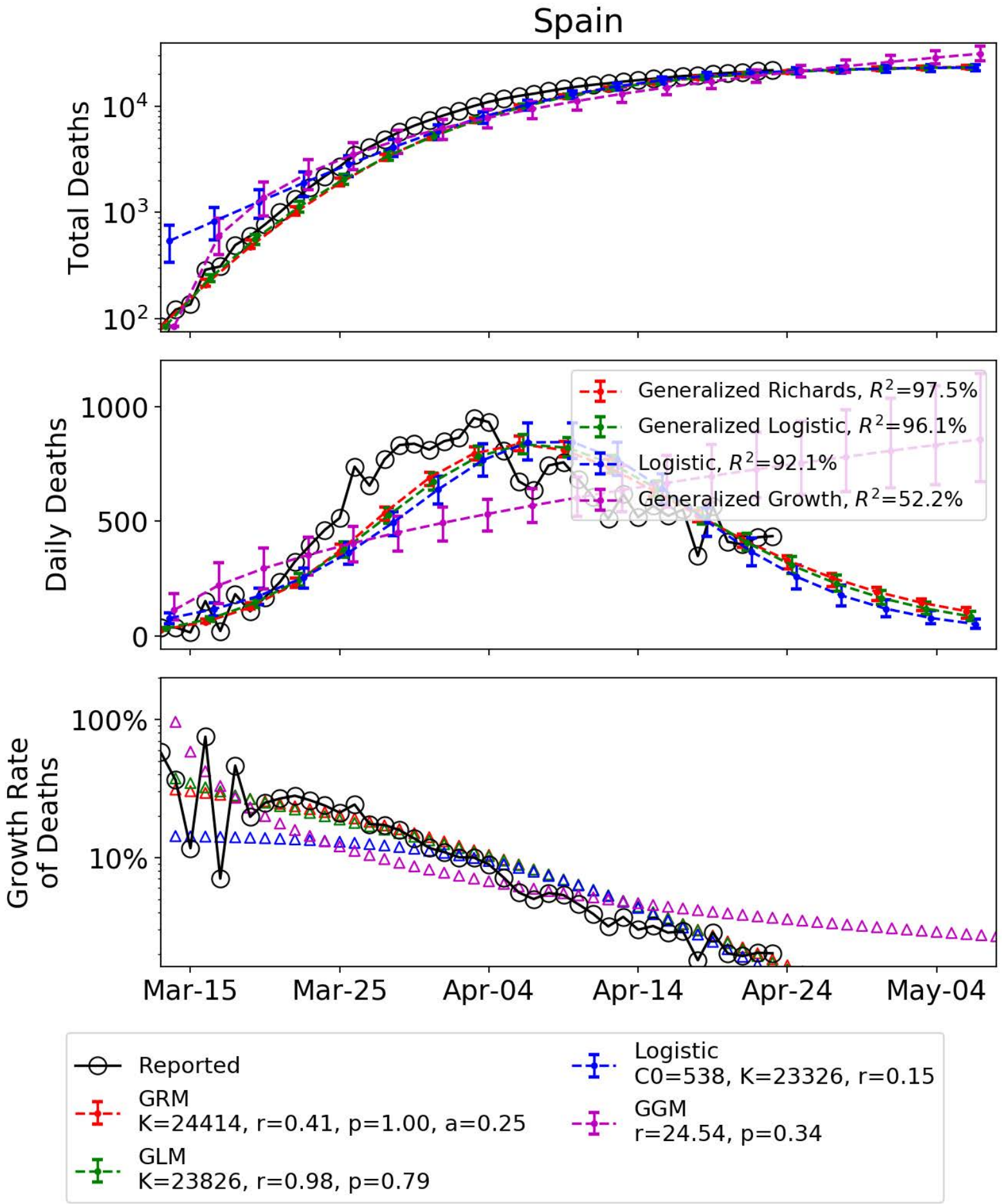
GGM
r=29.14, p=0.52

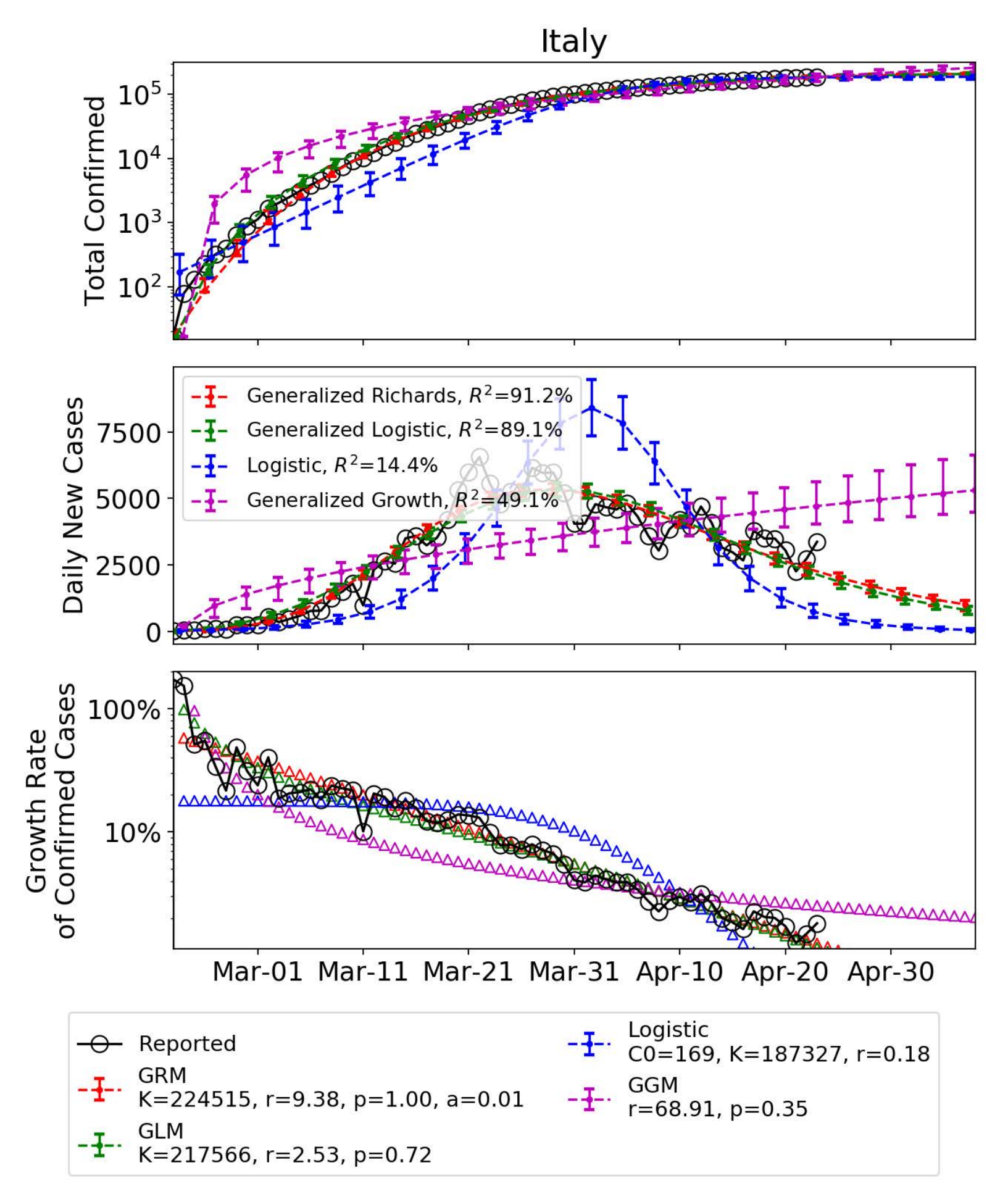

Europe
Total Deaths
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
Daily Deaths
10000
7500
5000
2500
0
Generalized Richards, $R^2$=99.8%
Generalized Logistic, $R^2$=99.6%
Logistic, $R^2$=96.5%
Generalized Growth, $R^2$=88.7%
Growth Rate of Deaths
100%
10%
Feb-25
Mar-06
Mar-16
Mar-26
Apr-05
Apr-15
Apr-25
May-05
Reported
GRM
K=156740, r=0.31, p=1.00, a=0.26
GLM
K=143889, r=0.57, p=0.86
Logistic
C0=69, K=116936, r=0.16
GGM
r=3.36, p=0.63

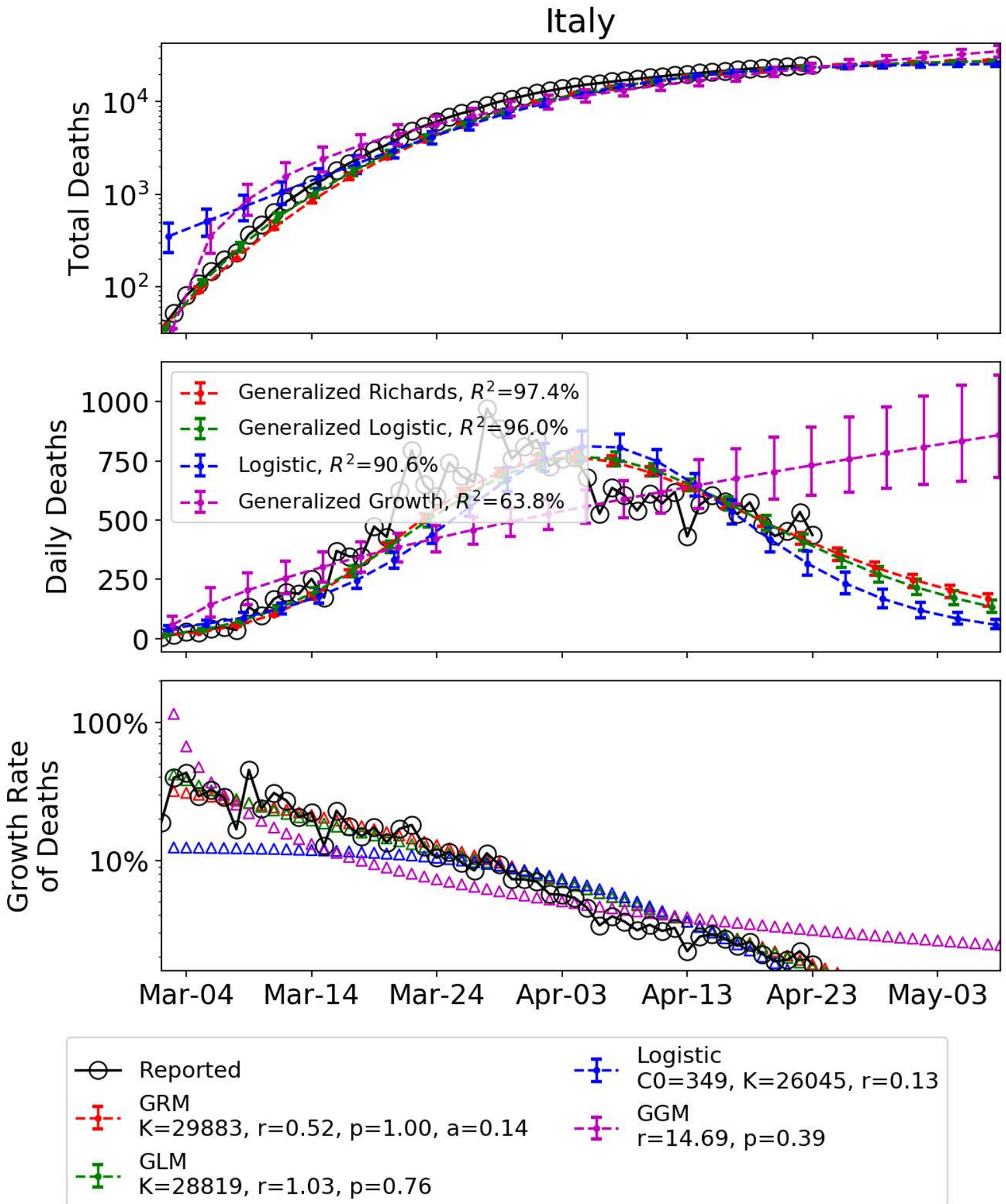

United States
Total Confirmed
$10^6$
$10^5$
$10^4$
$10^3$
Daily New Cases
60000
40000
20000
0
Generalized Richards, $R^2$=94.9%
Generalized Logistic, $R^2$=94.1%
Logistic, $R^2$=84.3%
Generalized Growth, $R^2$=80.2%
Growth Rate
of Confirmed Cases
100%
10%
Mar-11
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=1260188, r=0.63, p=1.00, a=0.12
GLM
K=1162088, r=1.82, p=0.79
Logistic
C0=1249, K=869210, r=0.17
GGM
r=23.84, p=0.54

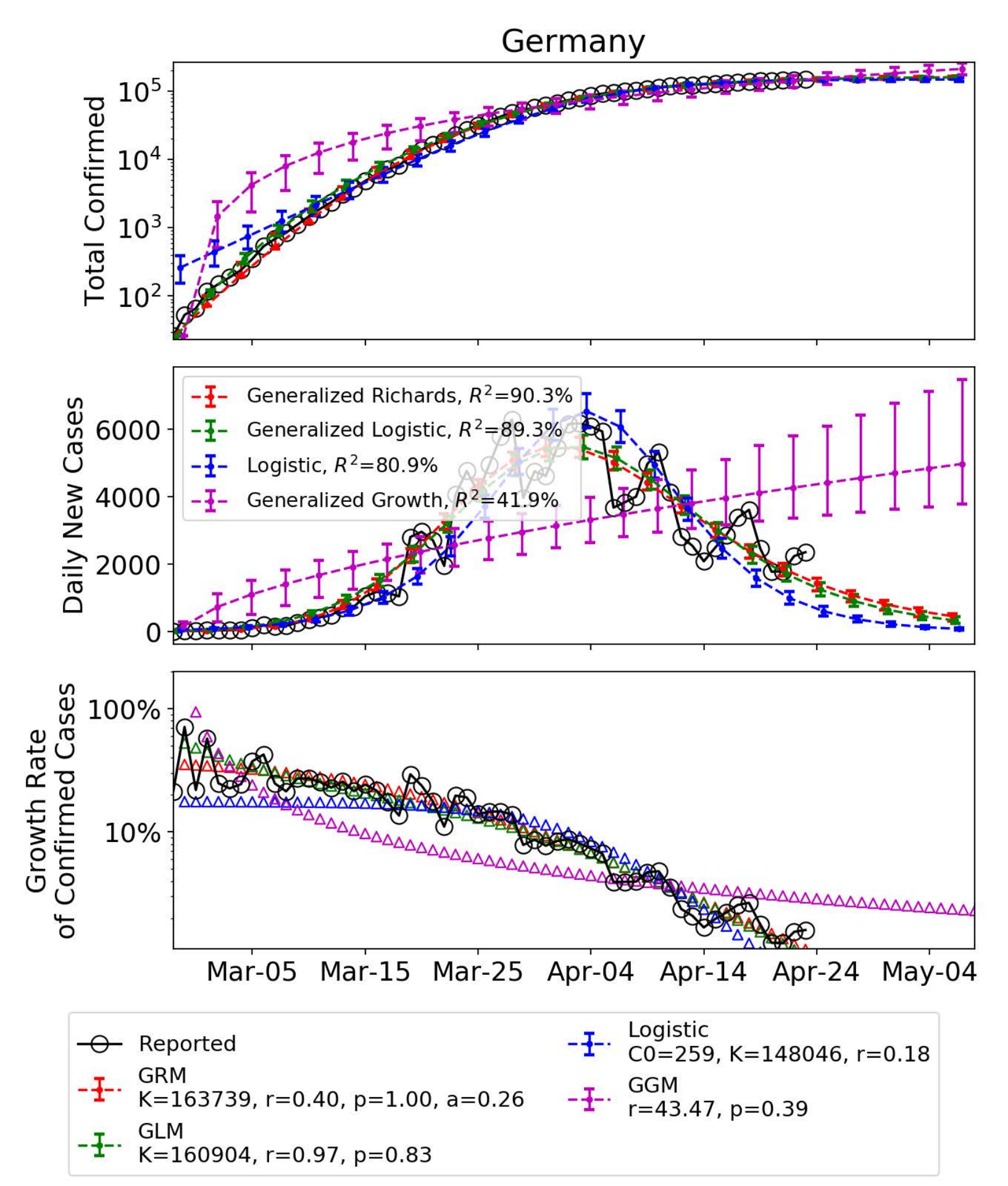

United States
Total Deaths
$10^5$
$10^4$
$10^3$
$10^2$
Daily Deaths
6000
4000
2000
0
Generalized Richards, $R^2$=99.1%
Generalized Logistic, $R^2$=99.1%
Logistic, $R^2$=99.0%
Generalized Growth, $R^2$=96.2%
Growth Rate of Deaths
100%
10%
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=53387, r=0.75, p=0.81, a=3.45
GLM
K=75042, r=0.42, p=0.89
Logistic
C0=191, K=68073, r=0.15
GGM
r=1.49, p=0.72

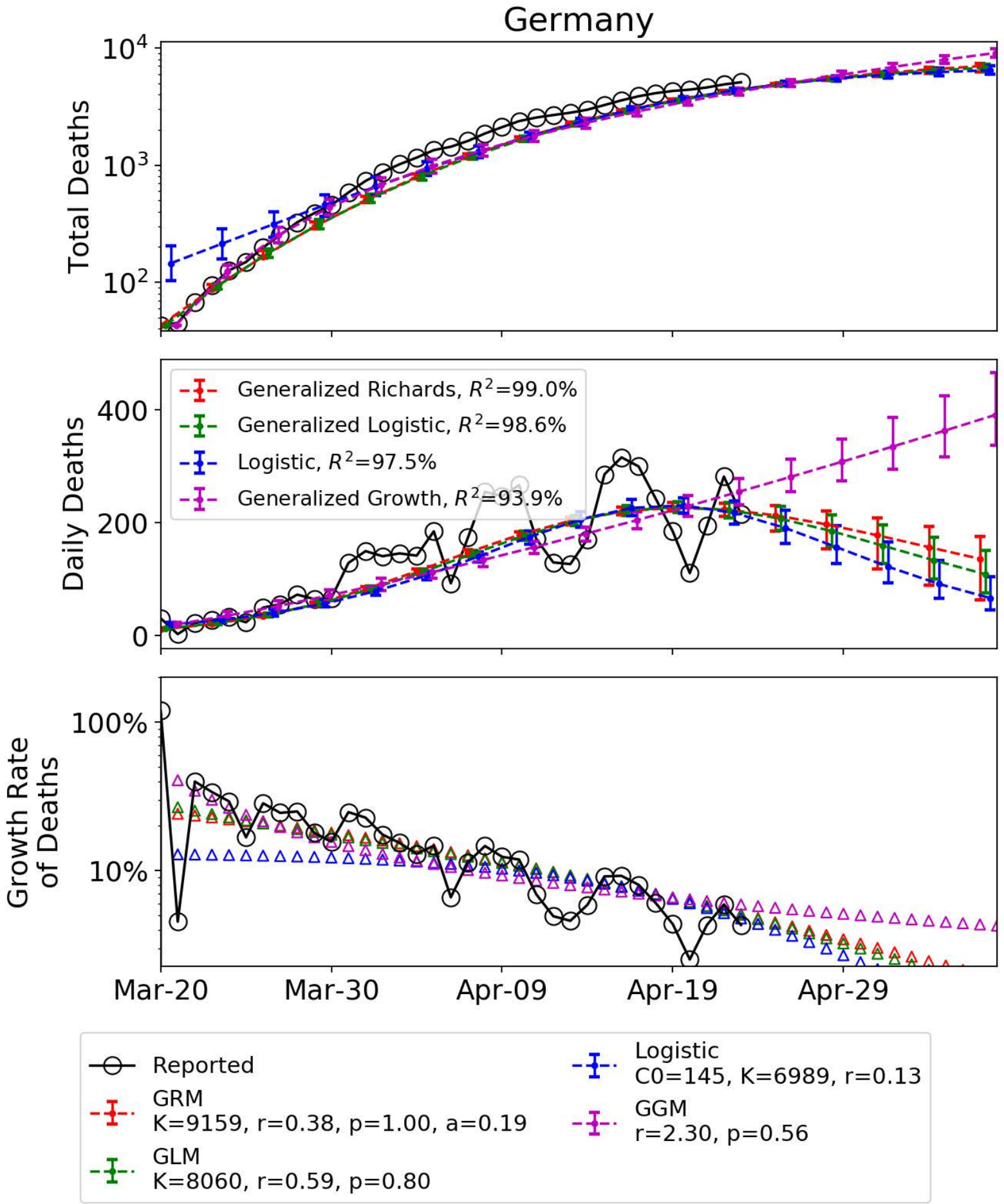

Spain
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
Daily New Cases
15000
10000
5000
0
Generalized Richards, $R^2$=90.2%
Generalized Logistic, $R^2$=88.0%
Logistic, $R^2$=37.2%
Generalized Growth, $R^2$=51.2%
Growth Rate
of Confirmed Cases
100%
10%
Mar-02
Mar-12
Mar-22
Apr-01
Apr-11
Apr-21
May-01
Reported
GRM
K=238746, r=0.67, p=1.00, a=0.14
GLM
K=233049, r=1.37, p=0.80
Logistic
C0=29, K=208389, r=0.23
GGM
r=32.19, p=0.43

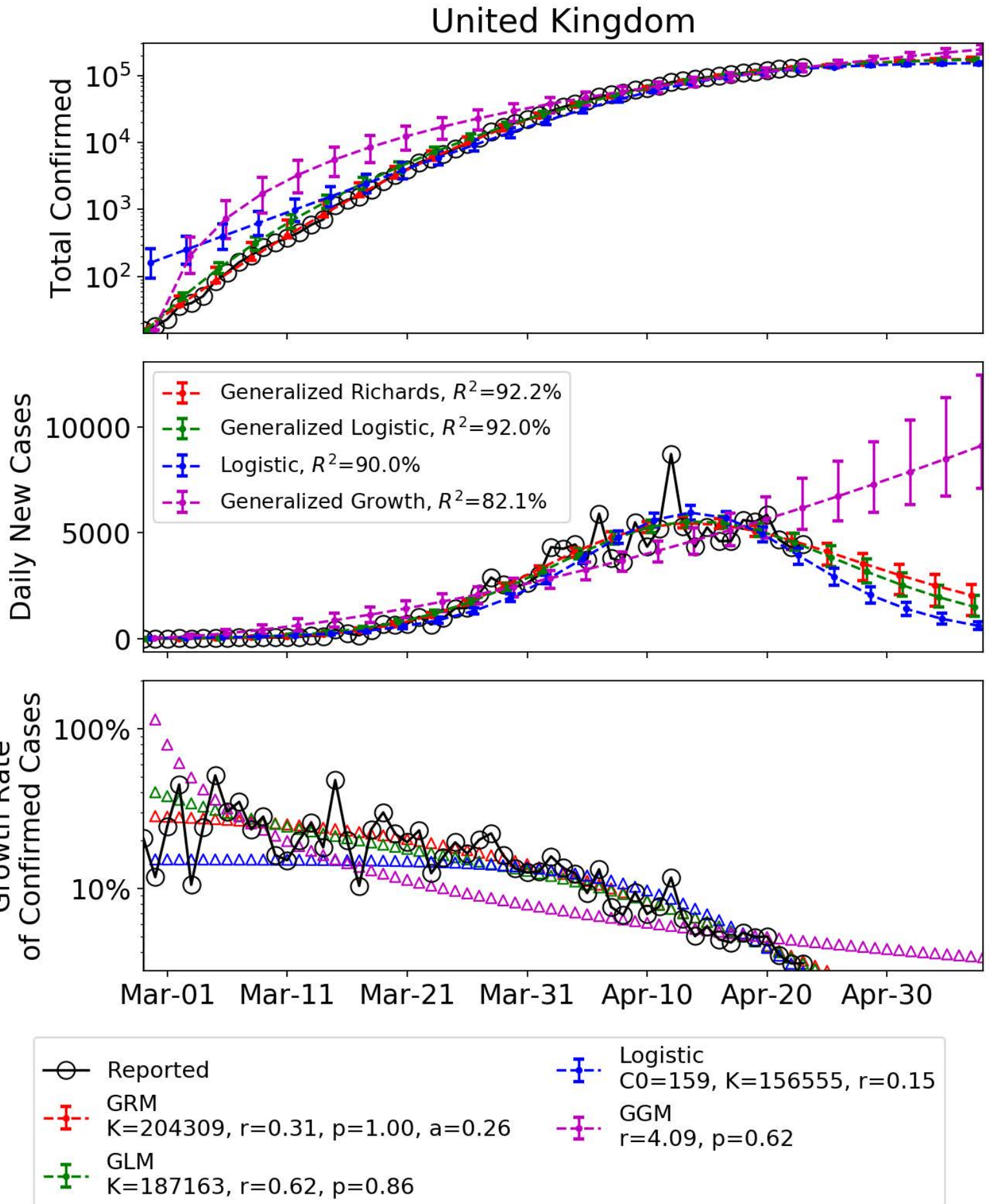

Spain
Total Deaths
$10^4$
$10^3$
$10^2$
Daily Deaths
1000
500
0
Generalized Richards, $R^2$=97.5%
Generalized Logistic, $R^2$=96.1%
Logistic, $R^2$=92.1%
Generalized Growth, $R^2$=52.2%
Growth Rate of Deaths
100%
10%
Mar-15
Mar-25
Apr-04
Apr-14
Apr-24
May-04
Reported
GRM
K=24414, r=0.41, p=1.00, a=0.25
GLM
K=23826, r=0.98, p=0.79
Logistic
C0=538, K=23326, r=0.15
GGM
r=24.54, p=0.34

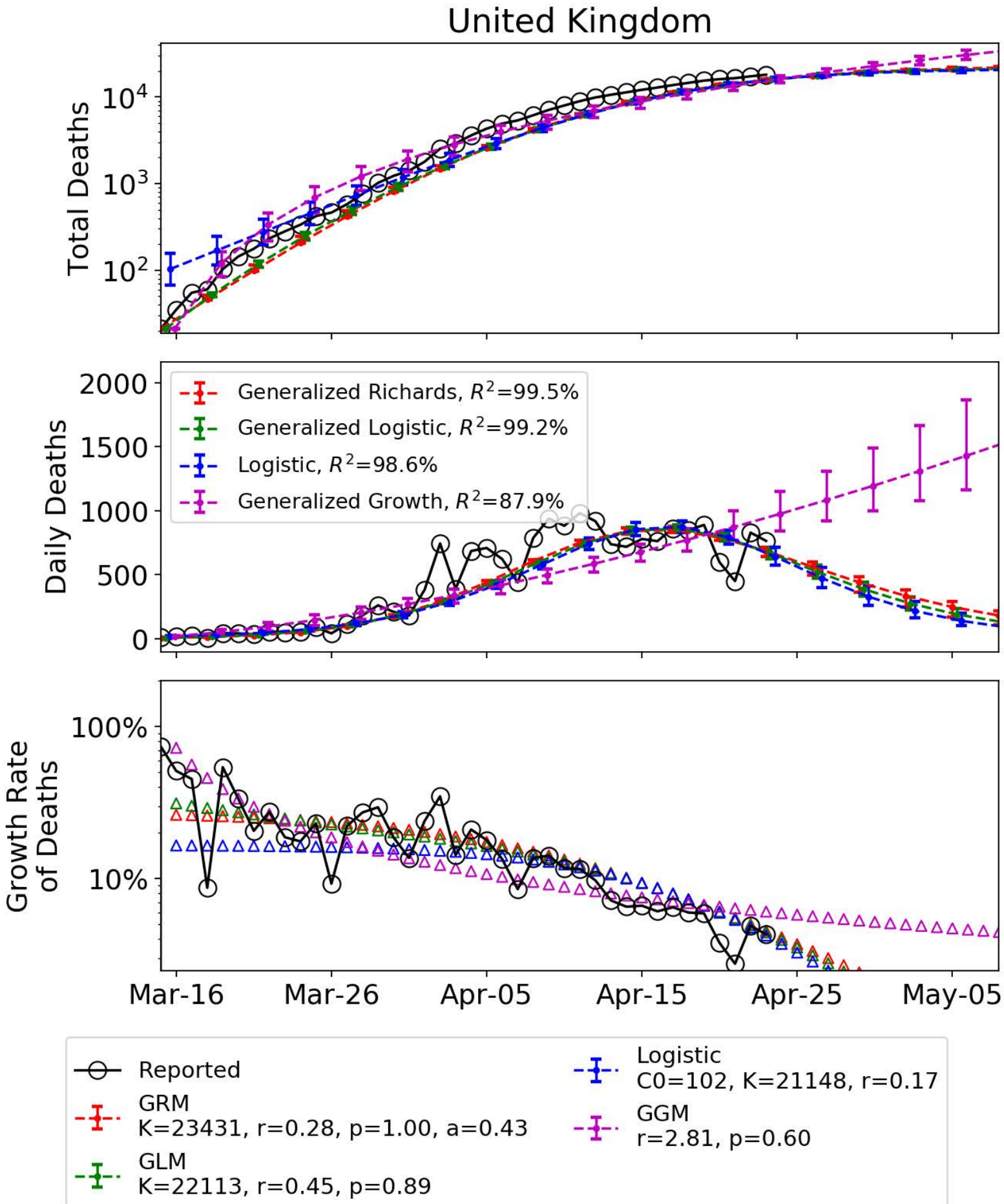

Italy
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
Daily New Cases
7500
5000
2500
0
Generalized Richards, $R^2$=91.2%
Generalized Logistic, $R^2$=89.1%
Logistic, $R^2$=14.4%
Generalized Growth, $R^2$=49.1%
Growth Rate
of Confirmed Cases
100%
10%
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=224515, r=9.38, p=1.00, a=0.01
GLM
K=217566, r=2.53, p=0.72
Logistic
C0=169, K=187327, r=0.18
GGM
r=68.91, p=0.35

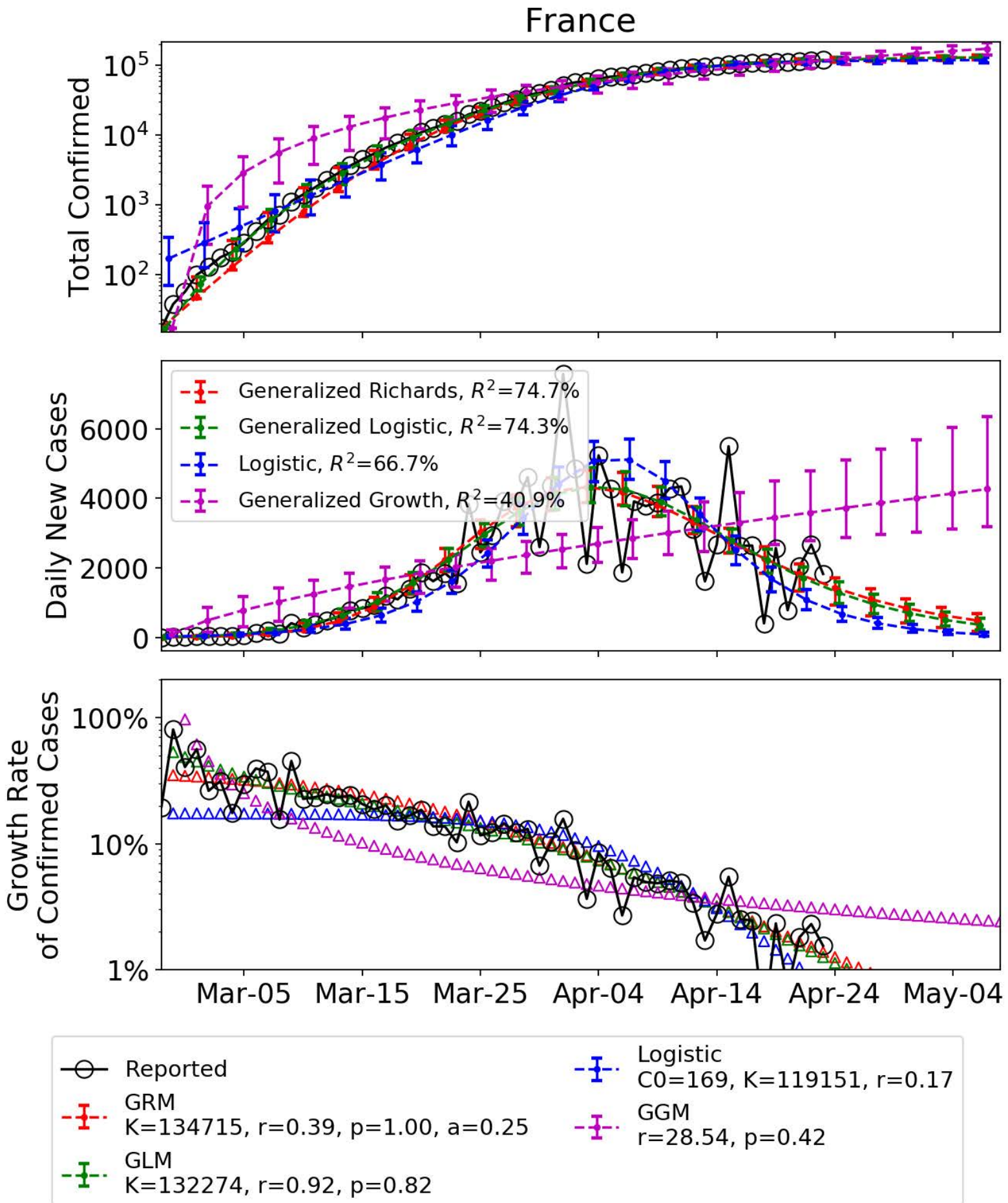

Italy
Total Deaths
$10^4$
$10^3$
$10^2$
Daily Deaths
1000
750
500
250
0
Generalized Richards, $R^2$=97.4%
Generalized Logistic, $R^2$=96.0%
Logistic, $R^2$=90.6%
Generalized Growth, $R^2$=63.8%
Growth Rate of Deaths
100%
10%
Mar-04
Mar-14
Mar-24
Apr-03
Apr-13
Apr-23
May-03
Reported
GRM
K=29883, r=0.52, p=1.00, a=0.14
GLM
K=28819, r=1.03, p=0.76
Logistic
C0=349, K=26045, r=0.13
GGM
r=14.69, p=0.39

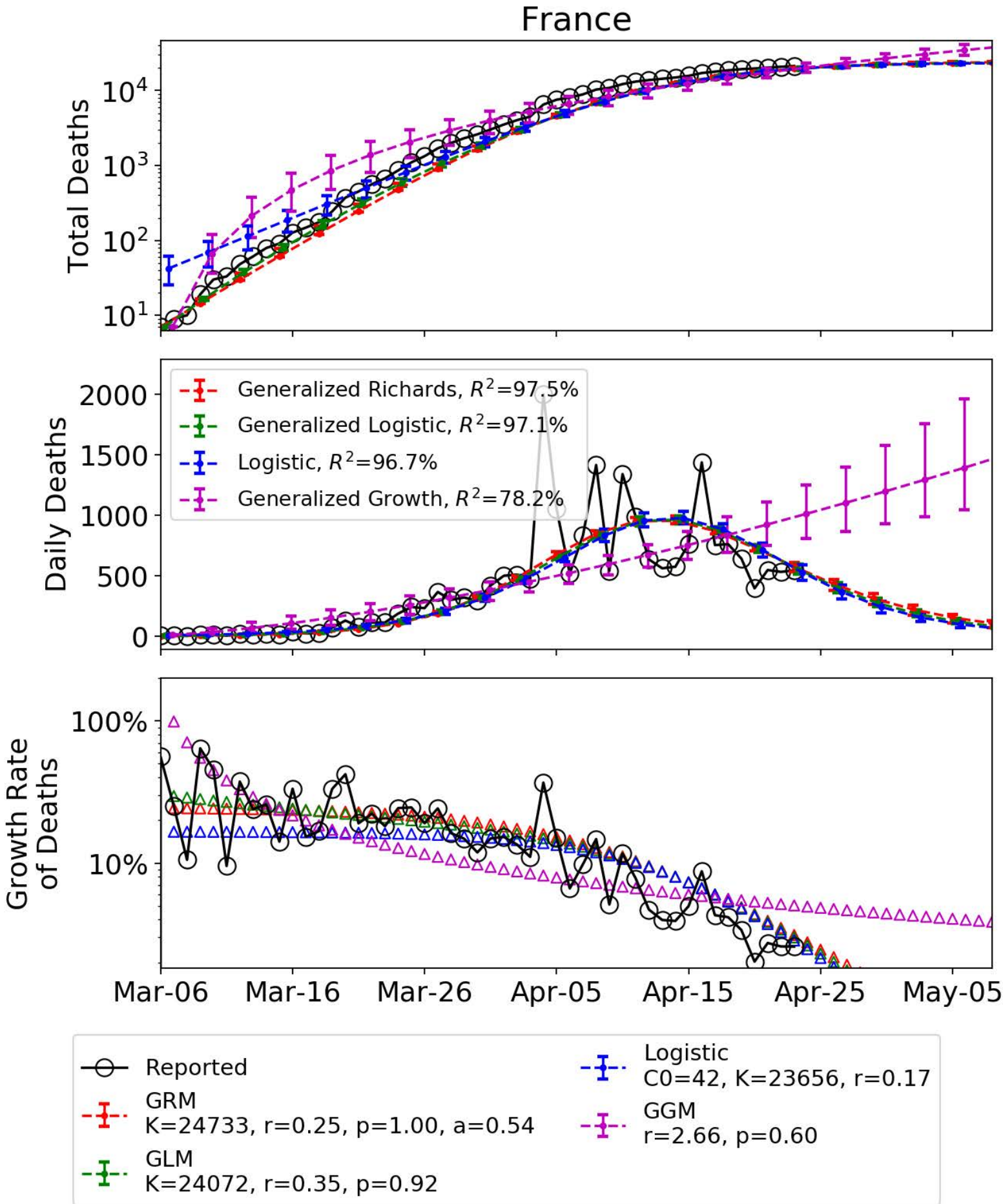

Germany
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
Daily New Cases
6000
4000
2000
0
Generalized Richards, $R^2$=90.3%
Generalized Logistic, $R^2$=89.3%
Logistic, $R^2$=80.9%
Generalized Growth, $R^2$=41.9%
Growth Rate
of Confirmed Cases
100%
10%
Mar-05
Mar-15
Mar-25
Apr-04
Apr-14
Apr-24
May-04
Reported
GRM
K=163739, r=0.40, p=1.00, a=0.26
GLM
K=160904, r=0.97, p=0.83
Logistic
C0=259, K=148046, r=0.18
GGM
r=43.47, p=0.39

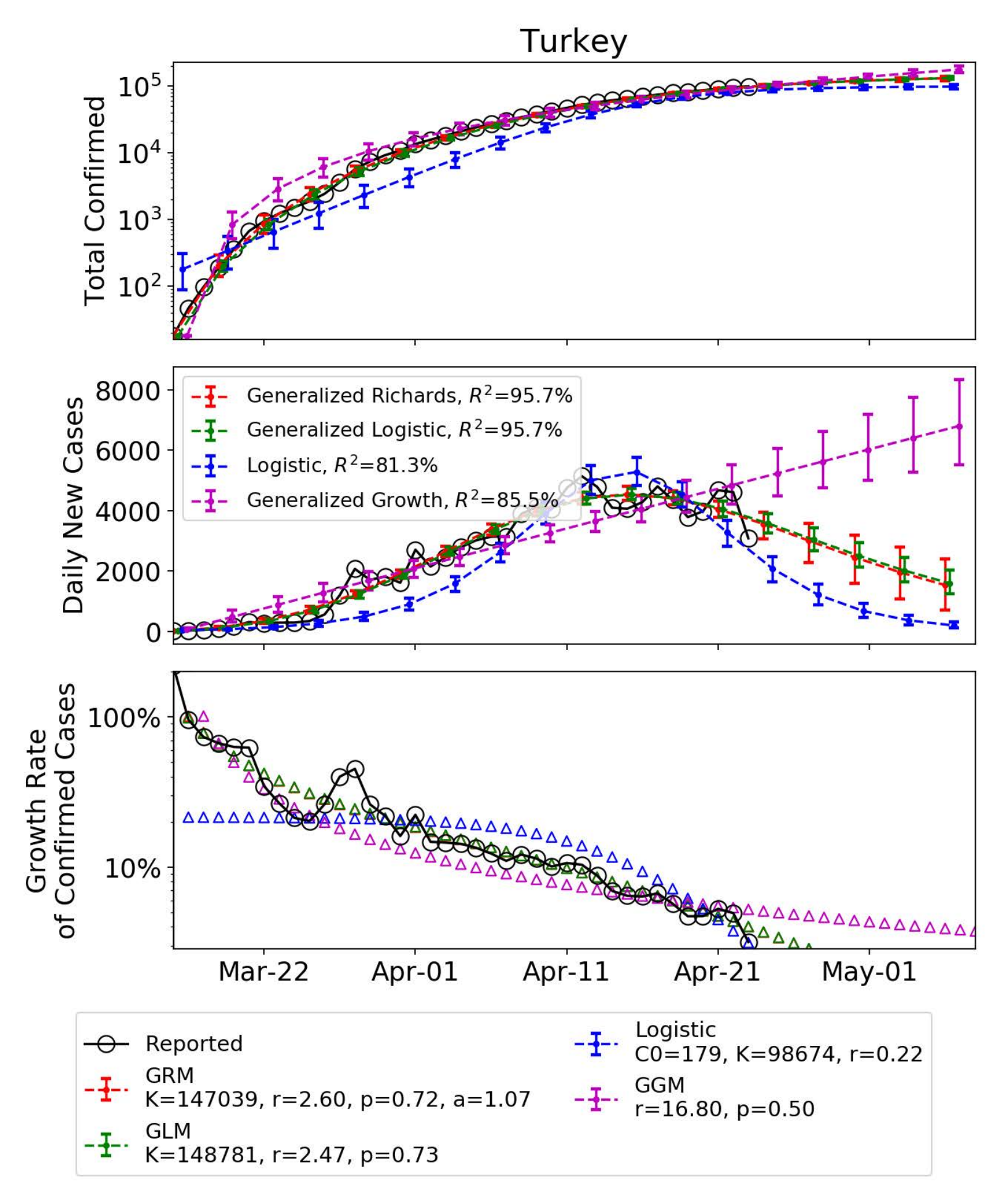

Germany
Total Deaths
$10^4$
$10^3$
$10^2$
Daily Deaths
400
200
0
Generalized Richards, $R^2$=99.0%
Generalized Logistic, $R^2$=98.6%
Logistic, $R^2$=97.5%
Generalized Growth, $R^2$=93.9%
Growth Rate of Deaths
100%
10%
Mar-20
Mar-30
Apr-09
Apr-19
Apr-29
Reported
GRM
K=9159, r=0.38, p=1.00, a=0.19
GLM
K=8060, r=0.59, p=0.80
Logistic
C0=145, K=6989, r=0.13
GGM
r=2.30, p=0.56

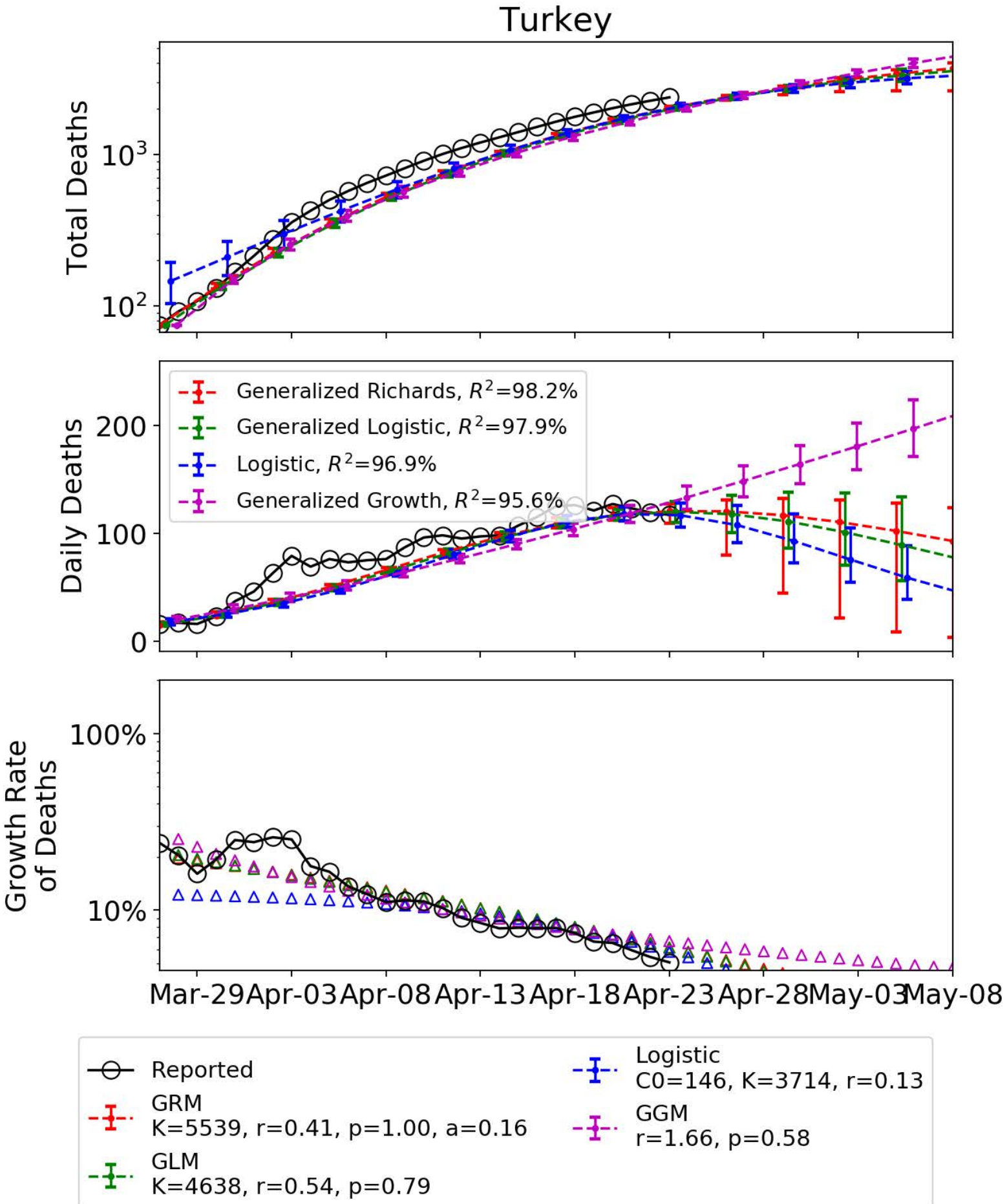

United Kingdom
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
Daily New Cases
10000
5000
0
Generalized Richards, $R^2$=92.2%
Generalized Logistic, $R^2$=92.0%
Logistic, $R^2$=90.0%
Generalized Growth, $R^2$=82.1%
Growth Rate of Confirmed Cases
100%
10%
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=204309, r=0.31, p=1.00, a=0.26
GLM
K=187163, r=0.62, p=0.86
Logistic
C0=159, K=156555, r=0.15
GGM
r=4.09, p=0.62

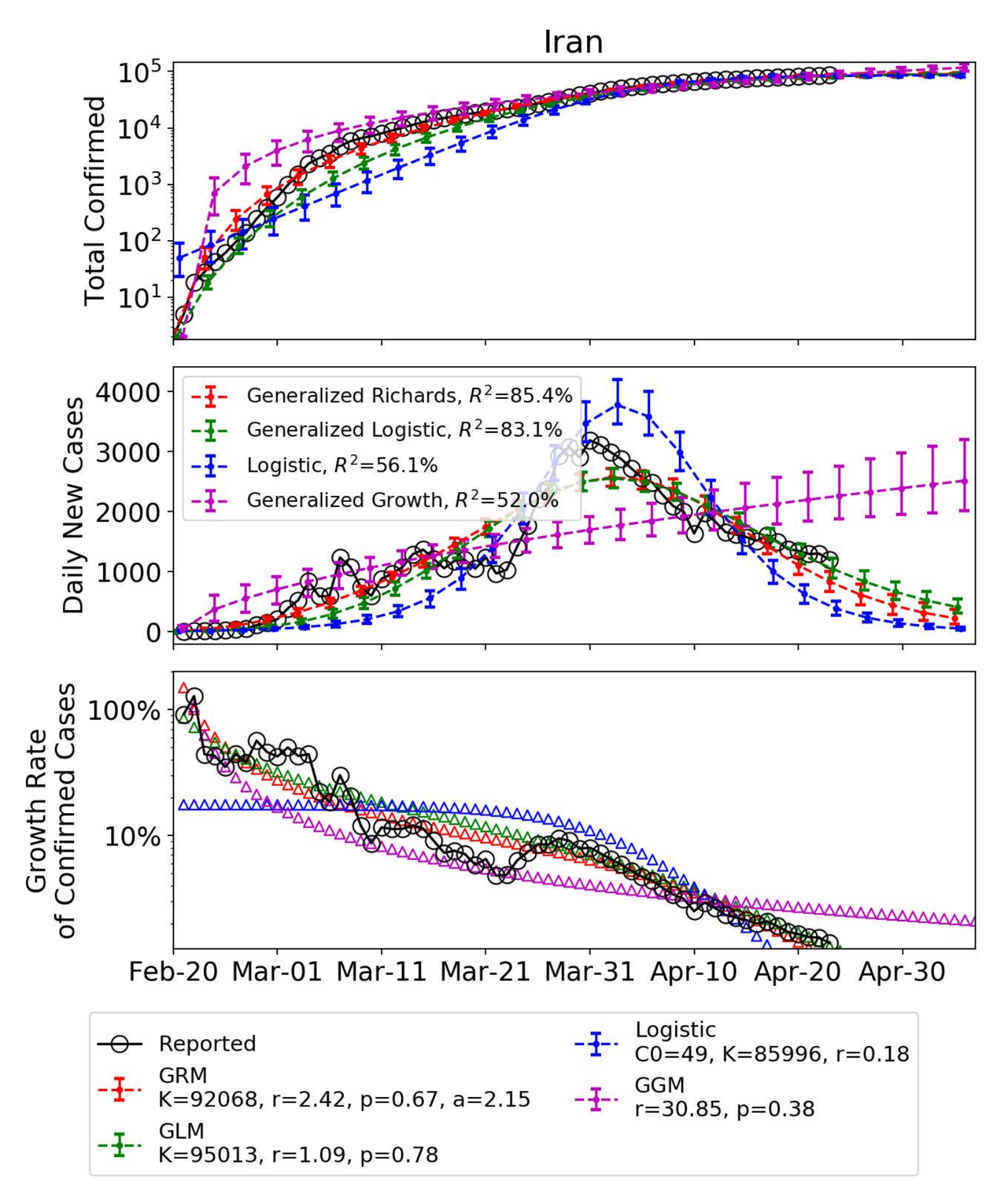

United Kingdom
Total Deaths
$10^4$
$10^3$
$10^2$
Daily Deaths
2000
1500
1000
500
0
Generalized Richards, $R^2$=99.5%
Generalized Logistic, $R^2$=99.2%
Logistic, $R^2$=98.6%
Generalized Growth, $R^2$=87.9%
Growth Rate of Deaths
100%
10%
Mar-16
Mar-26
Apr-05
Apr-15
Apr-25
May-05
Reported
GRM
K=23431, r=0.28, p=1.00, a=0.43
GLM
K=22113, r=0.45, p=0.89
Logistic
C0=102, K=21148, r=0.17
GGM
r=2.81, p=0.60

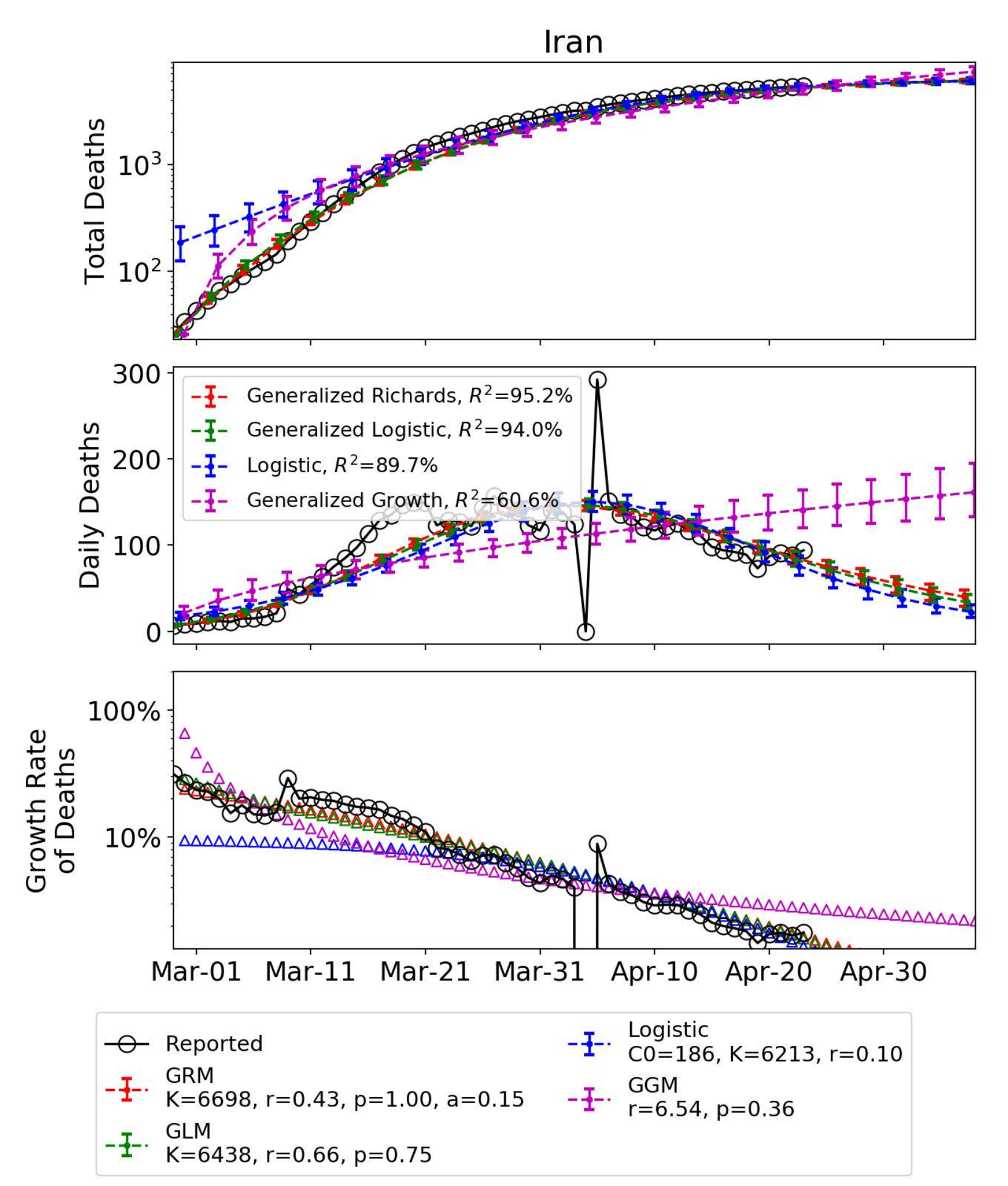

France
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
Daily New Cases
6000
4000
2000
0
Generalized Richards, $R^2$=74.7%
Generalized Logistic, $R^2$=74.3%
Logistic, $R^2$=66.7%
Generalized Growth, $R^2$=40.9%
Growth Rate
of Confirmed Cases
100%
10%
1%
Mar-05
Mar-15
Mar-25
Apr-04
Apr-14
Apr-24
May-04
Reported
GRM
K=134715, r=0.39, p=1.00, a=0.25
GLM
K=132274, r=0.92, p=0.82
Logistic
C0=169, K=119151, r=0.17
GGM
r=28.54, p=0.42

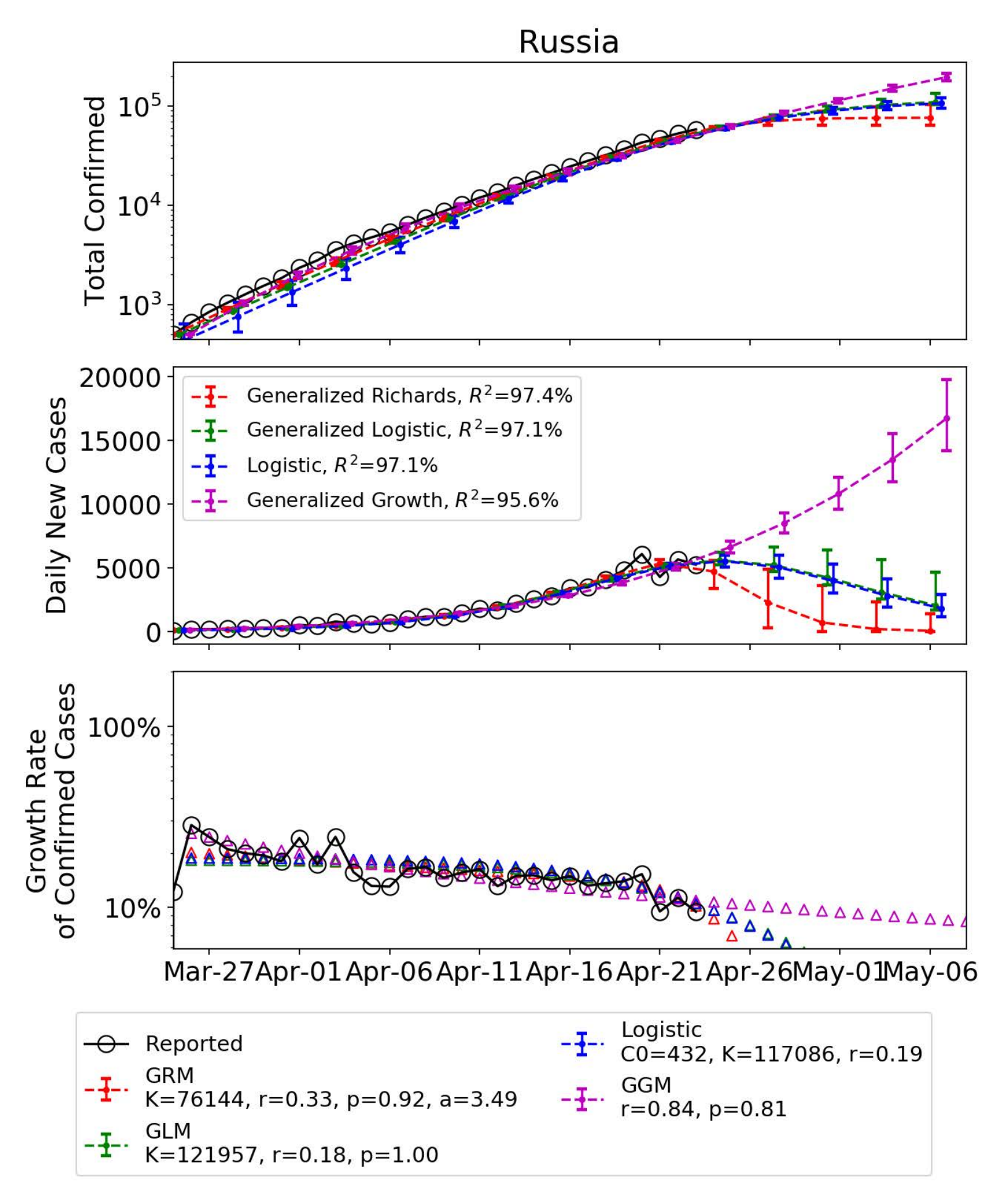

France
Total Deaths
$10^4$
$10^3$
$10^2$
$10^1$
Daily Deaths
2000
1500
1000
500
0
Generalized Richards, $R^2$=97.5%
Generalized Logistic, $R^2$=97.1%
Logistic, $R^2$=96.7%
Generalized Growth, $R^2$=78.2%
Growth Rate of Deaths
100%
10%
Mar-06
Mar-16
Mar-26
Apr-05
Apr-15
Apr-25
May-05
Reported
GRM
K=24733, r=0.25, p=1.00, a=0.54
GLM
K=24072, r=0.35, p=0.92
Logistic
C0=42, K=23656, r=0.17
GGM
r=2.66, p=0.60

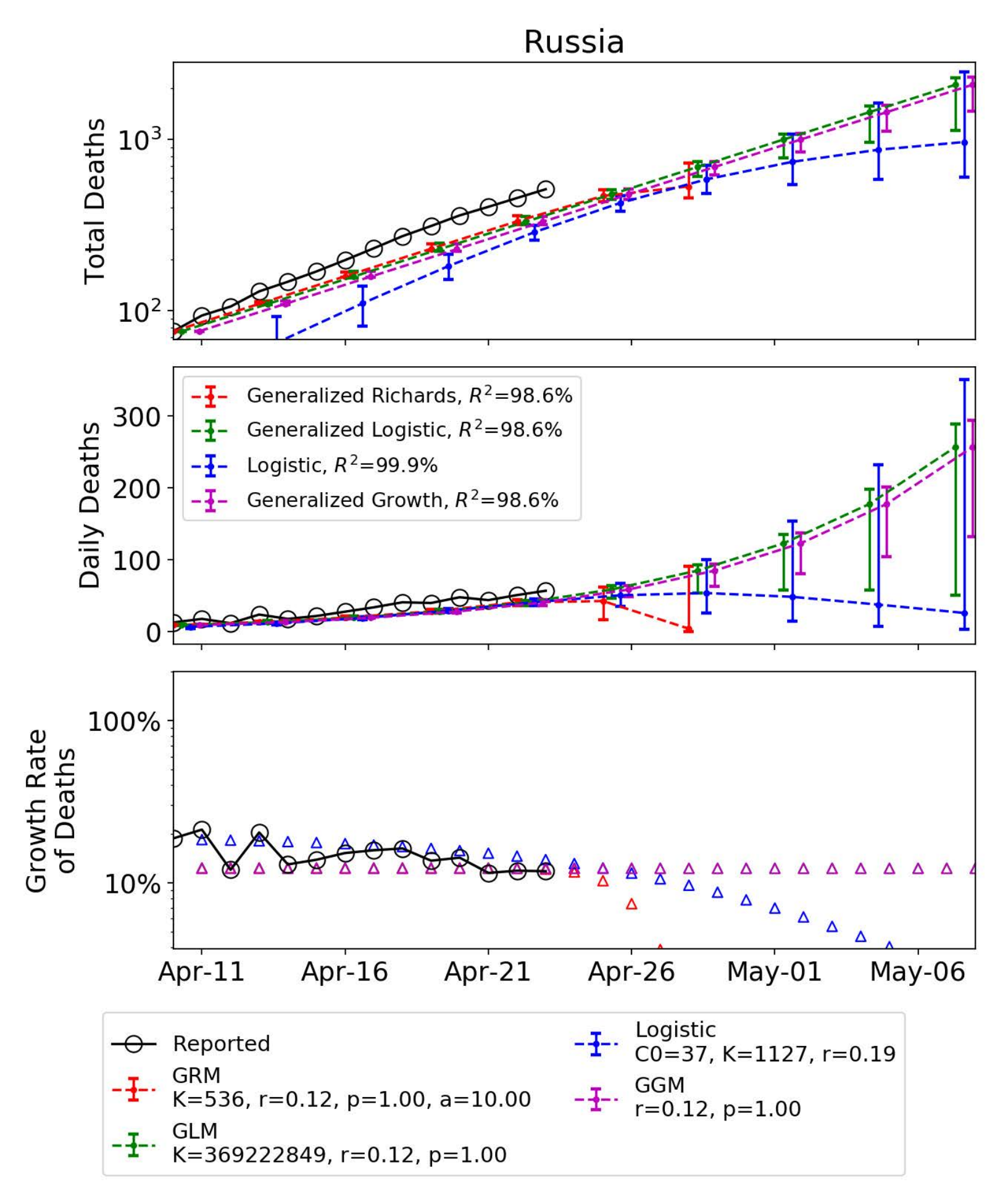

Turkey
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
Daily New Cases
8000
6000
4000
2000
0
Generalized Richards, $R^2$=95.7%
Generalized Logistic, $R^2$=95.7%
Logistic, $R^2$=81.3%
Generalized Growth, $R^2$=85.5%
Growth Rate
of Confirmed Cases
100%
10%
Mar-22
Apr-01
Apr-11
Apr-21
May-01
Reported
GRM
K=147039, r=2.60, p=0.72, a=1.07
GLM
K=148781, r=2.47, p=0.73
Logistic
C0=179, K=98674, r=0.22
GGM
r=16.80, p=0.50

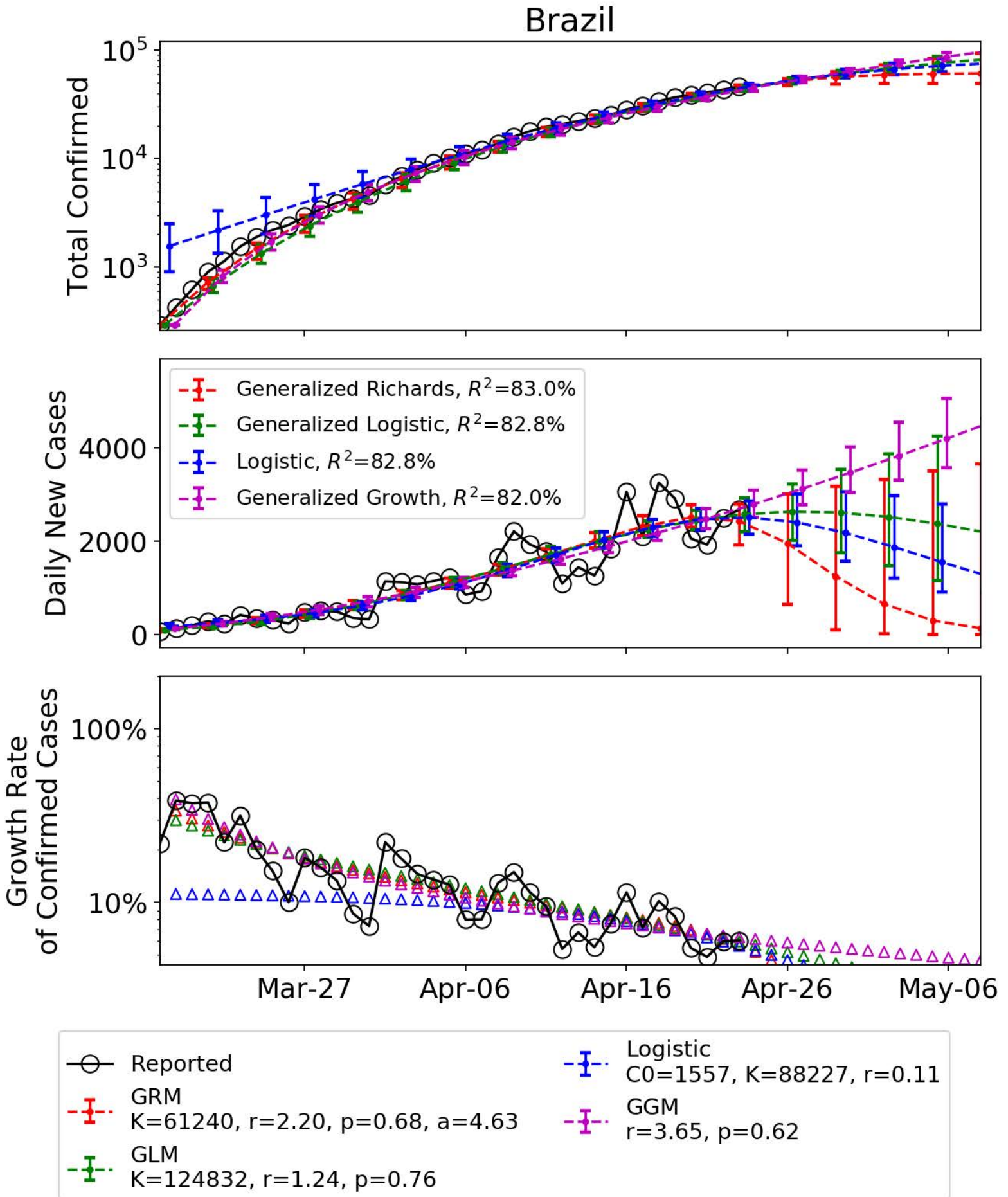

Turkey
Total Deaths
$10^3$
$10^2$
Daily Deaths
200
100
0
Generalized Richards, $R^2$=98.2%
Generalized Logistic, $R^2$=97.9%
Logistic, $R^2$=96.9%
Generalized Growth, $R^2$=95.6%
Growth Rate of Deaths
100%
10%
Mar-29
Apr-03
Apr-08
Apr-13
Apr-18
Apr-23
Apr-28
May-03
May-08
Reported
GRM
K=5539, r=0.41, p=1.00, a=0.16
GLM
K=4638, r=0.54, p=0.79
Logistic
C0=146, K=3714, r=0.13
GGM
r=1.66, p=0.58

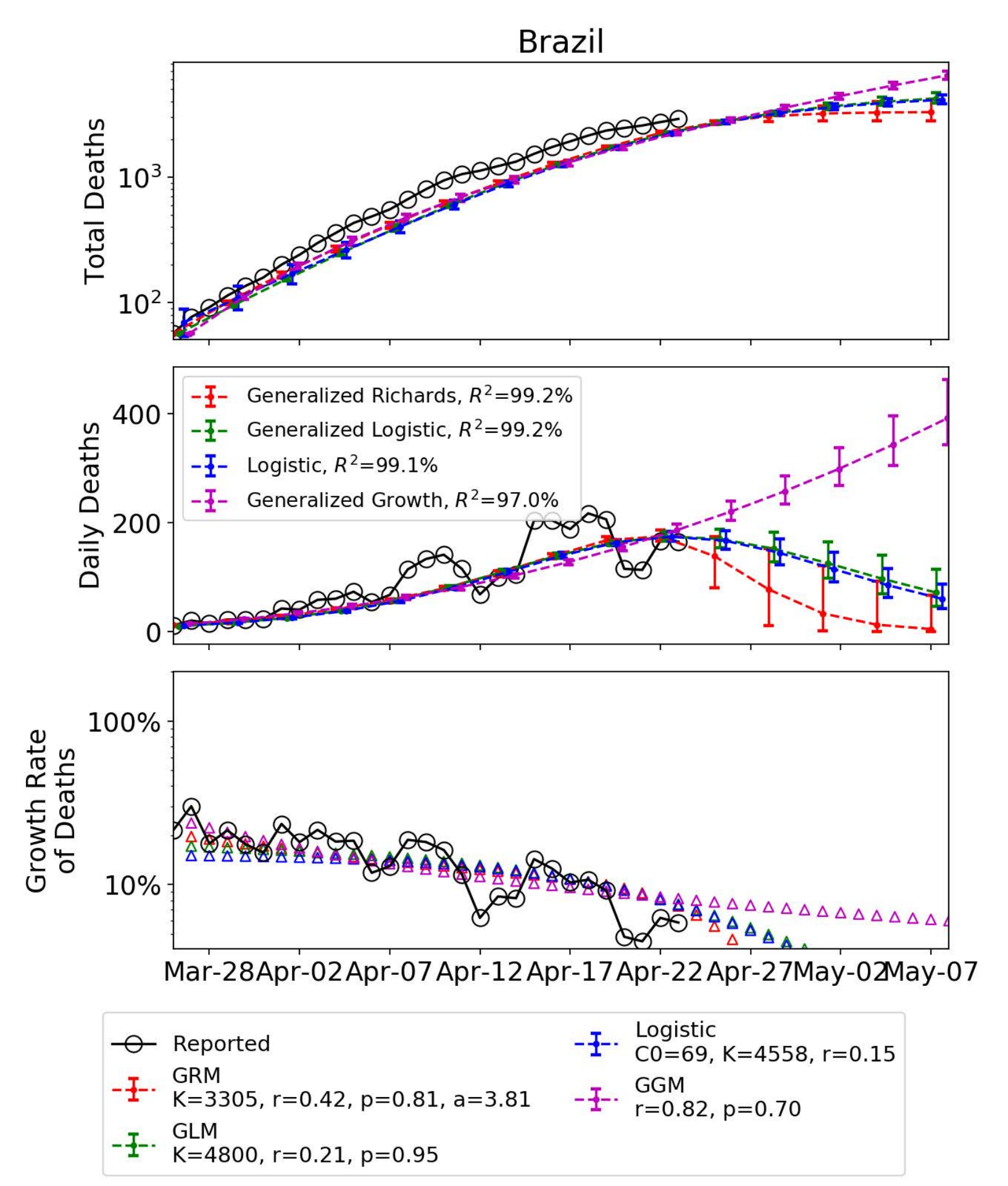

Iran
Total Confirmed
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
Daily New Cases
4000
3000
2000
1000
0
Generalized Richards, $R^2$=85.4%
Generalized Logistic, $R^2$=83.1%
Logistic, $R^2$=56.1%
Generalized Growth, $R^2$=52.0%
Growth Rate
of Confirmed Cases
100%
10%
Feb-20
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=92068, r=2.42, p=0.67, a=2.15
GLM
K=95013, r=1.09, p=0.78
Logistic
C0=49, K=85996, r=0.18
GGM
r=30.85, p=0.38

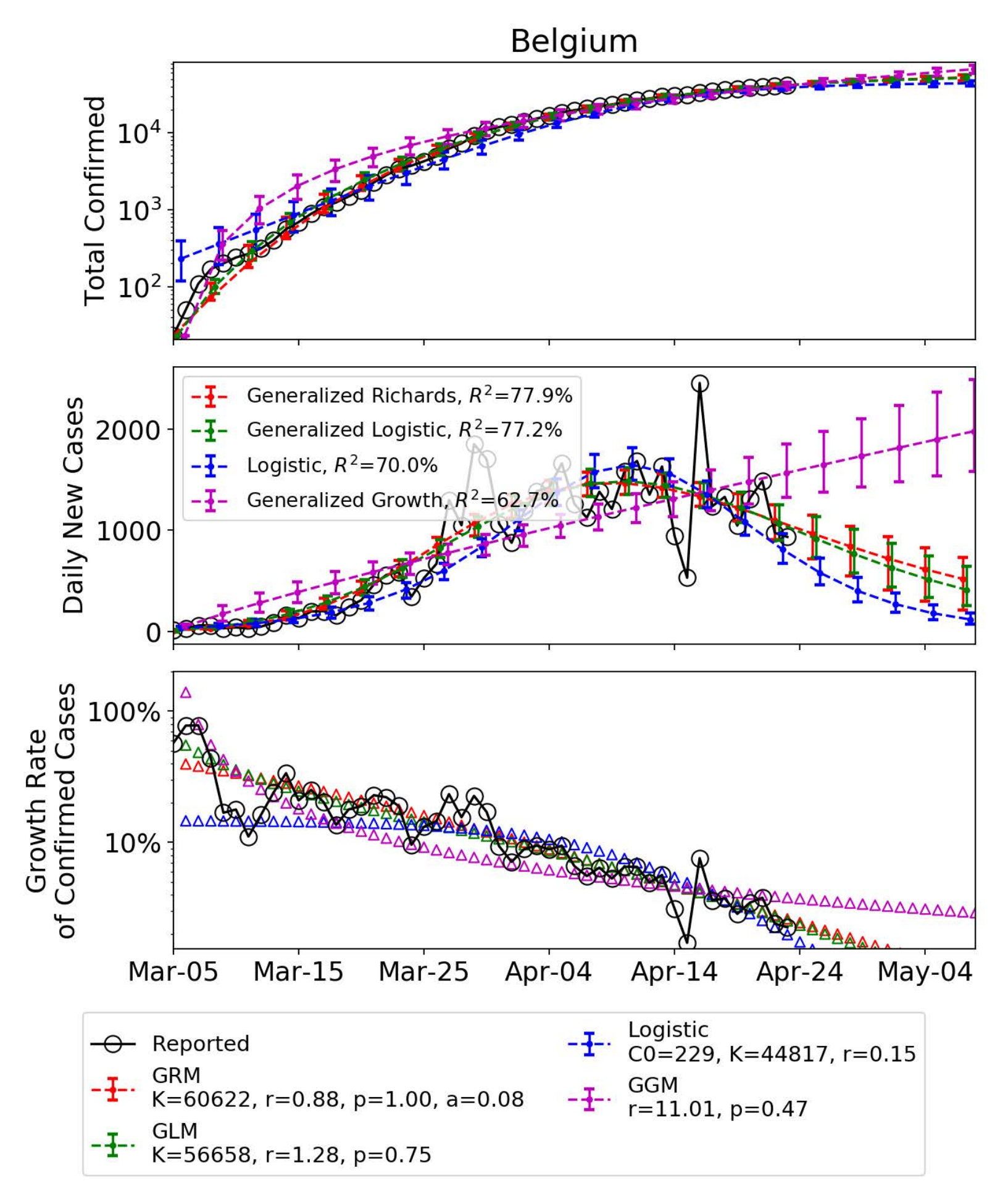

Iran
Total Deaths
$10^3$
$10^2$
Daily Deaths
300
200
100
0
Generalized Richards, $R^2$=95.2%
Generalized Logistic, $R^2$=94.0%
Logistic, $R^2$=89.7%
Generalized Growth, $R^2$=60.6%
Growth Rate of Deaths
100%
10%
Mar-01
Mar-11
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=6698, r=0.43, p=1.00, a=0.15
GLM
K=6438, r=0.66, p=0.75
Logistic
C0=186, K=6213, r=0.10
GGM
r=6.54, p=0.36

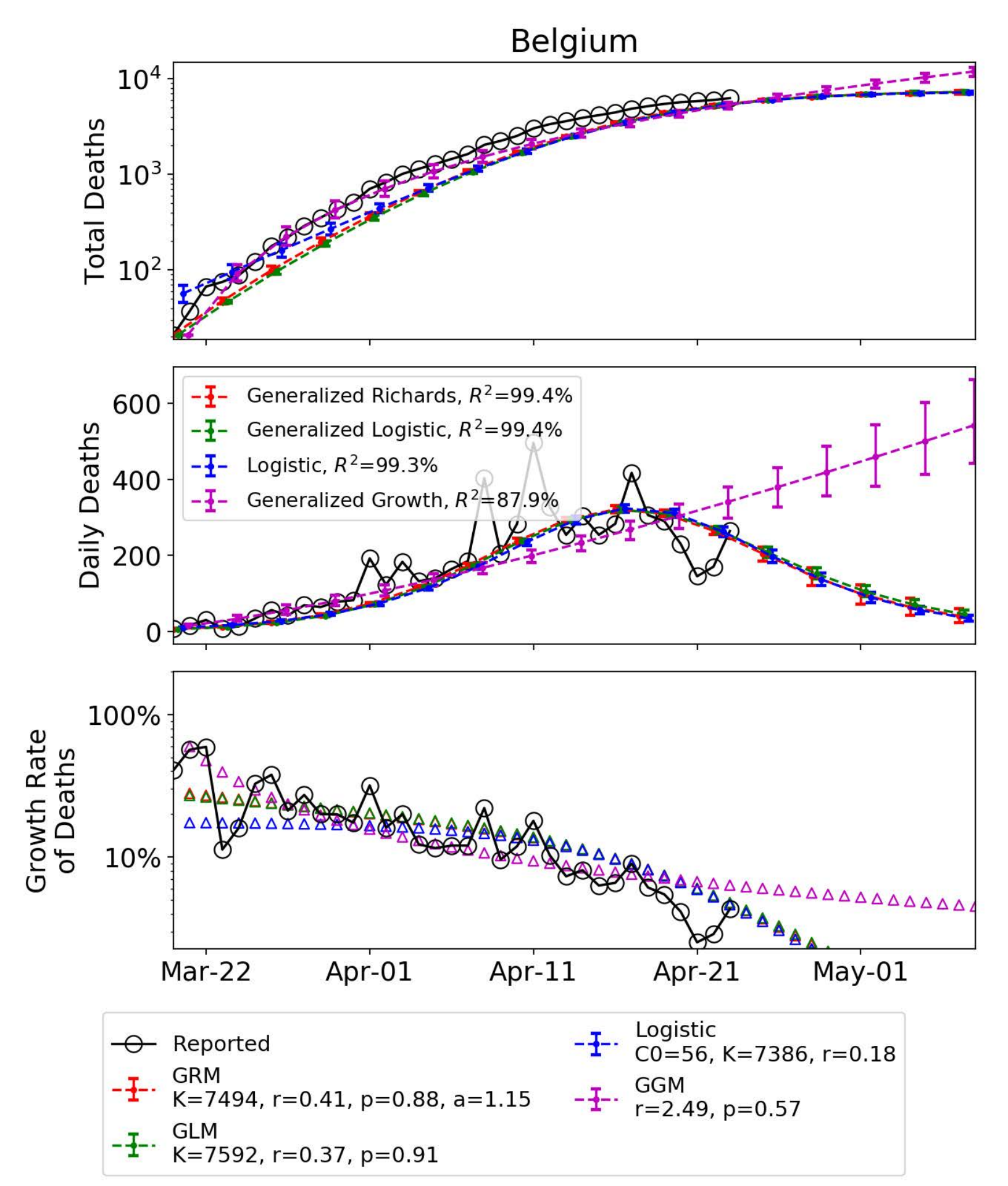

Russia
Total Confirmed
$10^5$
$10^4$
$10^3$
Daily New Cases
20000
15000
10000
5000
0
Generalized Richards, $R^2$=97.4%
Generalized Logistic, $R^2$=97.1%
Logistic, $R^2$=97.1%
Generalized Growth, $R^2$=95.6%
Growth Rate
of Confirmed Cases
100%
10%
Mar-27
Apr-01
Apr-06
Apr-11
Apr-16
Apr-21
Apr-26
May-01
May-06
Reported
GRM
K=76144, r=0.33, p=0.92, a=3.49
GLM
K=121957, r=0.18, p=1.00
Logistic
C0=432, K=117086, r=0.19
GGM
r=0.84, p=0.81

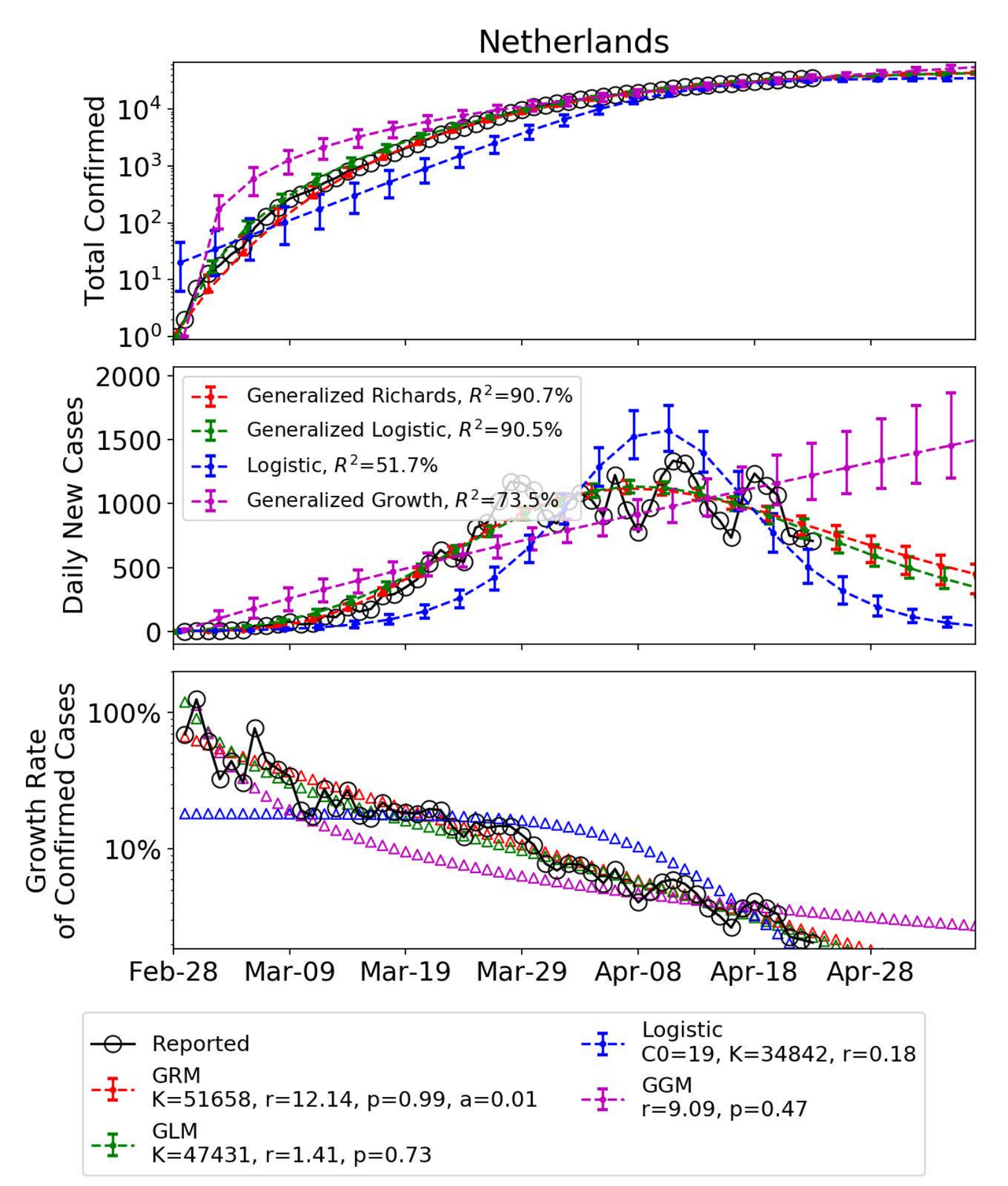

Russia
Total Deaths
$10^3$
$10^2$
Daily Deaths
300
200
100
0
Generalized Richards, $R^2$=98.6%
Generalized Logistic, $R^2$=98.6%
Logistic, $R^2$=99.9%
Generalized Growth, $R^2$=98.6%
Growth Rate of Deaths
100%
10%
Apr-11
Apr-16
Apr-21
Apr-26
May-01
May-06
Reported
GRM
K=536, r=0.12, p=1.00, a=10.00
GLM
K=369222849, r=0.12, p=1.00
Logistic
C0=37, K=1127, r=0.19
GGM
r=0.12, p=1.00

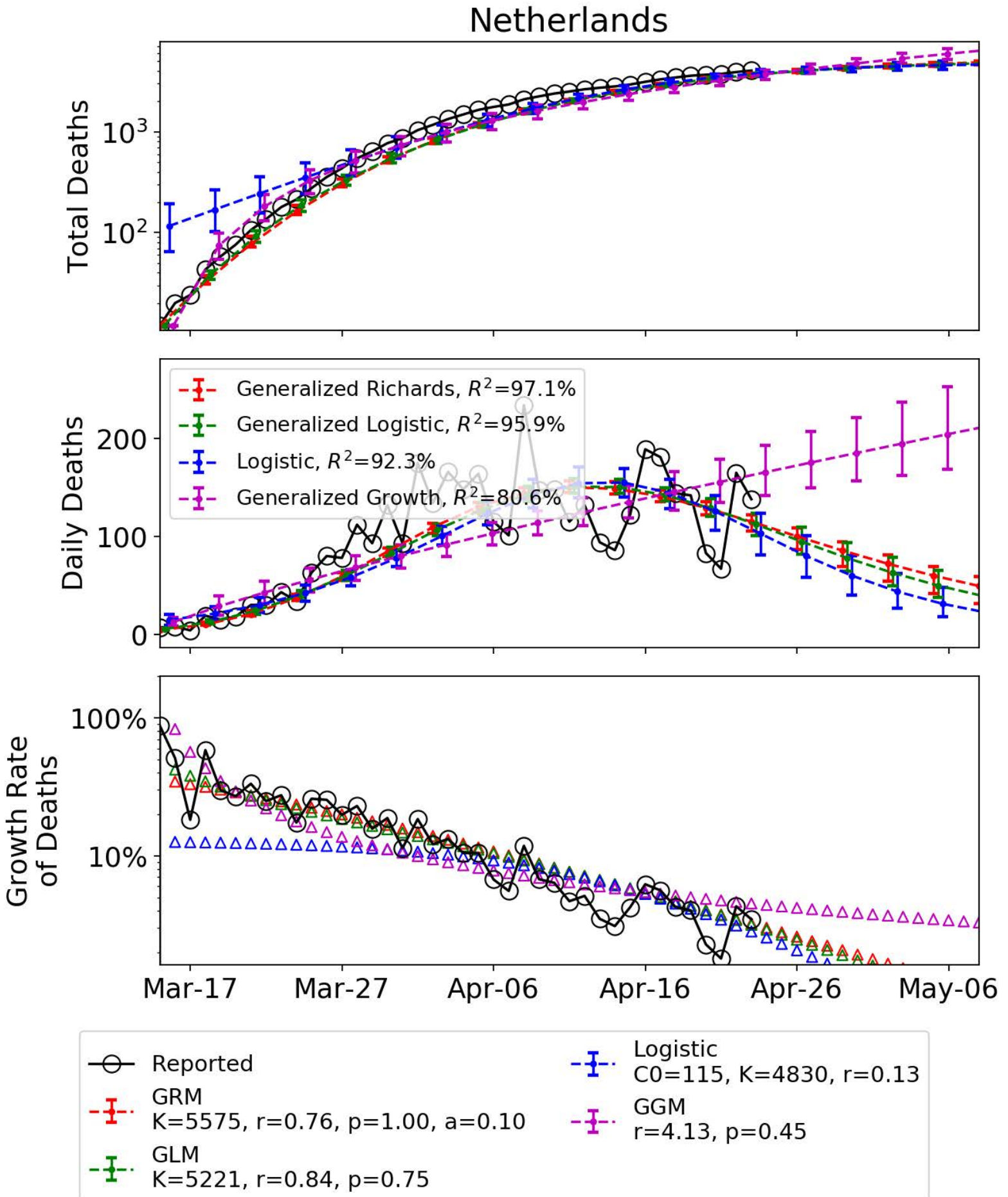

Brazil
Total Confirmed
$10^5$
$10^4$
$10^3$
Daily New Cases
4000
2000
0
Generalized Richards, $R^2$=83.0%
Generalized Logistic, $R^2$=82.8%
Logistic, $R^2$=82.8%
Generalized Growth, $R^2$=82.0%
Growth Rate
of Confirmed Cases
100%
10%
Mar-27
Apr-06
Apr-16
Apr-26
May-06
Reported
GRM
K=61240, r=2.20, p=0.68, a=4.63
GLM
K=124832, r=1.24, p=0.76
Logistic
C0=1557, K=88227, r=0.11
GGM
r=3.65, p=0.62

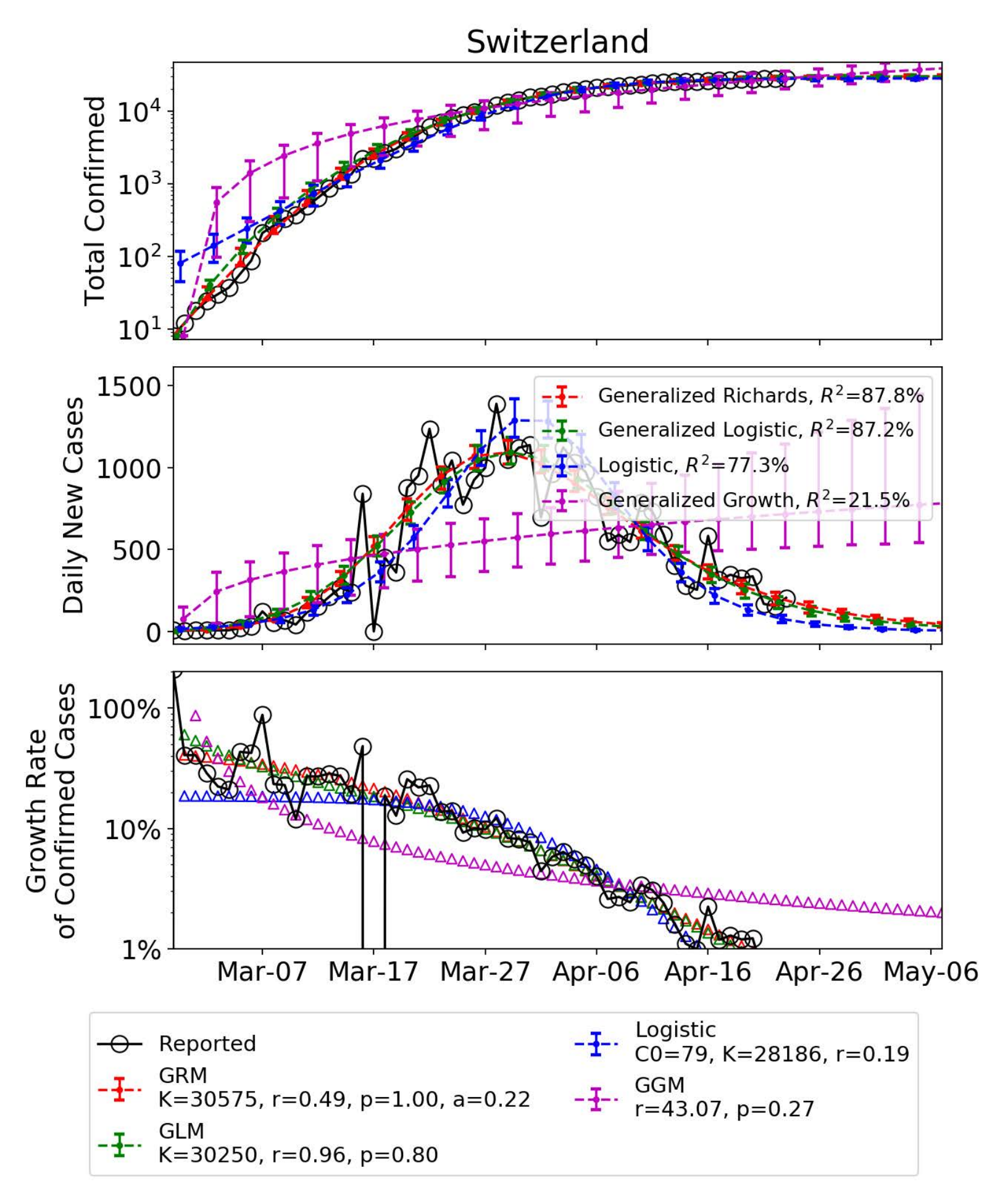

Brazil
Total Deaths
$10^3$
$10^2$
Daily Deaths
400
200
0
Generalized Richards, $R^2$=99.2%
Generalized Logistic, $R^2$=99.2%
Logistic, $R^2$=99.1%
Generalized Growth, $R^2$=97.0%
Growth Rate of Deaths
100%
10%
Mar-28
Apr-02
Apr-07
Apr-12
Apr-17
Apr-22
Apr-27
May-02
May-07
Reported
GRM
K=3305, r=0.42, p=0.81, a=3.81
GLM
K=4800, r=0.21, p=0.95
Logistic
C0=69, K=4558, r=0.15
GGM
r=0.82, p=0.70

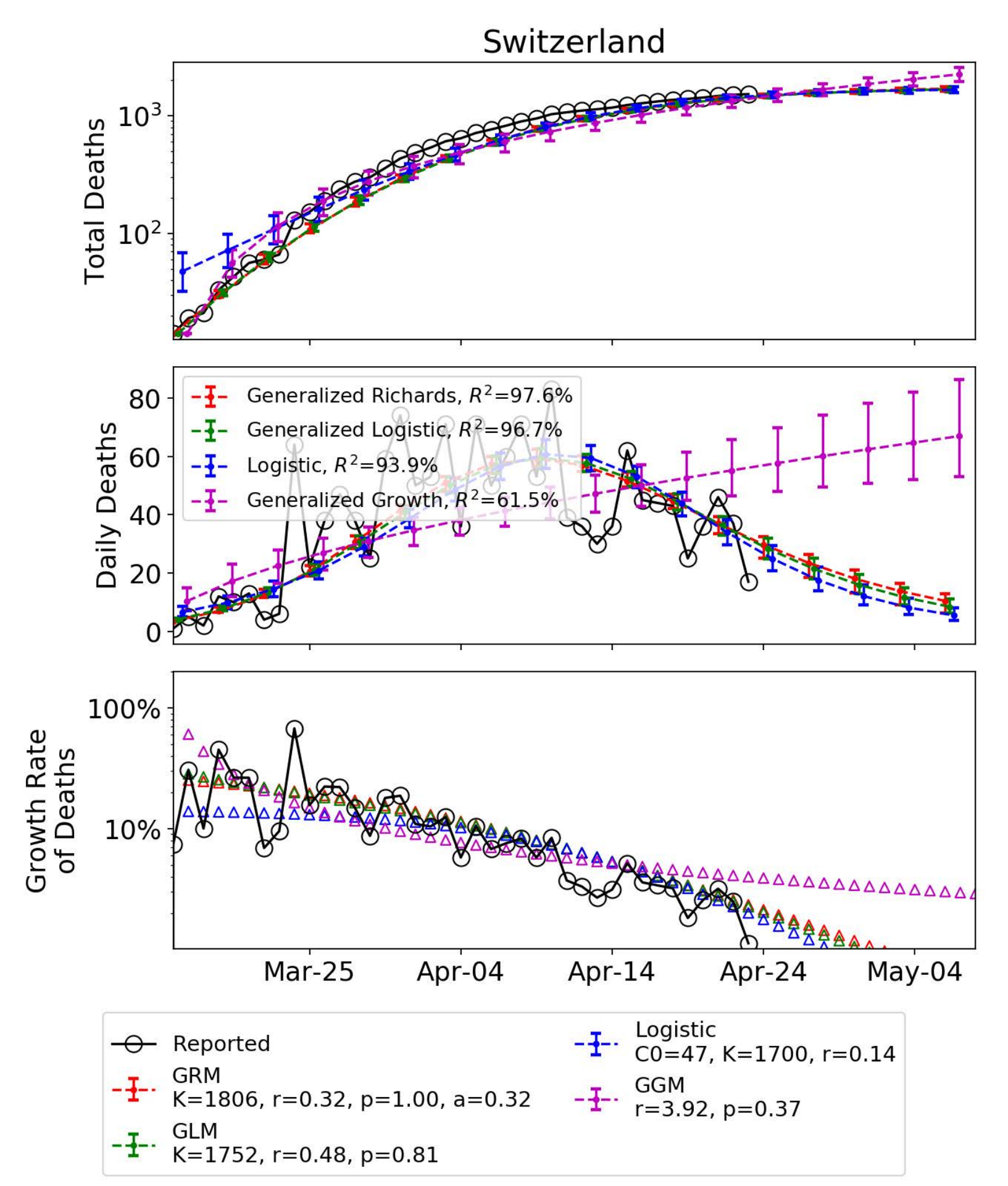

Belgium
Total Confirmed
$10^4$
$10^3$
$10^2$
Daily New Cases
2000
1000
0
Generalized Richards, $R^2$=77.9%
Generalized Logistic, $R^2$=77.2%
Logistic, $R^2$=70.0%
Generalized Growth, $R^2$=62.7%
Growth Rate
of Confirmed Cases
100%
10%
Mar-05
Mar-15
Mar-25
Apr-04
Apr-14
Apr-24
May-04
Reported
GRM
K=60622, r=0.88, p=1.00, a=0.08
GLM
K=56658, r=1.28, p=0.75
Logistic
C0=229, K=44817, r=0.15
GGM
r=11.01, p=0.47

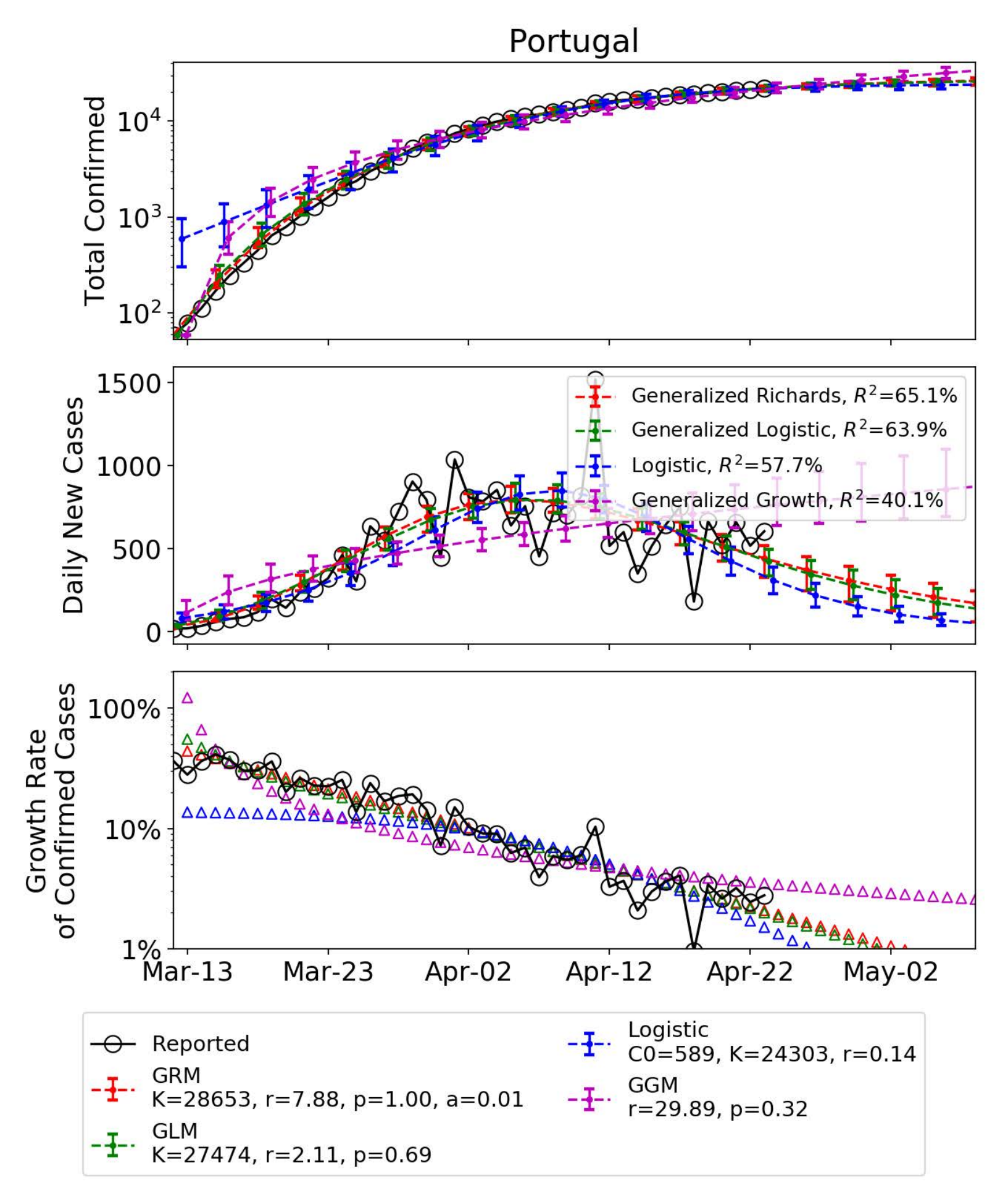

Belgium
Total Deaths
$10^4$
$10^3$
$10^2$
Daily Deaths
600
400
200
0
Generalized Richards, $R^2$=99.4%
Generalized Logistic, $R^2$=99.4%
Logistic, $R^2$=99.3%
Generalized Growth, $R^2$=87.9%
Growth Rate of Deaths
100%
10%
Mar-22
Apr-01
Apr-11
Apr-21
May-01
Reported
GRM
K=7494, r=0.41, p=0.88, a=1.15
GLM
K=7592, r=0.37, p=0.91
Logistic
C0=56, K=7386, r=0.18
GGM
r=2.49, p=0.57

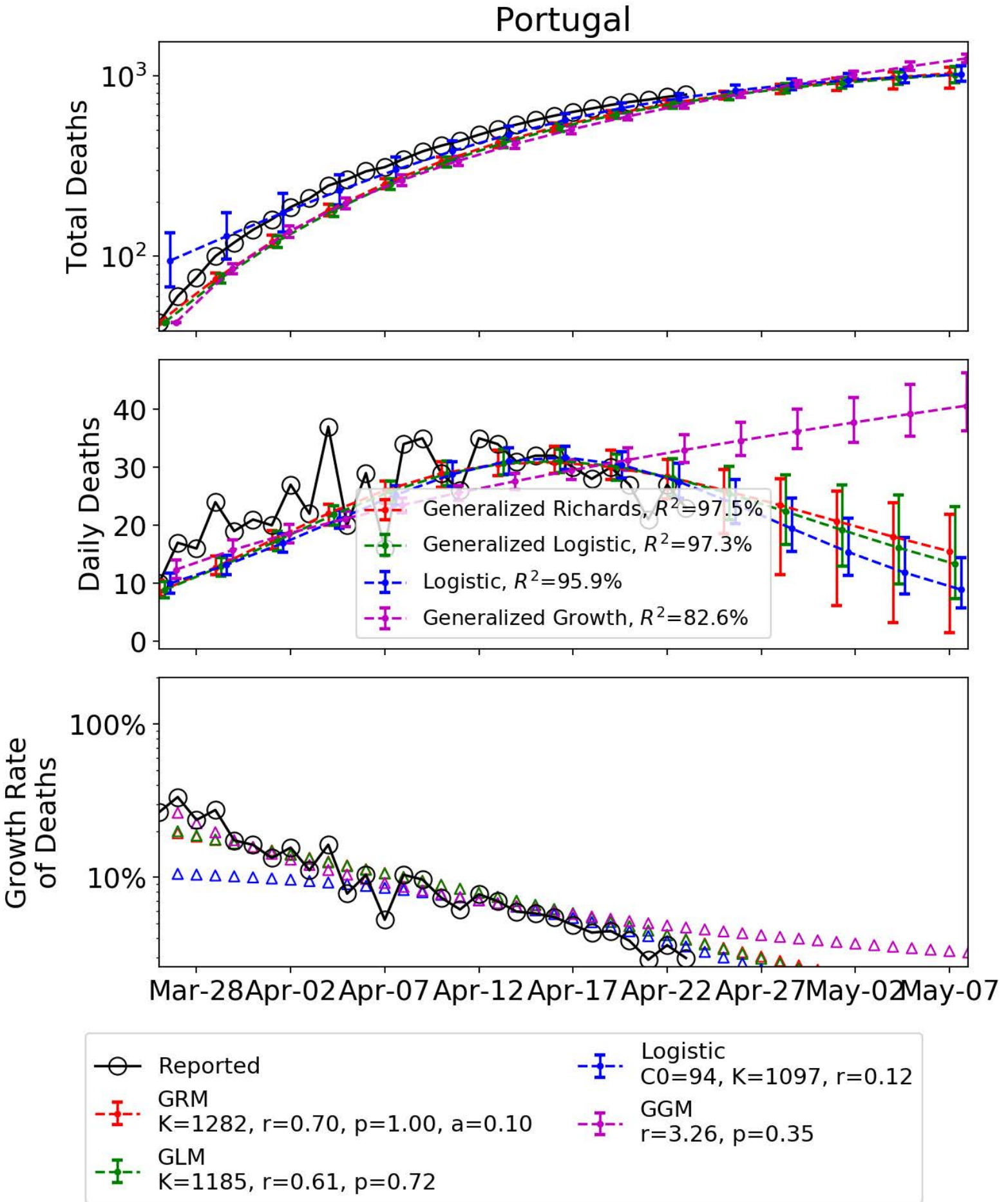

Netherlands
Total Confirmed
$10^4$
$10^3$
$10^2$
$10^1$
$10^0$
Daily New Cases
2000
1500
1000
500
0
Generalized Richards, $R^2$=90.7%
Generalized Logistic, $R^2$=90.5%
Logistic, $R^2$=51.7%
Generalized Growth, $R^2$=73.5%
Growth Rate
of Confirmed Cases
100%
10%
Feb-28
Mar-09
Mar-19
Mar-29
Apr-08
Apr-18
Apr-28
Reported
GRM
K=51658, r=12.14, p=0.99, a=0.01
GLM
K=47431, r=1.41, p=0.73
Logistic
C0=19, K=34842, r=0.18
GGM
r=9.09, p=0.47

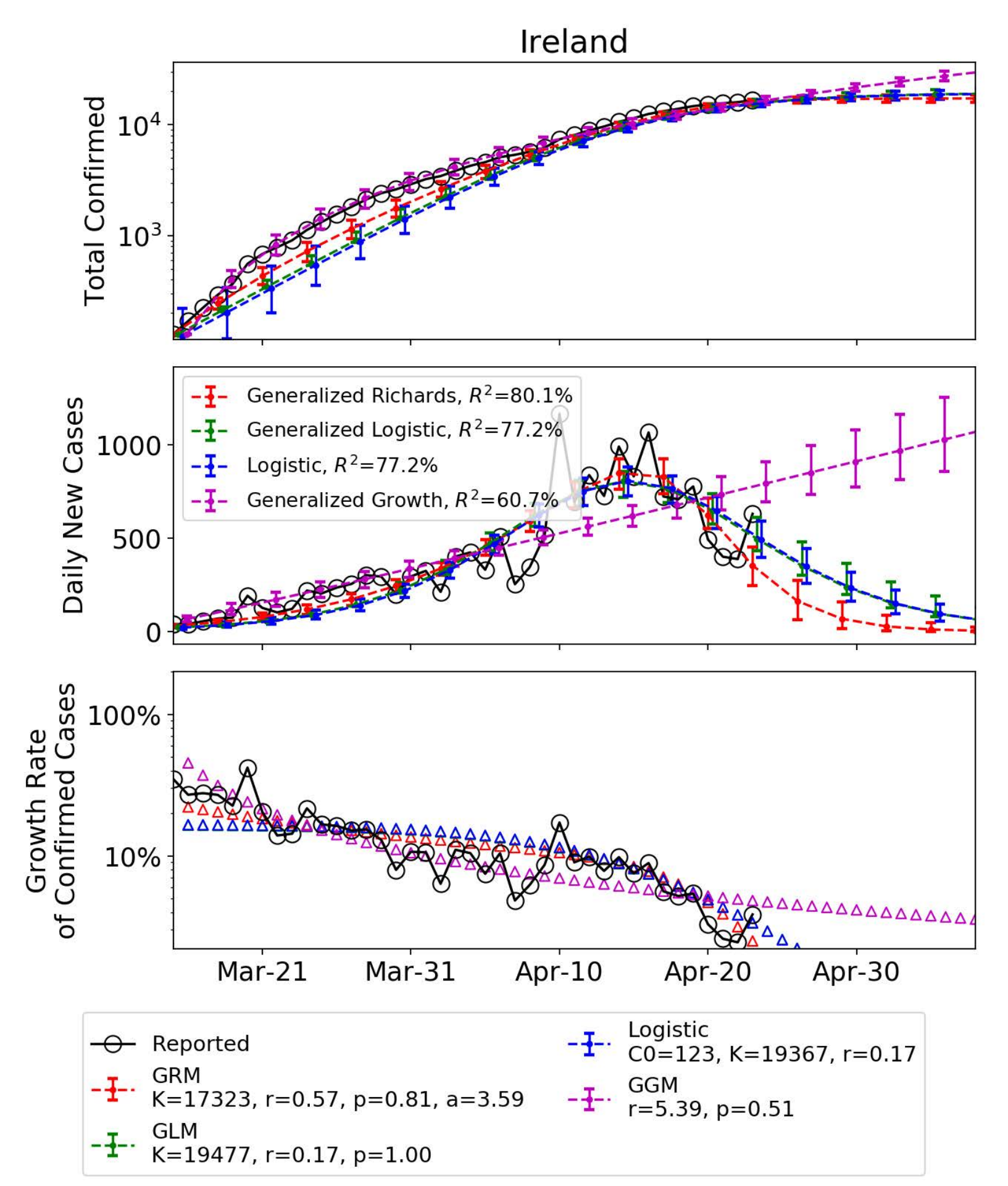

Netherlands
Total Deaths
$10^3$
$10^2$
Daily Deaths
200
100
0
Generalized Richards, $R^2$=97.1%
Generalized Logistic, $R^2$=95.9%
Logistic, $R^2$=92.3%
Generalized Growth, $R^2$=80.6%
Growth Rate of Deaths
100%
10%
Mar-17
Mar-27
Apr-06
Apr-16
Apr-26
May-06
Reported
GRM
K=5575, r=0.76, p=1.00, a=0.10
GLM
K=5221, r=0.84, p=0.75
Logistic
C0=115, K=4830, r=0.13
GGM
r=4.13, p=0.45

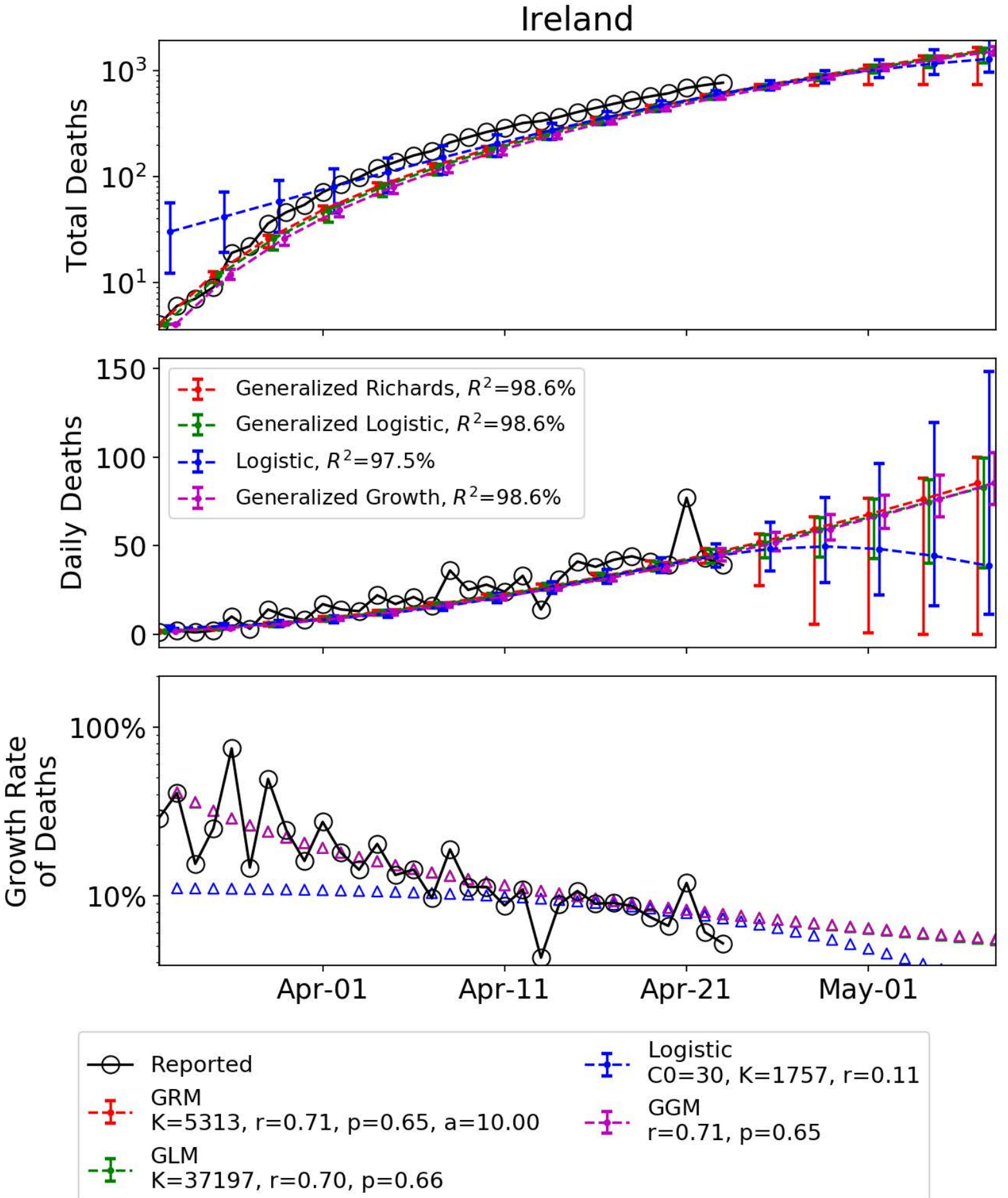

Switzerland
Total Confirmed
$10^4$
$10^3$
$10^2$
$10^1$
Daily New Cases
1500
1000
500
0
Generalized Richards, $R^2$=87.8%
Generalized Logistic, $R^2$=87.2%
Logistic, $R^2$=77.3%
Generalized Growth, $R^2$=21.5%
Growth Rate of Confirmed Cases
100%
10%
1%
Mar-07
Mar-17
Mar-27
Apr-06
Apr-16
Apr-26
May-06
Reported
GRM
K=30575, r=0.49, p=1.00, a=0.22
GLM
K=30250, r=0.96, p=0.80
Logistic
C0=79, K=28186, r=0.19
GGM
r=43.07, p=0.27

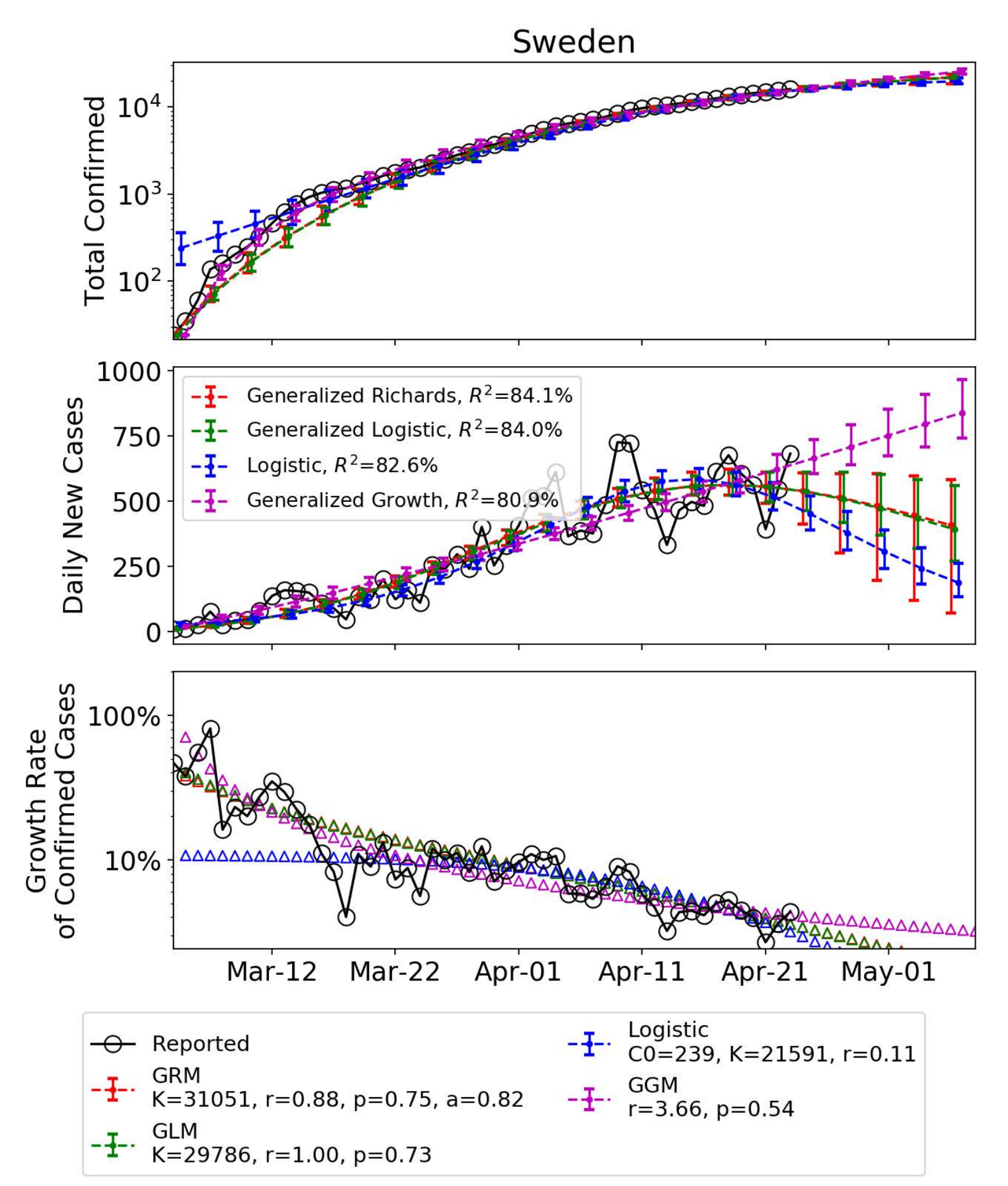

Switzerland
Total Deaths
$10^3$
$10^2$
Daily Deaths
80
60
40
20
0
Generalized Richards, $R^2$=97.6%
Generalized Logistic, $R^2$=96.7%
Logistic, $R^2$=93.9%
Generalized Growth, $R^2$=61.5%
Growth Rate of Deaths
100%
10%
Mar-25
Apr-04
Apr-14
Apr-24
May-04
Reported
GRM
K=1806, r=0.32, p=1.00, a=0.32
GLM
K=1752, r=0.48, p=0.81
Logistic
C0=47, K=1700, r=0.14
GGM
r=3.92, p=0.37

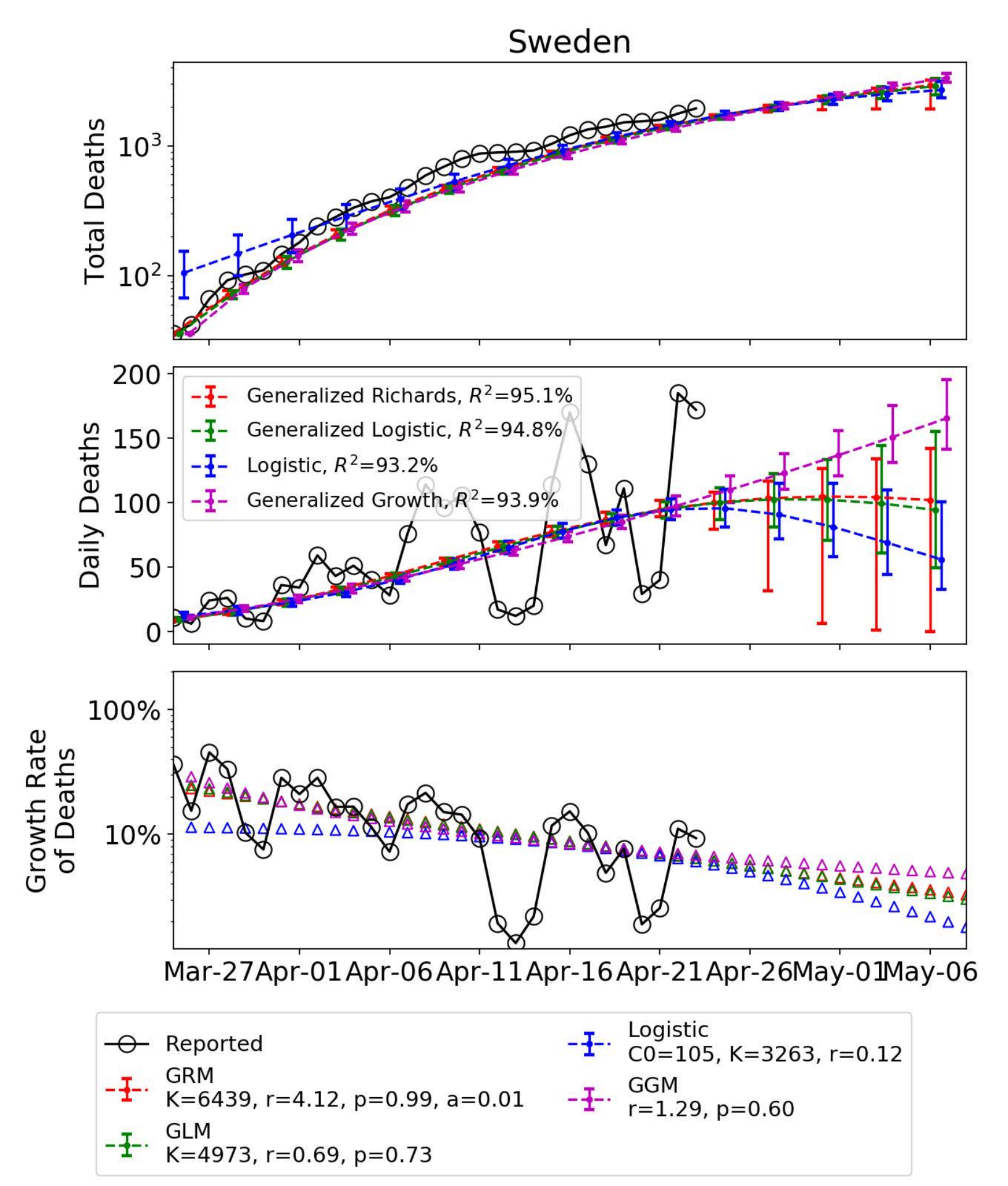

Portugal
Total Confirmed
$10^4$
$10^3$
$10^2$
Daily New Cases
1500
1000
500
0
Generalized Richards, $R^2$=65.1%
Generalized Logistic, $R^2$=63.9%
Logistic, $R^2$=57.7%
Generalized Growth, $R^2$=40.1%
Growth Rate
of Confirmed Cases
100%
10%
1%
Mar-13
Mar-23
Apr-02
Apr-12
Apr-22
May-02
Reported
GRM
K=28653, r=7.88, p=1.00, a=0.01
GLM
K=27474, r=2.11, p=0.69
Logistic
C0=589, K=24303, r=0.14
GGM
r=29.89, p=0.32

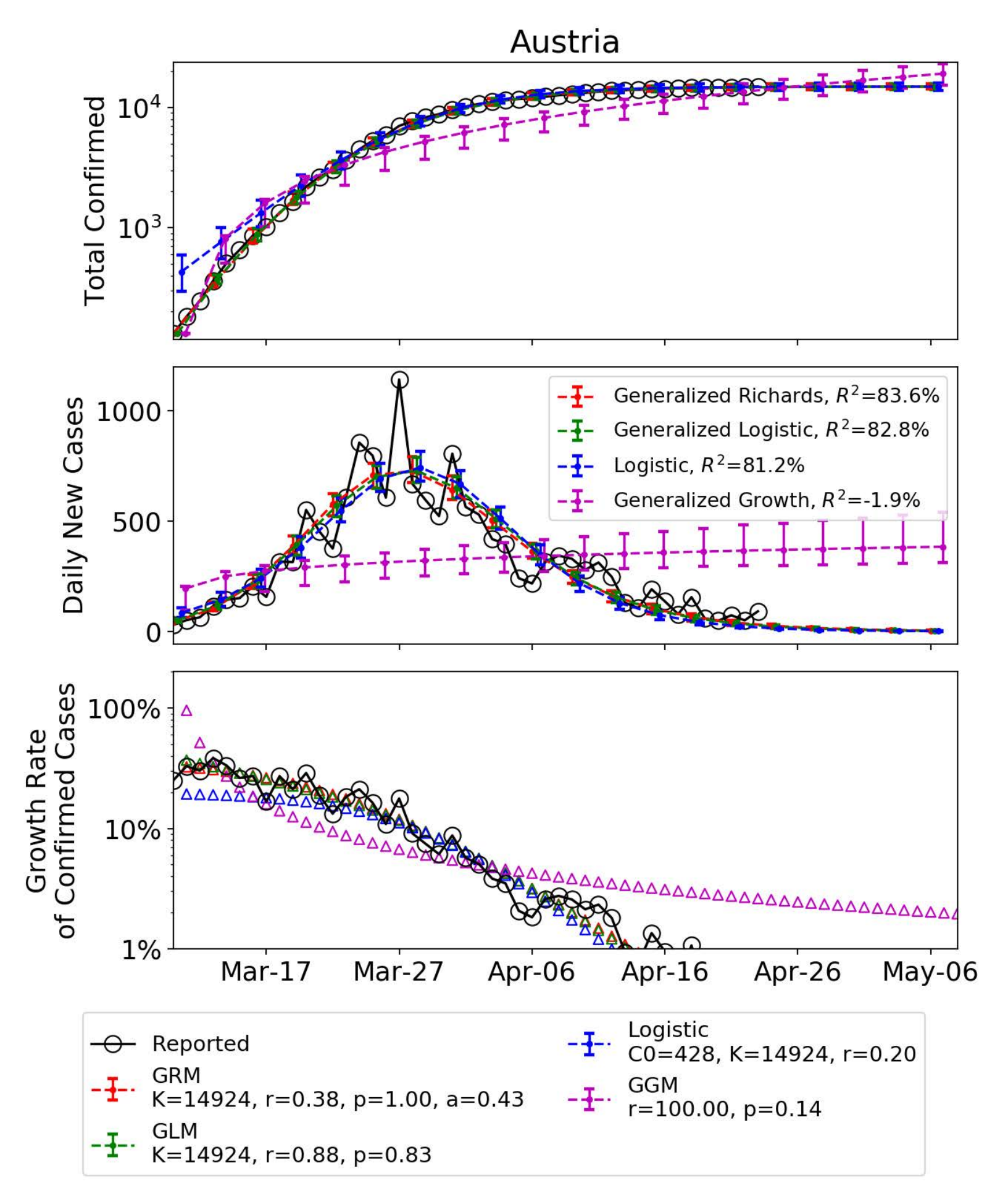

Portugal
Total Deaths
$10^3$
$10^2$
Daily Deaths
40
30
20
10
0
Generalized Richards, $R^2$=97.5%
Generalized Logistic, $R^2$=97.3%
Logistic, $R^2$=95.9%
Generalized Growth, $R^2$=82.6%
Growth Rate of Deaths
100%
10%
Mar-28
Apr-02
Apr-07
Apr-12
Apr-17
Apr-22
Apr-27
May-02
May-07
Reported
GRM
K=1282, r=0.70, p=1.00, a=0.10
GLM
K=1185, r=0.61, p=0.72
Logistic
C0=94, K=1097, r=0.12
GGM
r=3.26, p=0.35

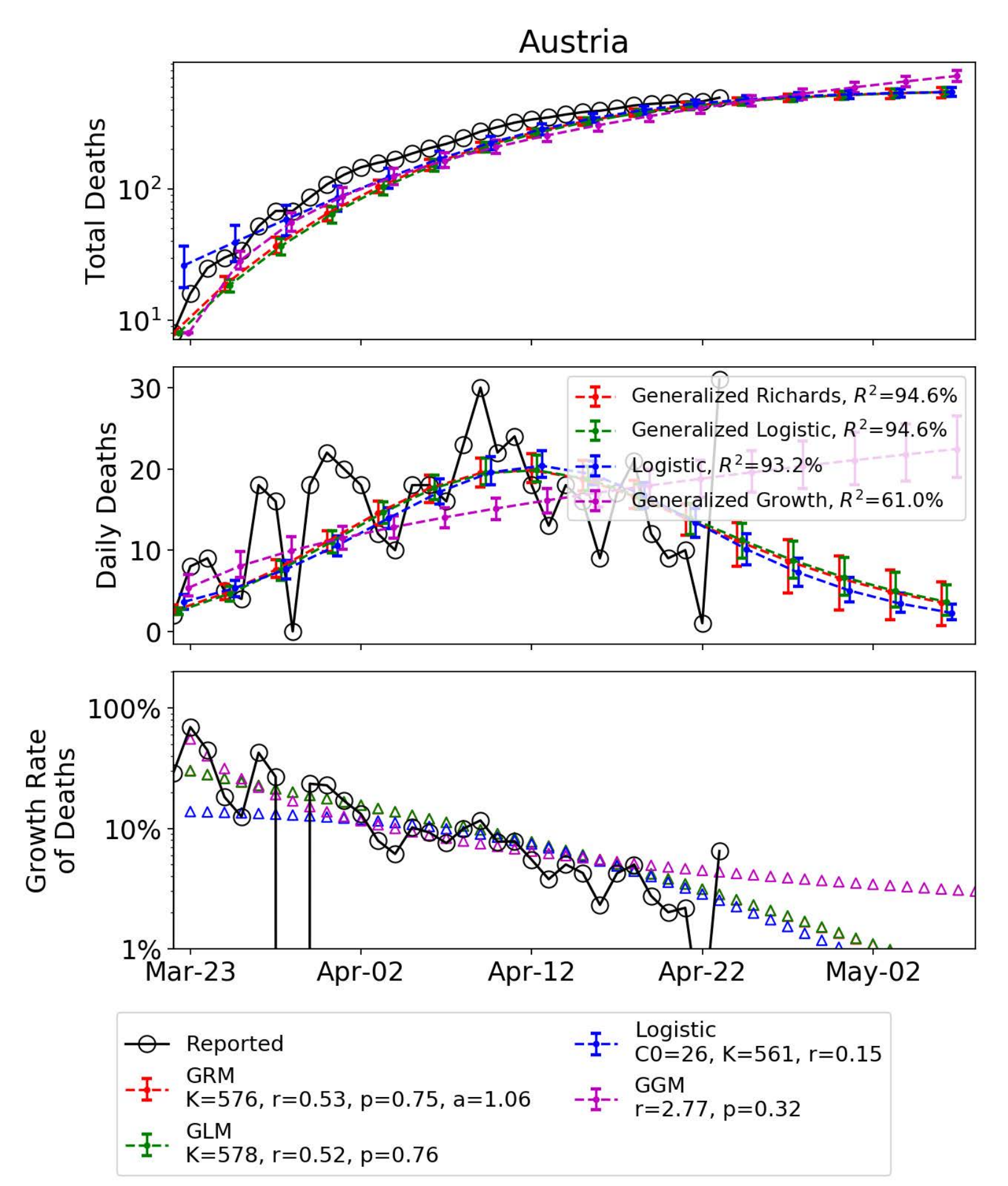

Ireland
Total Confirmed
$10^4$
$10^3$
Daily New Cases
1000
500
0
Generalized Richards, $R^2$=80.1%
Generalized Logistic, $R^2$=77.2%
Logistic, $R^2$=77.2%
Generalized Growth, $R^2$=60.7%
Growth Rate
of Confirmed Cases
100%
10%
Mar-21
Mar-31
Apr-10
Apr-20
Apr-30
Reported
GRM
K=17323, r=0.57, p=0.81, a=3.59
GLM
K=19477, r=0.17, p=1.00
Logistic
C0=123, K=19367, r=0.17
GGM
r=5.39, p=0.51

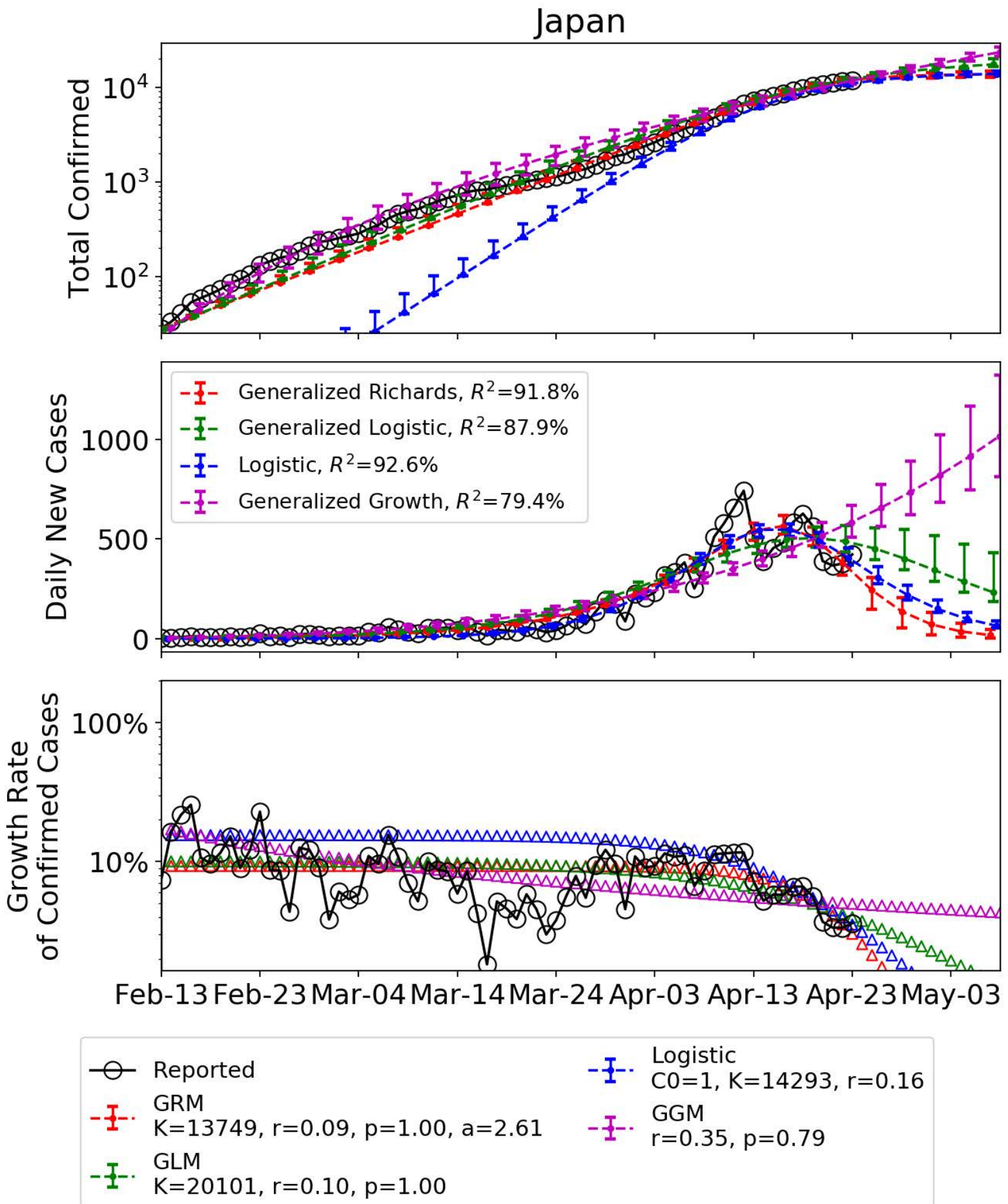

Ireland
Total Deaths
$10^3$
$10^2$
$10^1$
Daily Deaths
150
100
50
0
Generalized Richards, $R^2$=98.6%
Generalized Logistic, $R^2$=98.6%
Logistic, $R^2$=97.5%
Generalized Growth, $R^2$=98.6%
Growth Rate of Deaths
100%
10%
Apr-01
Apr-11
Apr-21
May-01
Reported
GRM
K=5313, r=0.71, p=0.65, a=10.00
GLM
K=37197, r=0.70, p=0.66
Logistic
C0=30, K=1757, r=0.11
GGM
r=0.71, p=0.65

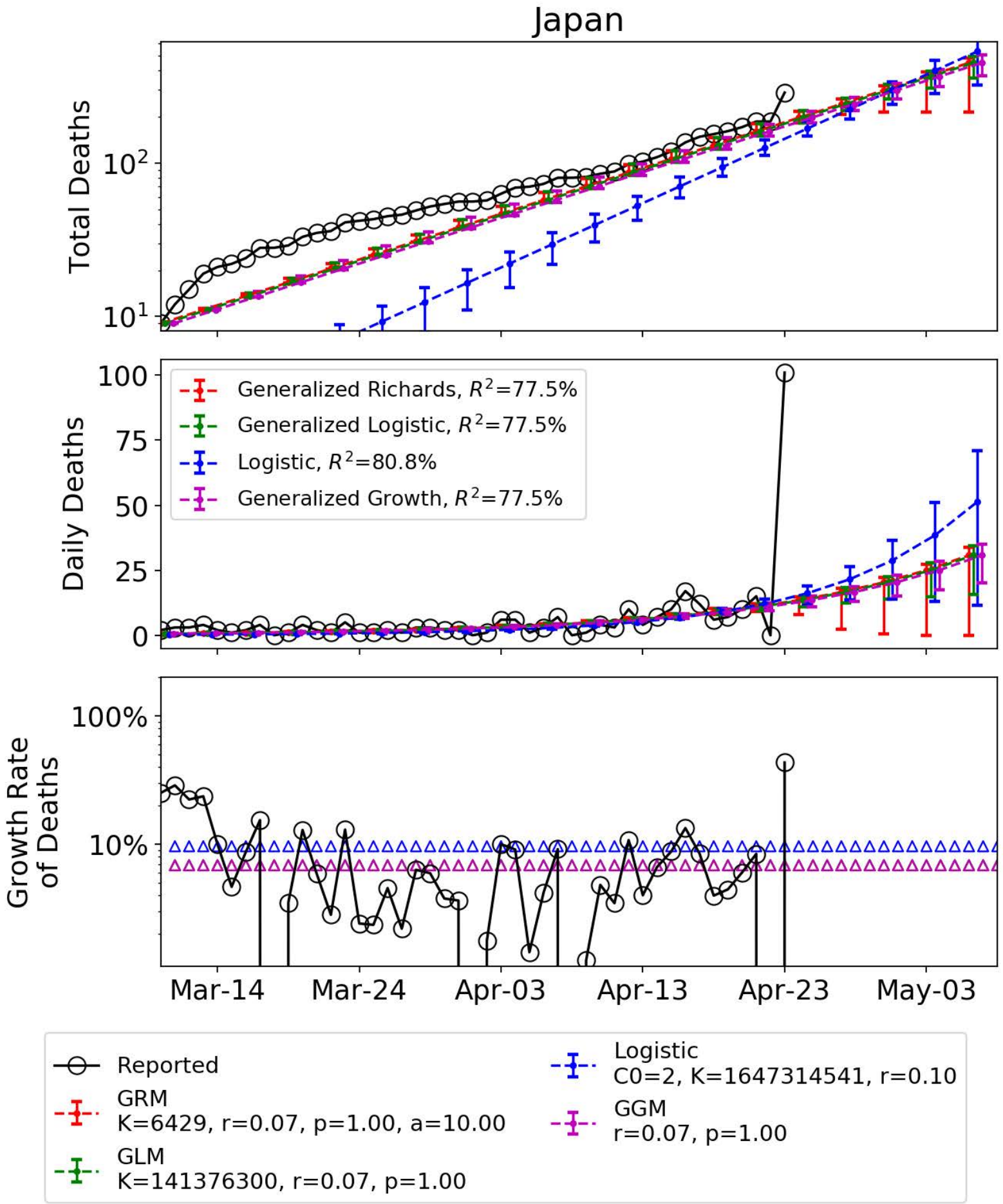

Sweden
Total Confirmed
$10^4$
$10^3$
$10^2$
Daily New Cases
1000
750
500
250
0
Generalized Richards, $R^2$=84.1%
Generalized Logistic, $R^2$=84.0%
Logistic, $R^2$=82.6%
Generalized Growth, $R^2$=80.9%
Growth Rate
of Confirmed Cases
100%
10%
Mar-12
Mar-22
Apr-01
Apr-11
Apr-21
May-01
Reported
GRM
K=31051, r=0.88, p=0.75, a=0.82
GLM
K=29786, r=1.00, p=0.73
Logistic
C0=239, K=21591, r=0.11
GGM
r=3.66, p=0.54


Sweden
Total Deaths
$10^3$
$10^2$
Daily Deaths
200
150
100
50
0
Generalized Richards, $R^2$=95.1%
Generalized Logistic, $R^2$=94.8%
Logistic, $R^2$=93.2%
Generalized Growth, $R^2$=93.9%
Growth Rate of Deaths
100%
10%
Mar-27
Apr-01
Apr-06
Apr-11
Apr-16
Apr-21
Apr-26
May-01
May-06
Reported
GRM
K=6439, r=4.12, p=0.99, a=0.01
GLM
K=4973, r=0.69, p=0.73
Logistic
C0=105, K=3263, r=0.12
GGM
r=1.29, p=0.60


Austria
Total Confirmed
$10^4$
$10^3$
Daily New Cases
1000
500
0
Generalized Richards, $R^2$=83.6%
Generalized Logistic, $R^2$=82.8%
Logistic, $R^2$=81.2%
Generalized Growth, $R^2$=-1.9%
Growth Rate
of Confirmed Cases
100%
10%
1%
Mar-17
Mar-27
Apr-06
Apr-16
Apr-26
May-06
Reported
GRM
K=14924, r=0.38, p=1.00, a=0.43
GLM
K=14924, r=0.88, p=0.83
Logistic
C0=428, K=14924, r=0.20
GGM
r=100.00, p=0.14


Austria
Total Deaths
$10^2$
$10^1$
Daily Deaths
30
20
10
0
Generalized Richards, $R^2$=94.6%
Generalized Logistic, $R^2$=94.6%
Logistic, $R^2$=93.2%
Generalized Growth, $R^2$=61.0%
Growth Rate of Deaths
100%
10%
1%
Mar-23
Apr-02
Apr-12
Apr-22
May-02
Reported
GRM
K=576, r=0.53, p=0.75, a=1.06
GLM
K=578, r=0.52, p=0.76
Logistic
C0=26, K=561, r=0.15
GGM
r=2.77, p=0.32


Japan
Total Confirmed
$10^4$
$10^3$
$10^2$
Daily New Cases
1000
500
0
Generalized Richards, $R^2$=91.8%
Generalized Logistic, $R^2$=87.9%
Logistic, $R^2$=92.6%
Generalized Growth, $R^2$=79.4%
Growth Rate
of Confirmed Cases
100%
10%
Feb-13
Feb-23
Mar-04
Mar-14
Mar-24
Apr-03
Apr-13
Apr-23
May-03
Reported
GRM
K=13749, r=0.09, p=1.00, a=2.61
GLM
K=20101, r=0.10, p=1.00
Logistic
C0=1, K=14293, r=0.16
GGM
r=0.35, p=0.79


Japan
Total Deaths
$10^2$
$10^1$
Daily Deaths
100
75
50
25
0
Generalized Richards, $R^2$=77.5%
Generalized Logistic, $R^2$=77.5%
Logistic, $R^2$=80.8%
Generalized Growth, $R^2$=77.5%
Growth Rate of Deaths
100%
10%
Mar-14
Mar-24
Apr-03
Apr-13
Apr-23
May-03
Reported
GRM
K=6429, r=0.07, p=1.00, a=10.00
GLM
K=141376300, r=0.07, p=1.00
Logistic
C0=2, K=1647314541, r=0.10
GGM
r=0.07, p=1.00