

Daily report

21-04-2020

**Analysis and prediction of COVID-19 for
EU-EFTA-UK and other countries**

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ a : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

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(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

EU+EFTA+UK countries keep bending the curve. At each fluctuation of ρ , during the period at which we remain below 1, the number of new cases is pulled down. As a consequence, next peak is smaller. **If this trend is maintained in time, control is possible. We would be talking about a final number of $K \approx 1,65$ million of reported cases, and we could reach the 90 % of these infections on May 20th.**

The other side of the story is the huge number of deaths, which has overcome 100,000. Nevertheless, we could have started the decreasing trend. After 13 days of more than 3,000 daily deaths, we are below this threshold for second consecutive day. Yesterday, there were 2,477 reported deaths, while today the number is 2,501.

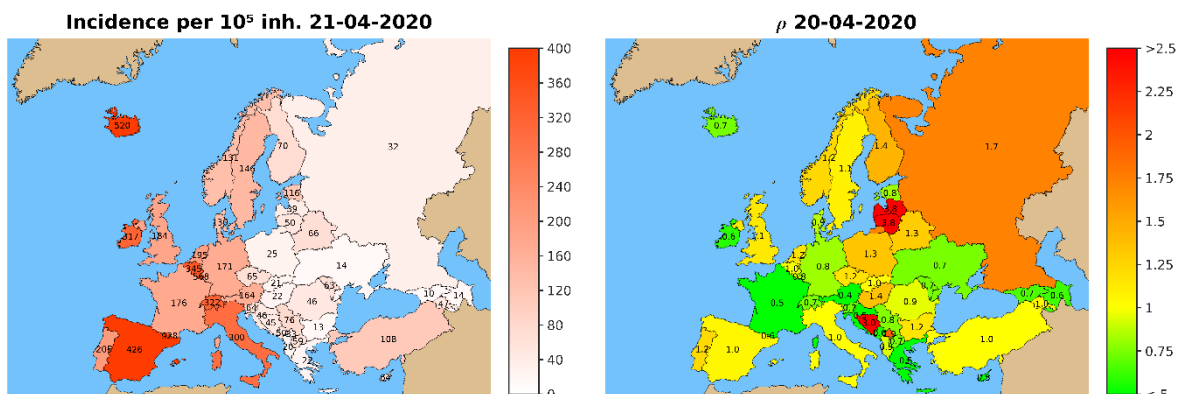
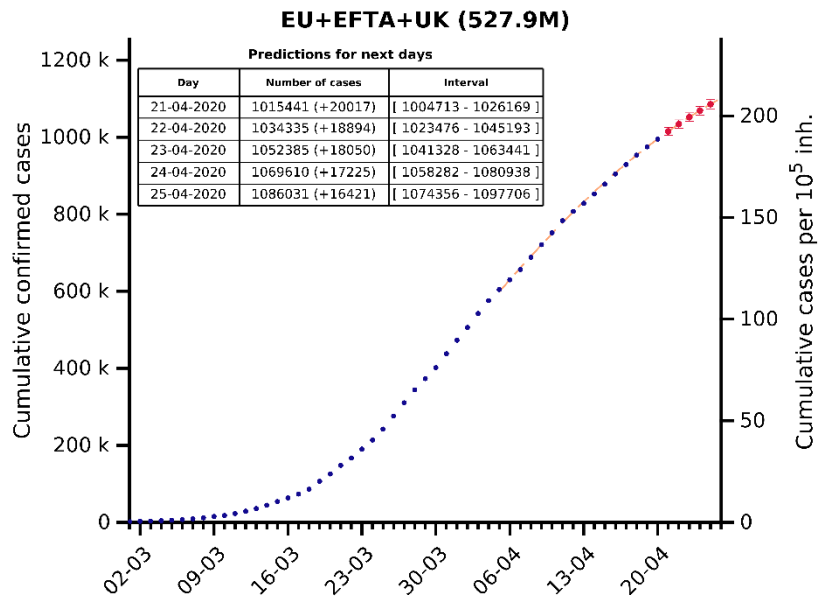
The analysis section of today's report is an extension of yesterday's one. We discuss how to estimate the real number of cases by assuming a lethality of 1 %, using Case Fatality Rate (CFR) as an indicator of real incidence.

Trends for specific countries

Luxembourg and **Iceland** have highest attack rate (618 and 487/10⁵ inh., respectively), although these values are probably conditioned by high diagnosis rate. These countries are followed by **Spain** (432), **Belgium** (352), **Ireland** (331), **Switzerland** (325) and **Italy** (305). If we look at the ranking by active cases given by 14-day attack rate, classification is led by **Ireland** (218/10⁵ inh.), which is followed by **Belgium** (169), **Spain** (141), **Luxembourg** (124) and **UK** (110). Among them, 3-day average ρ is above 1 for Luxembourg (2.03), Spain (1.13), UK (1.04) and Belgium (1.03), therefore being at higher risk of growth for the next days.

The country which has accounted for more deaths is **Italy** (24114) followed by **Spain** (20852), **France** (20265) and **UK** (16509), although in relative terms the worst situation is found in **Belgium**, with 51 deaths per 10⁵ inhabitants.

Among countries at low incidence, the ones with highest ρ are **Lithuania** (5.7), **Slovakia** (2.3) and **Latvia** (2.27). Their EPG do no still indicate immediate risk because the number of active cases (potential spreaders) is low, but this situation could be a symptom of the epidemic onset.



Situation and trends per country

Table of current situation in EU countries, according to data published by ECDC on April 15th. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	Mean $\rho^{(1)}$	EPG ⁽²⁾	EPG2 ⁽²⁾
Spain	200,210	432.0	20,852	45.0	65,178	140.6	1.13	159.5	181.0
Italy	181,228	304.9	24,114	40.6	48,681	81.9	0.96	78.7	75.7
Germany	143,457	175.1	4,598	5.6	44,232	54.0	1.06	57.3	60.8
United Kingdom	124,743	187.8	16,509	24.8	73,135	110.1	1.04	114.8	119.7
France	114,657	177.2	20,265	31.3	40,267	62.2	0.55	34.1	18.7
Belgium	39,983	352.0	5,828	51.3	19,169	168.8	1.03	173.8	178.9
Netherlands	33,405	196.7	3,751	22.1	14,602	86.0	1.10	94.3	103.5
Switzerland	27,826	324.7	1,141	13.3	6,252	73.0	0.87	63.2	54.7
Portugal	20,863	201.1	735	7.1	9,133	88.1	1.08	95.3	103.2
Ireland	15,652	331.2	687	14.5	10,288	217.7	0.74	161.0	119.1
Austria	14,783	169.7	470	5.4	2,486	28.5	0.54	15.5	8.5
Sweden	14,777	150.2	1,580	16.1	7,571	77.0	1.34	102.8	137.3
Poland	9,593	25.1	380	1.0	5,180	13.6	1.38	18.7	25.8
Romania	8,936	45.2	451	2.3	4,879	24.7	1.05	25.9	27.2
Denmark	7,515	131.6	364	6.4	2,834	49.6	0.99	49.2	48.8
Norway	7,113	132.5	154	2.9	1,358	25.3	1.20	30.5	36.7
Czech Republic	6,914	65.2	196	1.8	2,092	19.7	1.24	24.5	30.4
Finland	3,868	70.3	98	1.8	1,692	30.7	1.52	46.8	71.1
Luxembourg	3,558	617.7	75	13.0	715	124.1	2.03	252.0	511.5
Greece	2,245	20.1	116	1.0	490	4.4	0.30	1.3	0.4
Hungary	2,098	21.5	213	2.2	1,281	13.1	1.33	17.4	23.1
Croatia	1,881	44.6	47	1.1	659	15.6	0.51	8.0	4.1
Iceland	1,773	486.7	10	2.7	211	57.9	0.89	51.7	46.2
Estonia	1,535	117.0	40	3.0	427	32.5	1.22	39.8	48.6
Lithuania	1,350	46.4	37	1.3	507	17.4	5.72	99.7	570.1
Slovenia	1,335	64.2	74	3.6	314	15.1	1.33	20.1	26.7
Slovakia	1,173	21.5	13	0.2	639	11.7	2.31	27.1	62.6
Bulgaria	929	13.0	43	0.6	380	5.3	1.99	10.6	21.2
Cyprus	772	66.0	17	1.5	307	26.2	0.51	13.5	6.9
Latvia	739	37.5	5	0.3	197	10.0	2.27	22.6	51.3
Malta	431	100.5	3	0.7	190	44.3	ND	ND	ND
Liechtenstein	82	212.7	1	2.6	4	10.4	ND	ND	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

⁽¹⁾ Disclaimer: parameter ρ is very sensitive and experiments daily variations. Mean ρ is averaged per 3 consecutive days, but it can still vary the following days. ⁽²⁾ EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10⁵ inhabitants of last 14 days (i.e. density of cases) by ρ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 10 days is multiplied by ρ^2 .

Highlights for countries with highest number of reported cases

- ✓ UK could be on the top of the peak, while Spain, Italy, Germany and France keep on showing a decreasing trend. Expected new cases for next days are at the range of 5,000 (UK), 3,900 (Spain), 2,500 (Italy), 1,500 (Germany) and 1,200 (France).
- ✓ Spanish data seem to have recovered the decreasing trend, after the changes in data reporting and protocols. The dynamics of France is still undetermined, since reported data do not correspond to observed case fatality rate. There can be a significant underdiagnosis.
- ✓ Spreading rates of these countries keep fluctuating around 1 except France, which shows an empirical ρ of 0.5.

Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

Countries	Days since the first 50 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	59	11	16
France	53	10	20
Germany	53	12	17
Spain	52	7	12
United Kingdom	49	11	19
Norway	48	9	24
Switzerland	48	9	12
Netherlands	47	11	20
Sweden	47	10	28
Austria	46	10	14
Belgium	46	11	14
Greece	45	16	ND
Iceland	45	5	15
Denmark	43	4	30
Czech Republic	42	11	ND
Finland	41	12	ND
Portugal	41	9	15
Slovenia	41	6	ND
Ireland	40	8	18
Romania	40	11	ND
Estonia	39	5	30
Poland	39	8	ND
Bulgaria	37	11	ND
Luxembourg	37	6	7
Slovakia	37	13	ND
Croatia	36	12	ND
Latvia	35	12	ND
Cyprus	34	12	ND
Hungary	34	8	ND
Malta	33	8	ND
Lithuania	32	9	ND
Liechtenstein	27	9	11

Analysis: Estimating real incidence in European countries.

As discussed in last report (April 20th) a lethality of around 1% seems a good estimation for COVID-19 in European countries. Assuming this value for lethality, reported Case Fatality Rate (CFR) in each country can be used for evaluating real incidence. Sections 1 to 4 explain the methodology. Results are shown in point 5.

1. Estimation of real number of cases

From previous studies in China, it seems that death caused by COVID-19 occurs around 18 days after the first symptoms¹. We call this value *Time to Death* (TtD = 18 days). **Assuming a lethality of 1%**, the cumulative number of deaths in a certain day should correspond to 1 % of total cases 18 days before. For instance, on April 20th the reported mortality in Spain was 20852 cases. This value should be a 1% of the total cases 18 days ago. Therefore, on April 2nd the total number of cases would be:

$$\frac{20,852}{0.01} = 2,085,200 \approx 2,090,000 \text{cases.}$$

Nevertheless, on April 2nd there were reported in Spain only 110,238 cases. Then, the percentage of diagnosed cases would be:

$$\frac{110,000}{2,090,000} = 5,3\%$$

This value is very low and, in fact, unrealistic, because **no country is able to detect infected COVID-19 patients at their very initial symptoms**. To give a realistic and homogenous diagnostic rate, we must establish the **minimum of days needed to be able to detect a patient from the onset of symptoms**. First, the patient feels sufficiently sick and contacts the Health Service. From this contact, the doctor needs to be suspicious that the person has the disease and request a test. Then, this test must be available, performed and the result received and annotated. We are calling this delay as **Diagnostic Delay (DD)** and it can be **different for each country or region**.

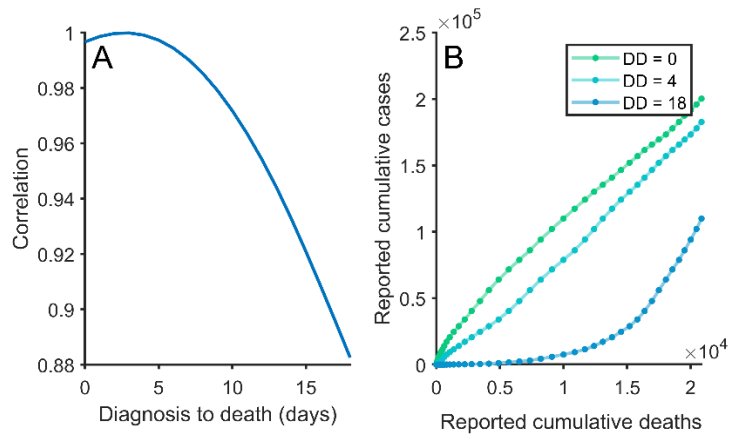
2. Estimation of the time from diagnosis to death and the diagnostic delay

To find DD of each country we use the correlation between cases and deaths. As deaths are a fraction of the reported cases, we expect to find a correlation between these two quantities. The time between reported cases and estimated cases will be named as time from *Diagnosis to Death* (DtD):

$$TtD = DD + DtD$$

In the next figure we can see the correlation between reported cases and reported deaths assuming different DtD for Spain (panel A). As we expected, correlations have values close to 1 and have a clearly defined maximum. **We assume this maximum represents DtD**. To assume a possible error, time interval is estimated as the points where the correlation is greater than 99% of the observed maximum. We decided to set a lower limit of 4 days and a higher limit of 14 days because we believe that times outside this range would be unrealistic situations. For countries that have not seen a clear correlation, we explored the entire DtD interval (4 to 14 days). As shown in the second panel of the figure (B), the best correlation is found when reported cases and reported deaths are nearly perfect alienated. In the case of Spain, we find the best correlation when DtD \approx 4 days. Therefore, diagnosis delay in this country would be DD \approx 18 – 4 = 14 days.

¹ Zhou, Fei, et al., 2020 "Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study." The Lancet.



3. Estimation of diagnosis rate

Given the TtD (18 days) and the DtD (specific of each country), we can recalculate Case Fatality Rate and Diagnostic Rate (DR) as follows:

$$CFR(t) = \frac{deaths(t)}{cases(t - DtD)}$$

$$DR(t) = \frac{reported(t - DtD)}{estimated(t - TtD)}$$

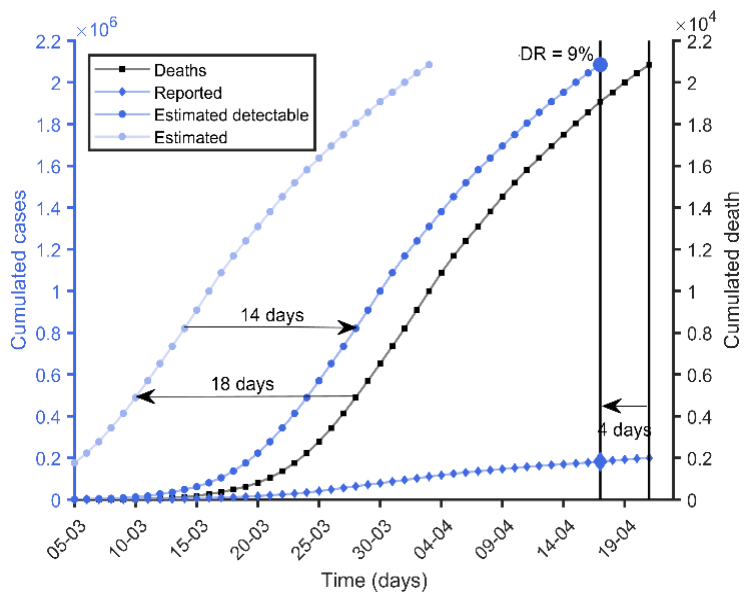
For Spain, we estimated that DtD is 4 days (i.e., Diagnosis to Death time \approx 4 days). Then, corrected CFR and percentage of diagnosis would be:

$$CFR(t) = \frac{deaths(t)}{cases(t - 4)} = \frac{20852}{182816} = \mathbf{11,4\%}$$

$$DR(t) = \frac{reported(t - 4)}{estimated(t - 18)} = \frac{182816}{2090000} = \mathbf{8,7\%}$$

In the following figure, the process of determining Diagnosis Rate is shown. The curves represent:

- Black squares: reported number of deaths (y-axis in the right).
- Light blue dots: number of estimated cases, obtained by multiplying by 100 the number of deaths and shifting the result 18 days back.
- Dark blue dots: estimated detectable cases assuming the DD obtained from correlations, so, displacing estimated cases DD days to the right (in the case of Spain, DD \approx 14 days).
- Dark blue diamonds: reported cases.



Comparing estimated detectable with reported at a certain day, we can estimate the Diagnosis Rate (DR).

4. Estimating current number of infected

Assuming that the Diagnosis Rate (DR) has remained constant during the last days we can compute the number of detectable real cases today as:

$$estimated(t) = \frac{detected(t)}{DR}$$

which, for the case of Spain gives rise to:

$$estimated = \frac{200,210}{0.087} = 2301264 \approx 2.3M$$

5. Results for all countries

This analysis was repeated for countries with **more than 100 reported death cases in April 20th**. The table below shows the Diagnostic Delay (DD) and Diagnosis to Death (DtD) estimations for these countries, as well as a more accurate estimation of the current CFR in each country. There are 4 countries with an estimated CFR above 20%, which means that at least 1 individual dies for each 5 detected cases. In these countries, probably, they are only detecting cases at hospital that need a severe assistance.

Country	Delay to detection (DD)			Dianostic to death (DtD)			CFR		
	Value	min	max	DE	DE_i	DE_s	Value	min	max
Austria	8	5	11	10	7	13	3,5%	3,3%	3,7%
Belgium	8	4	13	10	5	14	21,9%	17,5%	27,9%
Czech Republic	8	4	12	10	6	14	3,4%	3,2%	4,1%
Denmark	13	4	14	5	4	14	5,4%	5,3%	7,7%
France	10	6	14	8	4	12	21,1%	18,7%	24,7%
Germany	7	4	11	11	7	14	4,1%	3,7%	4,6%
Greece	13	8	14	5	4	10	5,3%	5,3%	5,8%
Hungary	4	4	13	14	5	14	25,8%	12,8%	25,8%
Ireland	7	4	14	11	4	14	9,4%	5,2%	12,7%
Italy	14	9	14	4	4	9	14,3%	14,3%	15,9%
Netherlands	13	8	14	5	4	10	13,3%	12,8%	16,2%
Poland	11	6	14	7	4	12	5,5%	4,8%	7,3%
Portugal	13	9	14	5	4	9	4,1%	3,9%	4,6%
Romania	14	9	14	4	4	9	5,9%	5,9%	7,6%
Spain	14	11	14	4	4	7	11,4%	11,4%	12,3%
Sweden	5	4	13	13	5	14	20,3%	13,2%	21,7%
Norway	9	4	14	9	4	14	2,4%	2,3%	2,7%
Switzerland	10	6	14	8	4	12	4,5%	4,3%	5,0%
United Kingdom	14	9	14	4	4	9	16,0%	16,0%	21,2%

In the second table we show an **estimation of the detection rate** in each country and the **estimated real incidence** in April 20th. It is important to note that, as the number of estimated cases is computed using the reported cases, this estimation is for the day that these reported cases had their firsts symptoms.

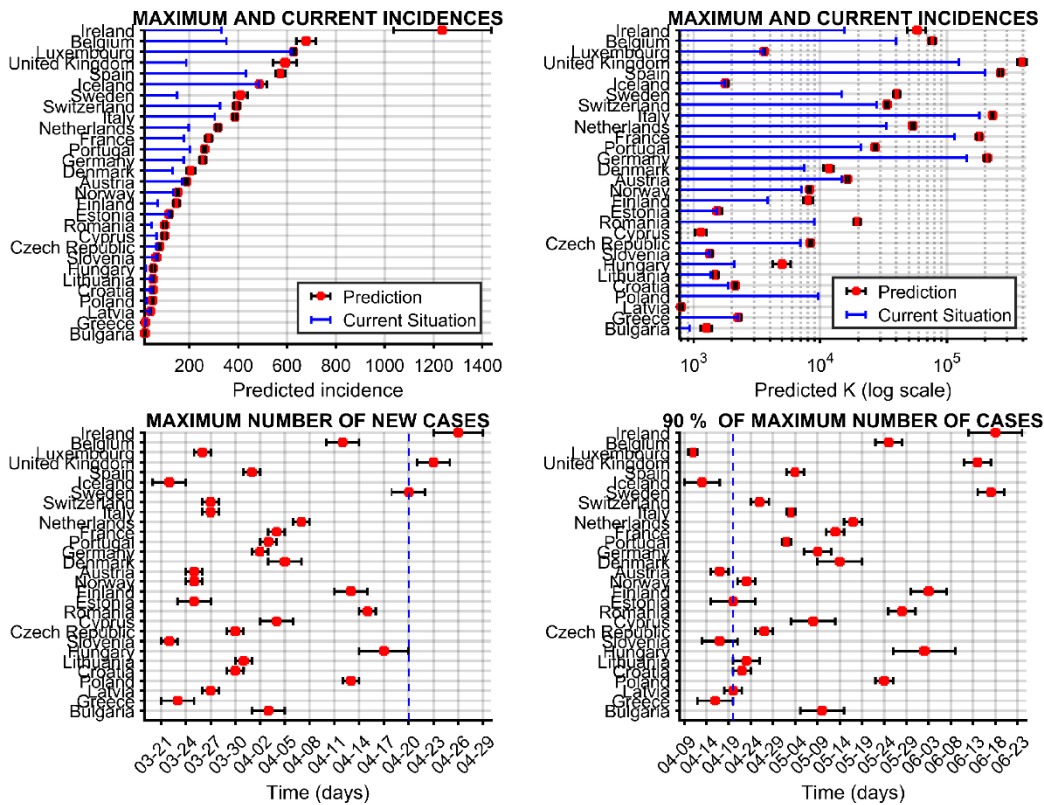
There are some countries with a **low Diagnosis Rate** like **Belgium, France, Hungary, Italy, Netherlands, Spain, Sweden and United Kingdom**. There are also 4 countries that have **more than 2 million estimated cases: France, Italy, Spain and United Kingdom**. In fact, it is estimated that these 19 countries together would have around 12 million estimated cases, in contrast with the 1 million cases reported. Among these countries, Belgium's results suggest that this country would have the worst situation, with an incidence of 7,600 cases per 10⁵ inhabitants, followed by Spain (4,900/10⁵ inh.) and Italy (4,300/10⁵ inh.).

Country	Diagnostic Rate			Number of estimated cases			Number of estimated cases /10 ⁵ inh.		
	Value	min	max	Value	min	max	Value	min	max
Austria	29%	27%	30%	51000	49000	55000	570	550	610
Belgium	5%	4%	6%	880000	700000	1120000	7600	6000	9600
Czech Republic	29%	25%	31%	24000	22000	28000	220	210	260
Denmark	18%	13%	19%	41000	40000	58000	710	690	1000
France	5%	4%	5%	2400000	2100000	2800000	3700	3300	4300
Germany	25%	22%	27%	580000	530000	660000	700	630	790
Greece	19%	17%	19%	12000	12000	13000	110	110	120
Hungary	4%	4%	8%	54000	27000	54000	560	280	560
Ireland	11%	8%	19%	150000	80000	200000	3000	1600	4000
Italy	7%	6%	7%	2600000	2600000	2900000	4300	4300	4800
Netherlands	8%	6%	8%	440000	430000	540000	2600	2500	3200
Poland	18%	14%	21%	53000	46000	70000	140	120	190
Portugal	25%	22%	25%	85000	82000	96000	830	800	950
Romania	17%	13%	17%	53000	53000	68000	270	270	350
Spain	9%	8%	9%	2300000	2300000	2500000	4900	4900	5200
Sweden	5%	5%	8%	300000	190000	320000	3000	1900	3200
Norway	41%	37%	44%	17000	16000	19000	320	300	350
Switzerland	22%	20%	23%	130000	120000	140000	1500	1400	1600
United Kingdom	6%	5%	6%	2000000	2000000	2600000	2900	2900	3900

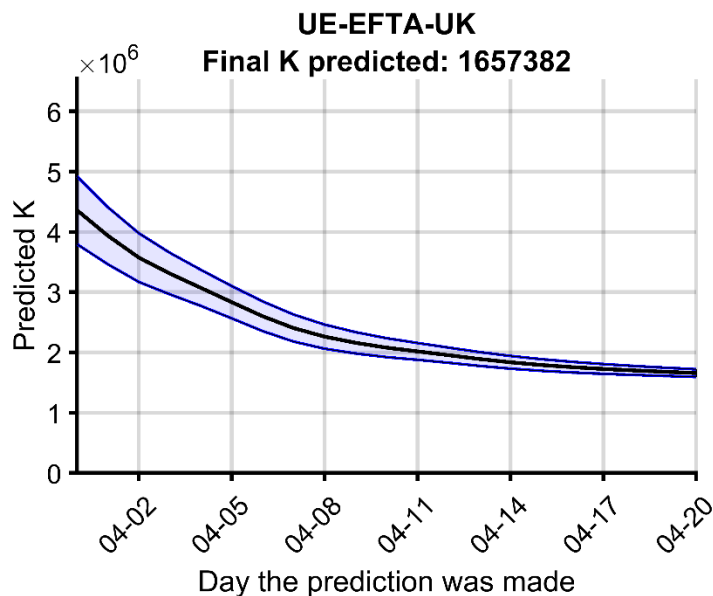
Long-term predictions

Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date. See details in Report from 11th April 2020.

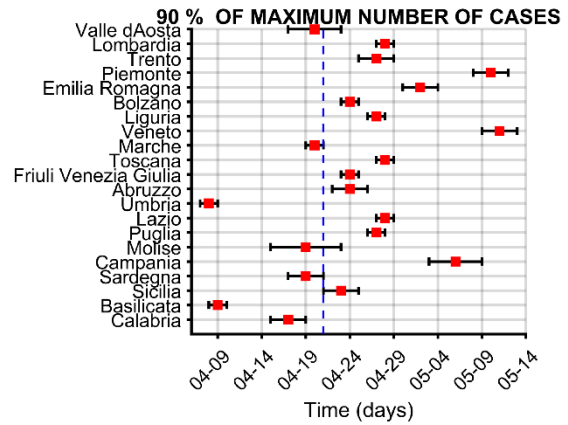
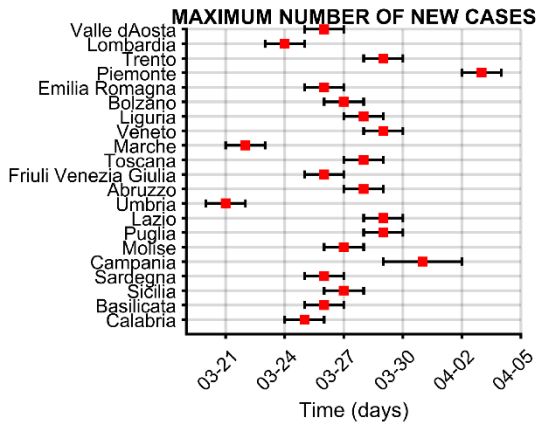
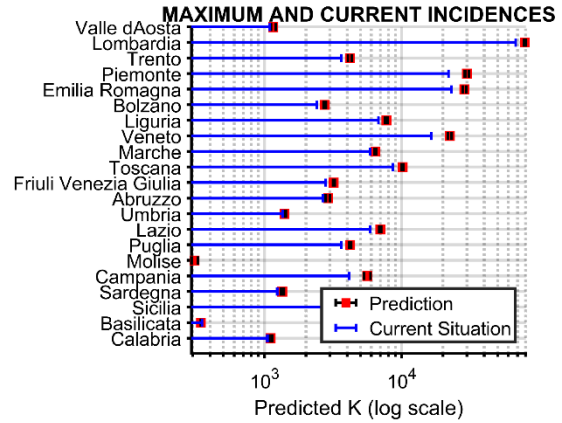
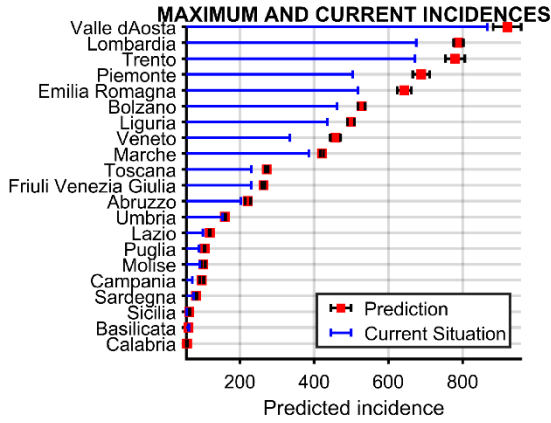
UE-EFTA-UK countries



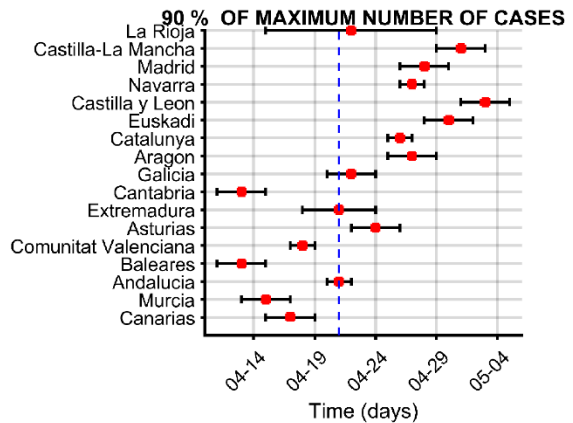
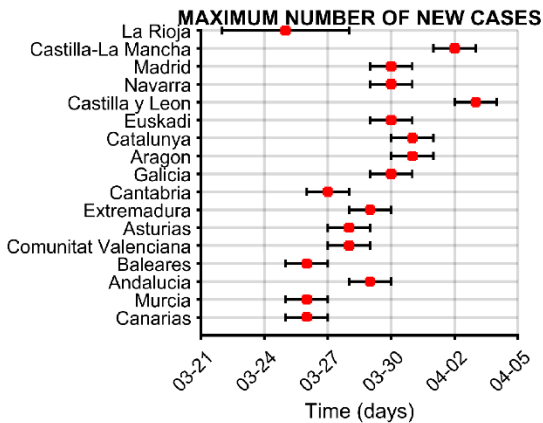
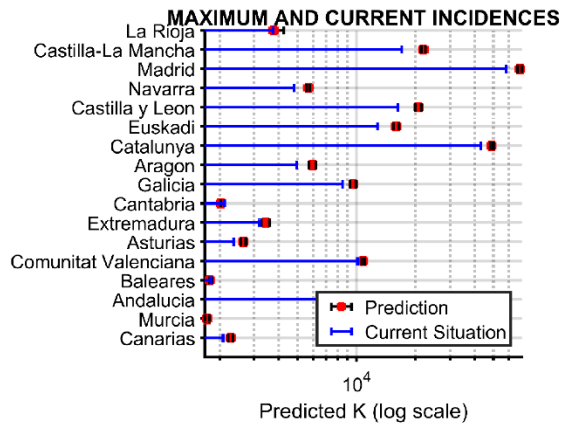
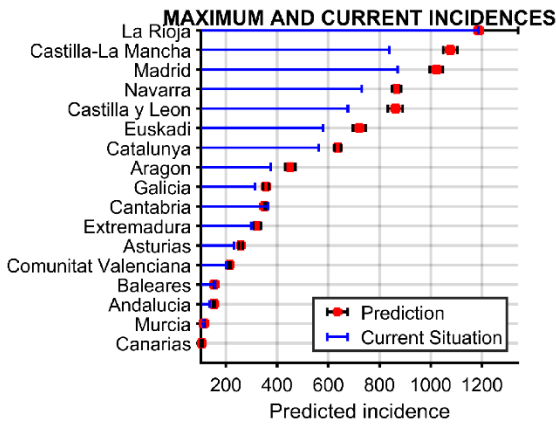
Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



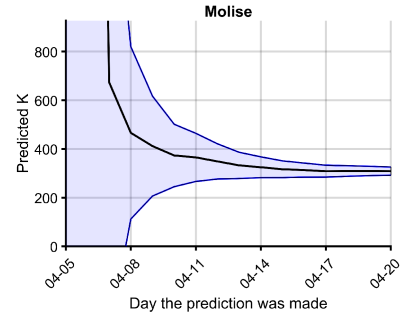
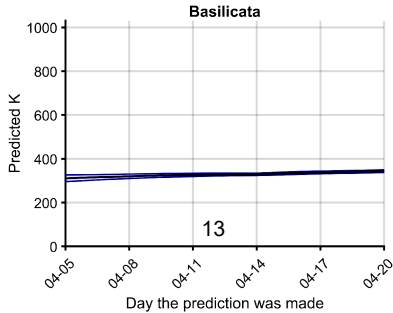
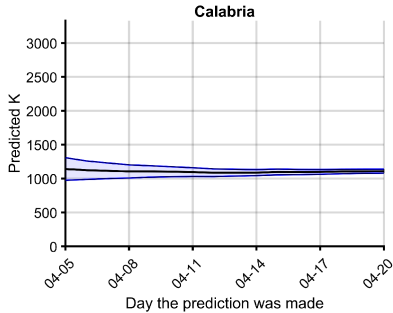
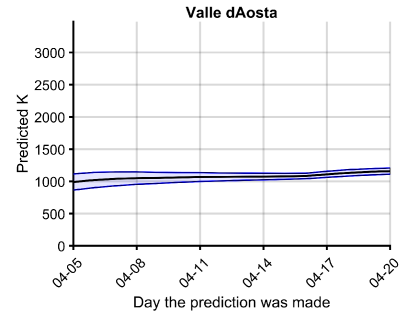
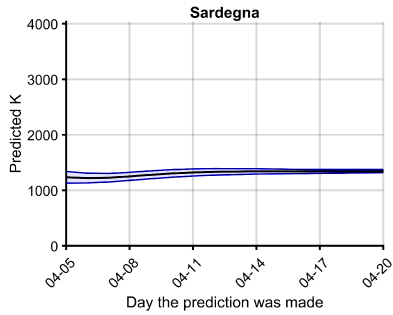
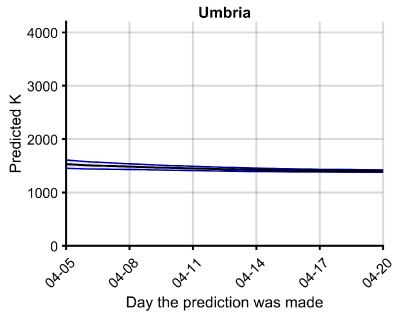
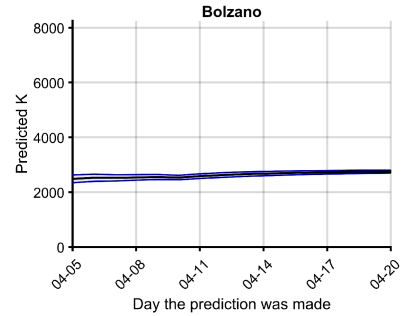
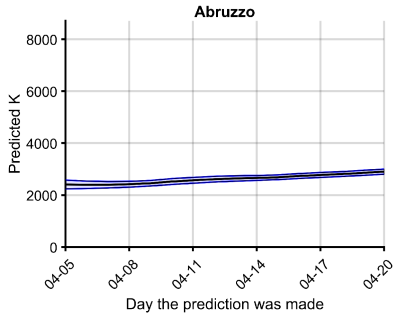
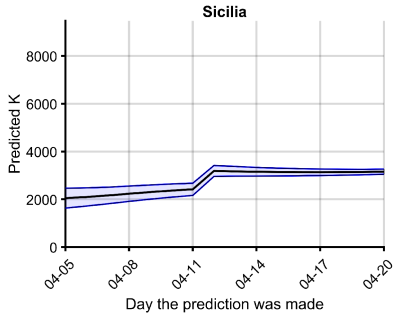
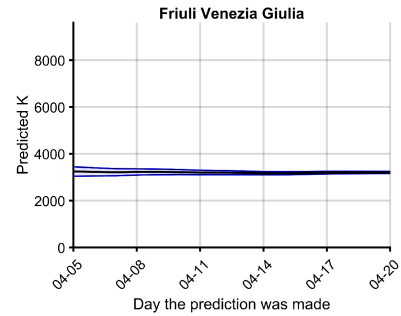
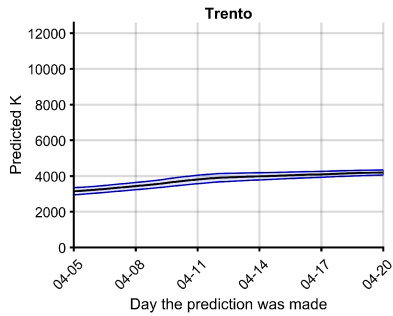
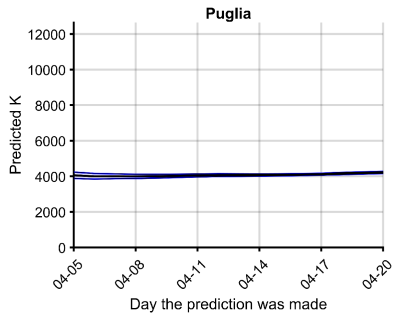
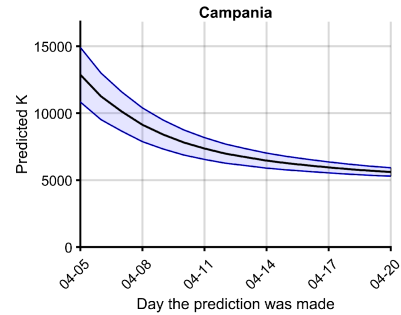
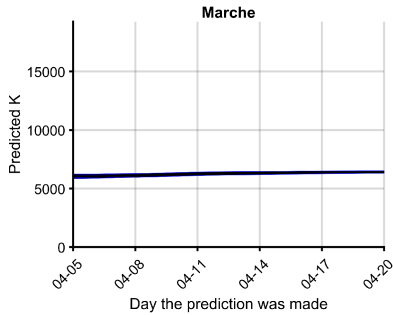
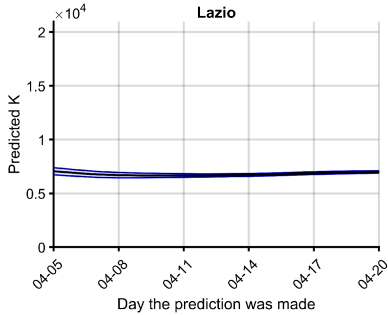
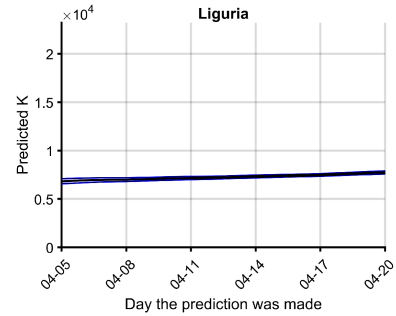
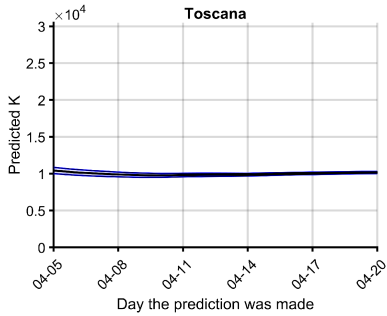
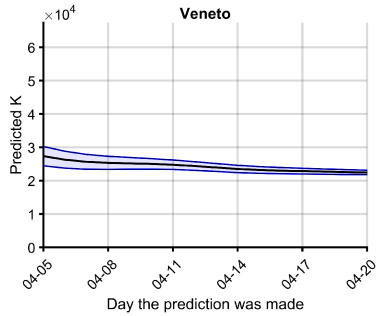
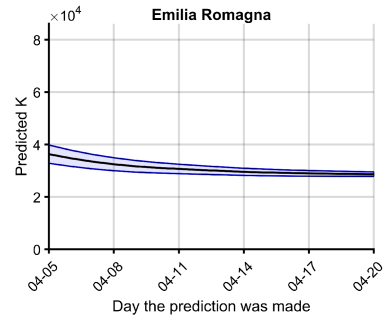
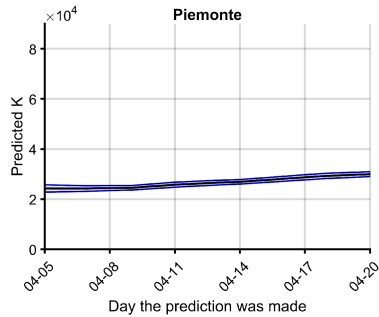
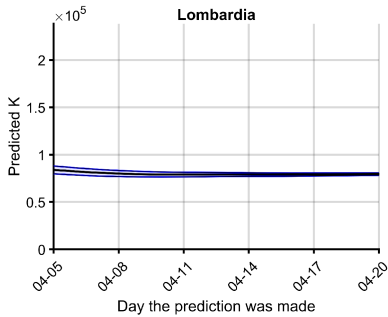
Italian regions



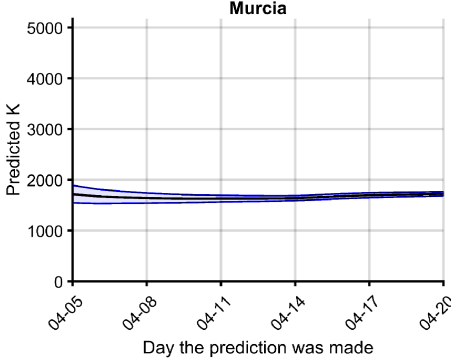
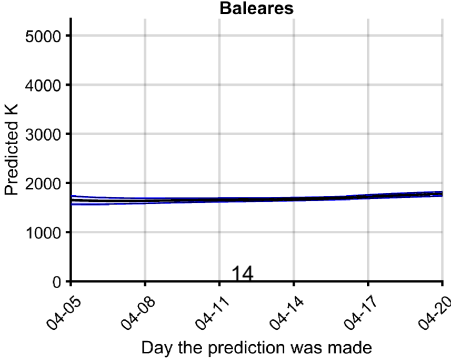
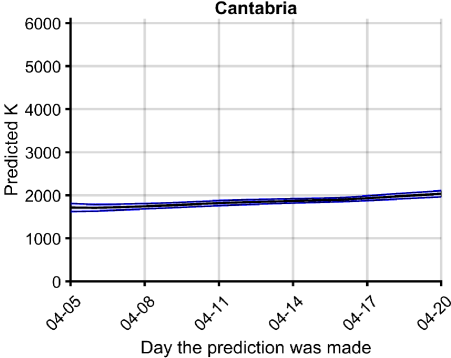
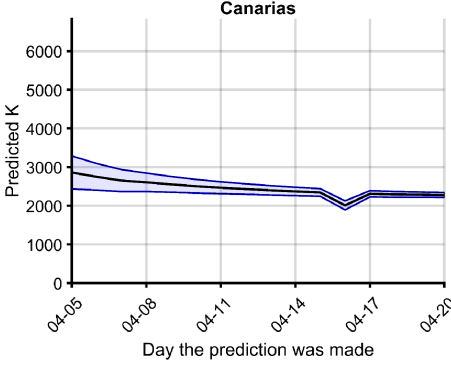
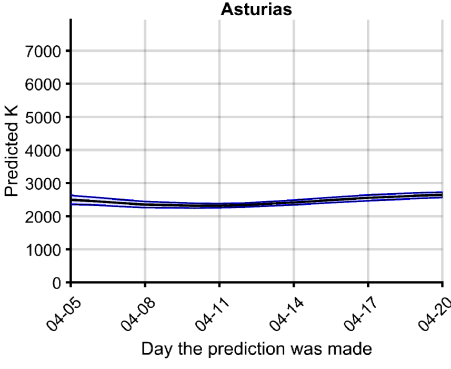
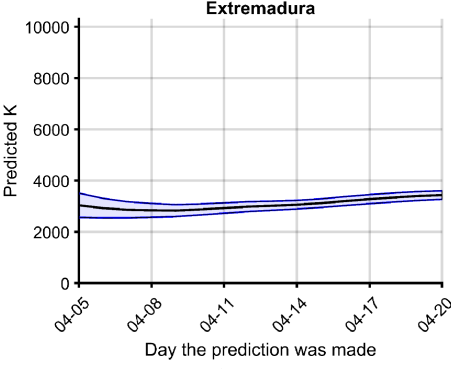
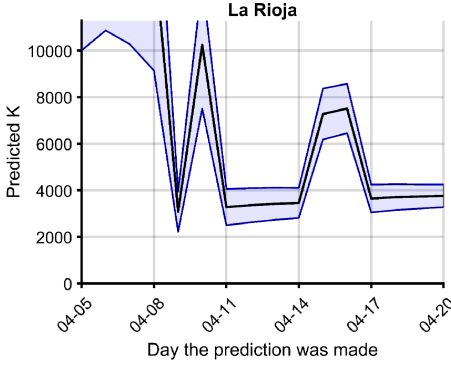
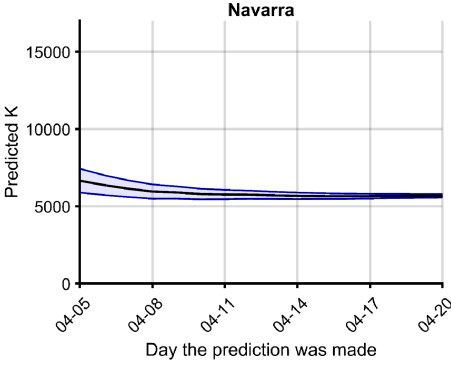
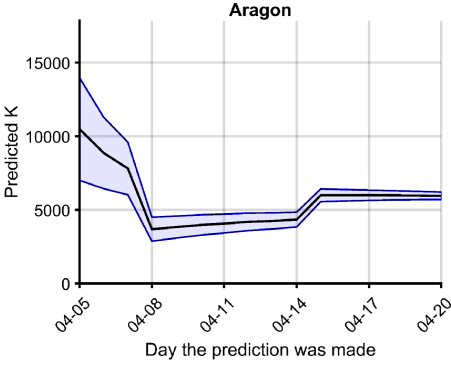
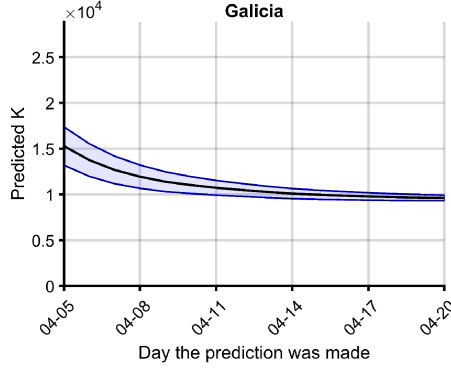
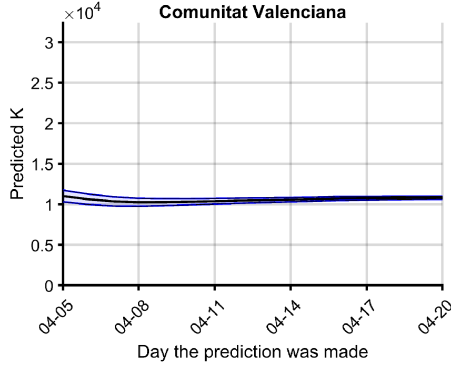
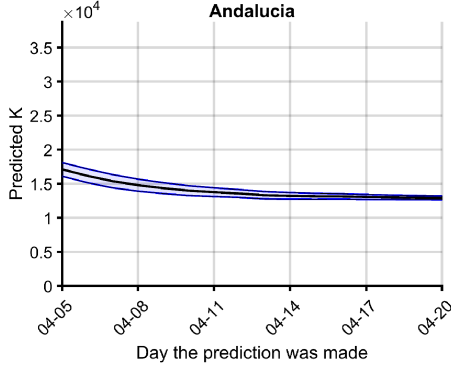
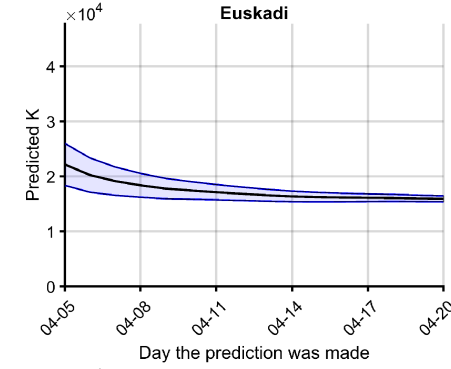
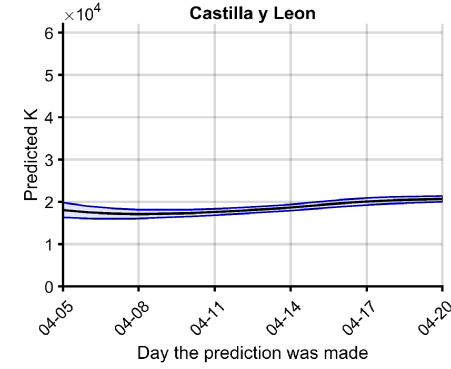
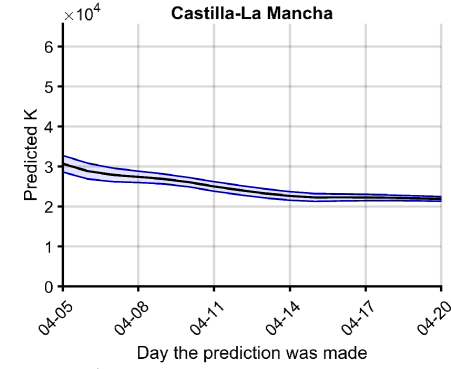
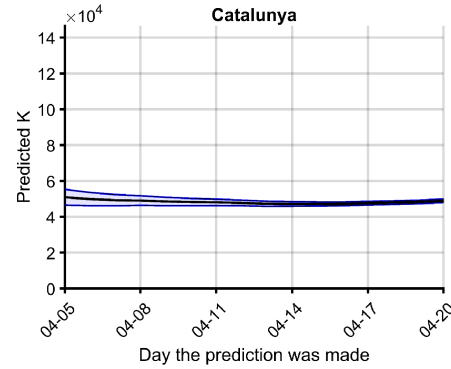
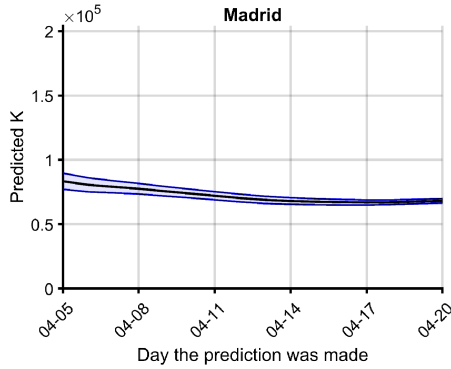
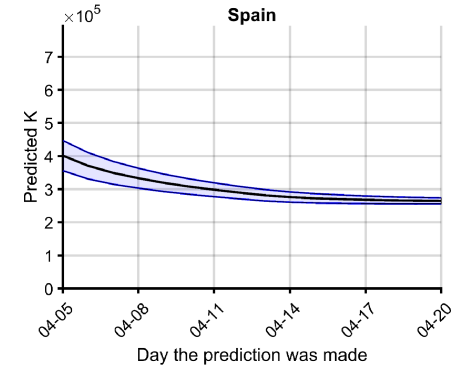
Spanish regions



2020-04-21



2020-04-21



Situation and tendencies in Italian and Spanish regions

Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh	Mean $\rho^{(1)}$	EPG ⁽²⁾	EPG2 ⁽²⁾
Lombardia	67,931	676.5	12,579	125.3	15,606	155.4	0.89	138.5	123.4
Emilia Romagna	23,092	517.8	3,147	70.6	5,267	118.1	0.98	115.7	113.4
Piemonte	21,955	504.0	2,485	57.0	8,612	197.7	0.97	191.1	184.7
Veneto	16,404	334.4	1,154	23.5	4,479	91.3	1.25	114.5	143.7
Toscana	8,603	230.7	686	18.4	2,430	65.2	0.78	50.8	39.5
Liguria	6,764	436.2	990	63.8	2,007	129.4	1.09	140.9	153.3
Lazio	5,895	100.3	363	6.2	1,746	29.7	0.76	22.5	17.0
Marche	5,877	385.3	834	54.7	1,167	76.5	0.81	62.1	50.4
Campania	4,135	71.3	317	5.5	987	17.0	0.62	10.5	6.4
Puglia	3,622	89.9	351	8.7	1,108	27.5	1.20	33.0	39.6
Trento	3,614	337.0	376	35.1	1,138	106.1	1.25	133.1	166.9
Sicilia	2,835	56.7	206	4.1	738	14.8	1.16	17.1	19.9
Friuli Venezia Giulia	2,792	229.8	241	19.8	639	52.6	0.79	41.3	32.4
Abruzzo	2,667	203.3	271	20.7	868	66.2	1.41	93.4	131.9
Bolzano	2,410	2,243.2	251	233.6	599	557.5	0.67	370.9	246.8
Umbria	1,353	153.4	60	6.8	90	10.2	2.19	22.4	49.1
Sardegna	1,236	75.4	93	5.7	301	18.4	1.06	19.5	20.7
Valle d'Aosta	1,093	870.2	126	100.3	258	205.4	1.87	384.9	721.4
Calabria	1,047	53.8	76	3.9	214	11.0	0.69	7.5	5.2
Basilicata	350	62.2	24	4.3	59	10.5	0.83	8.7	7.3
Molise	282	92.3	18	5.9	58	19.0	1.87	35.6	66.6

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

Spain

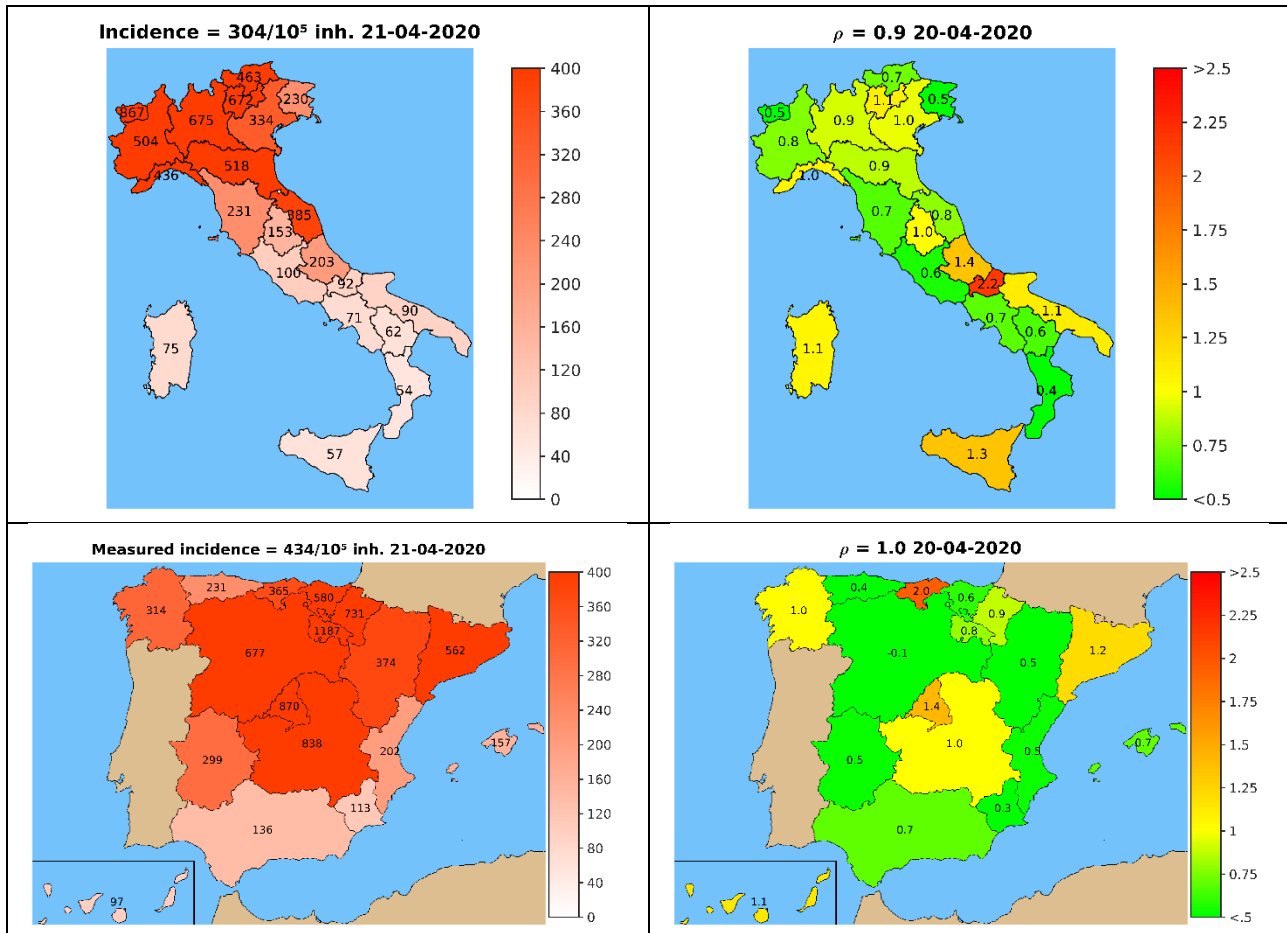
Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulated deaths	Mortality rate / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	Mean $\rho^{(1)}$	EPG ⁽²⁾	EPG2 ⁽²⁾
Madrid	57,997	873.4	7,460	112.3	17,528	263.9	1.67	441.7	739.1
Catalunya	43,112	569.9	4,152	54.9	14,789	195.5	1.34	262.5	352.5
Castilla-La Mancha	17,045	837.4	2,075	101.9	7,464	366.7	1.19	436.4	519.3
Castilla y Leon	16,259	675.2	1,521	63.2	5,182	215.2	0.10	22.5	2.4
Euskadi	12,810	588.1	1,103	50.6	3,789	174.0	0.82	142.2	116.2
Andalucia	11,447	135.8	1,017	12.1	2,680	31.8	0.68	21.8	14.9
Comunitat Valenciana	10,084	202.7	1,089	21.9	2,641	53.1	0.51	27.3	14.0
Galicia	8,468	313.6	360	13.3	2,137	79.1	0.8	66.6	56.0
Aragon	4,938	373.9	643	48.7	1,489	112.7	0.75	84.8	63.7
Navarra	4,781	735.6	397	61.1	1,426	219.4	0.9	193.9	171.4
La Rioja	3,763	1,200.0	294	93.8	917	292.4	0.96	280.7	269.4
Extremadura	3,196	300.0	397	37.3	1,080	101.4	0.91	92.0	83.4
Asturias	2,365	231.3	202	19.8	686	67.1	0.53	35.5	18.8
Cantabria	2,123	365.0	165	28.4	622	106.9	2.47	264.5	654.3
Canarias	2,085	94.5	120	5.4	360	16.3	0.99	16.2	16.1
Baleares	1,808	152.2	161	13.6	439	37.0	1.49	55.2	82.5
Murcia	1,681	113.0	120	8.1	398	26.8	0.41	11.0	4.5
Ceuta	111	130.8	4	4.7	28	33.0	ND	ND	ND
Melilla	105	123.9	2	2.4	13	15.3	ND	ND	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

⁽¹⁾ Disclaimer: parameter ρ is very sensitive and experiments daily variations. Mean ρ is averaged per 3 consecutive days, but it can still vary the following days. ⁽²⁾ EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10⁵ inhabitants of last 10 days (i.e. density of cases) by ρ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 10 days is multiplied by ρ^2 .

Maps of Italian and Spanish regions

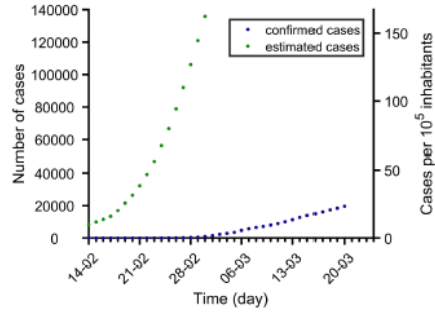
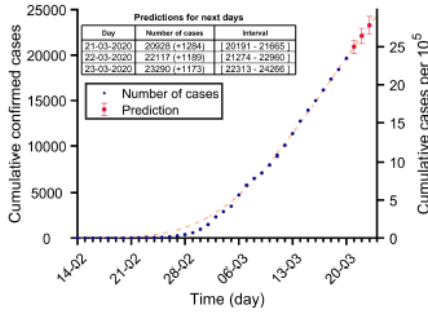
Cumulated incidence and spreading rate (ρ) in Europe, Italian regions and Spanish autonomous communities.



Legend: Countries' reports details

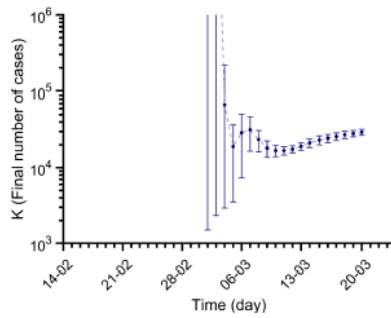
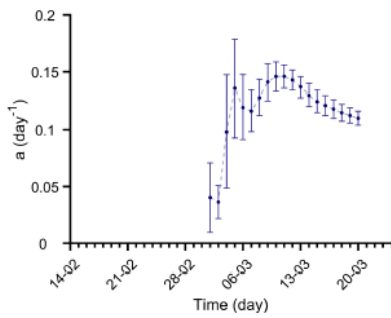
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: 23/10⁵

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)



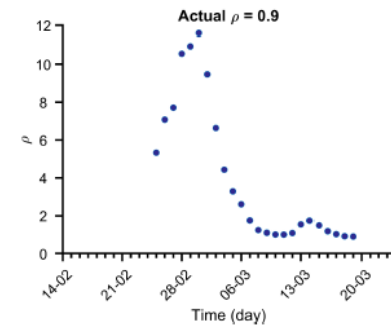
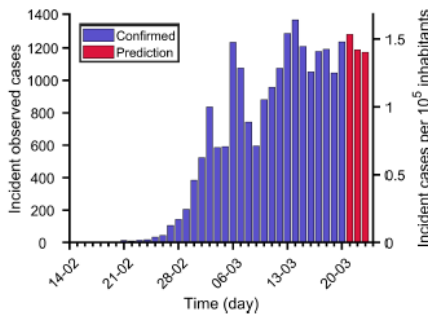
Estimated cases using death rate (see Methods)

Fitted a value using points prior to each date



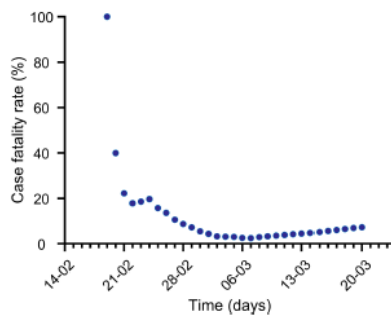
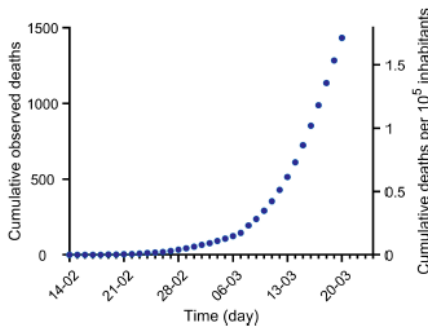
Fitted K value using points prior to each date

Reported and predicted new cases



Evolution of ρ , a parameter related with Reproduction number (see Methods)

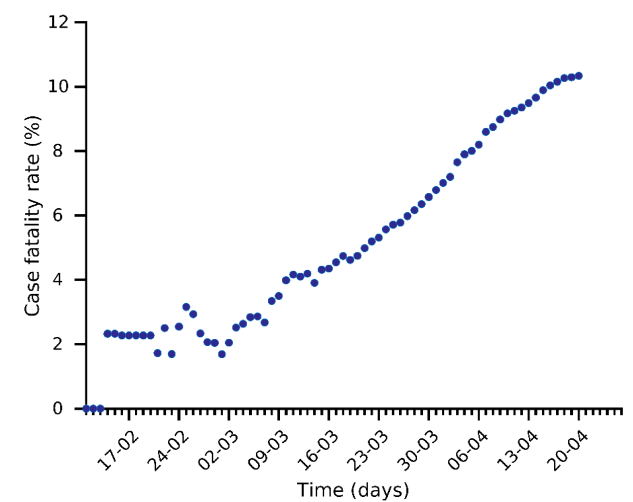
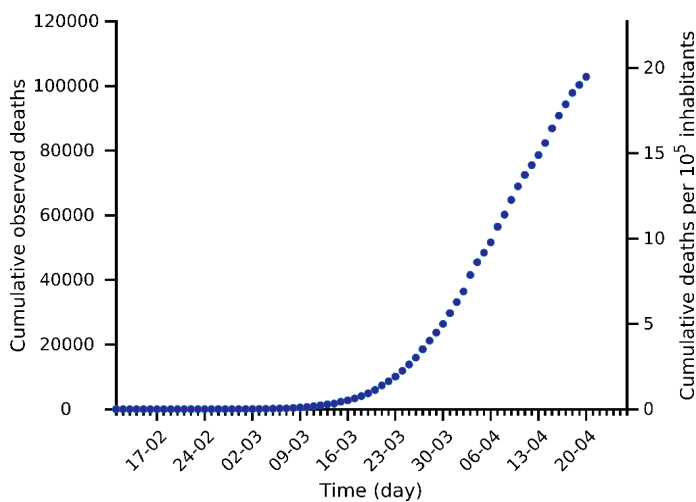
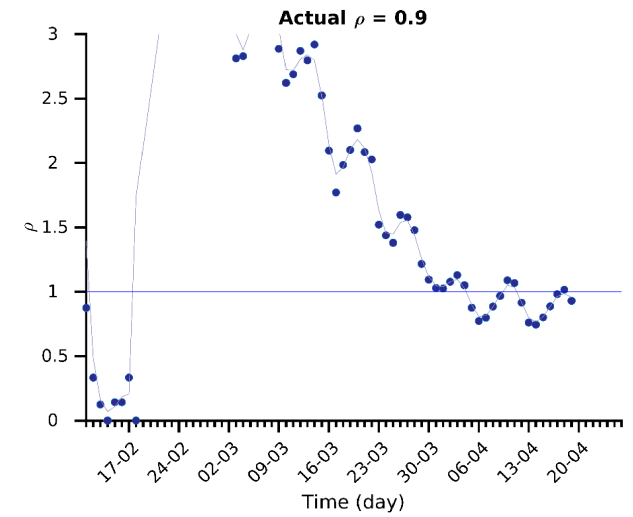
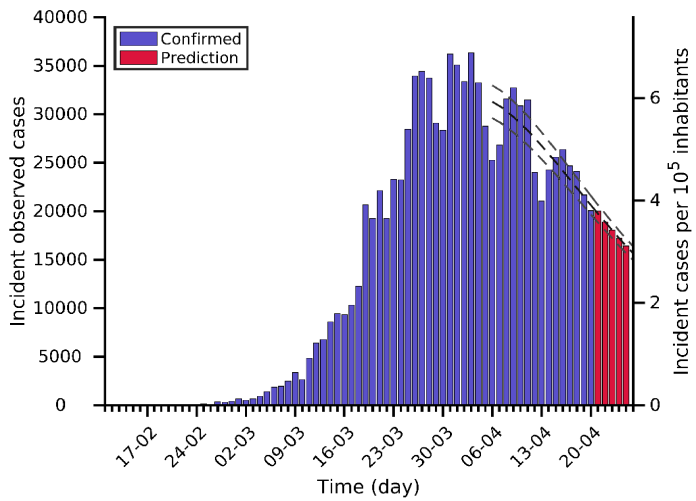
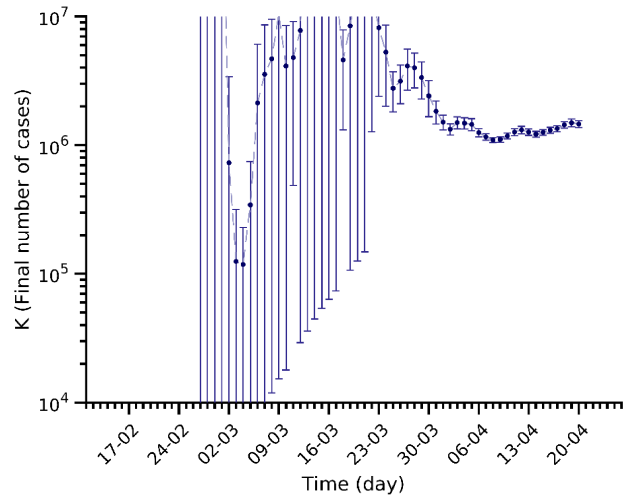
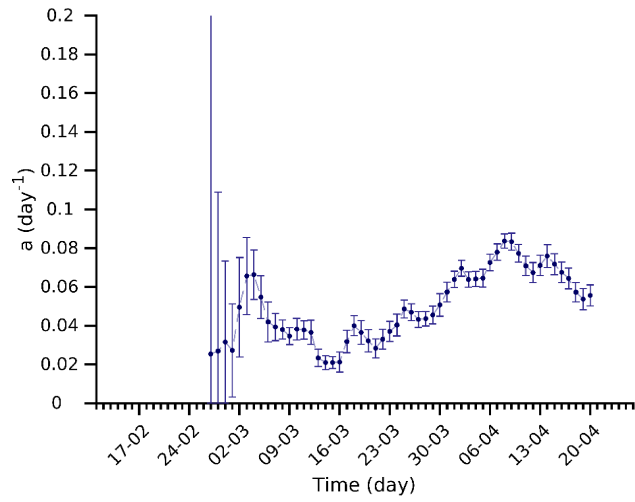
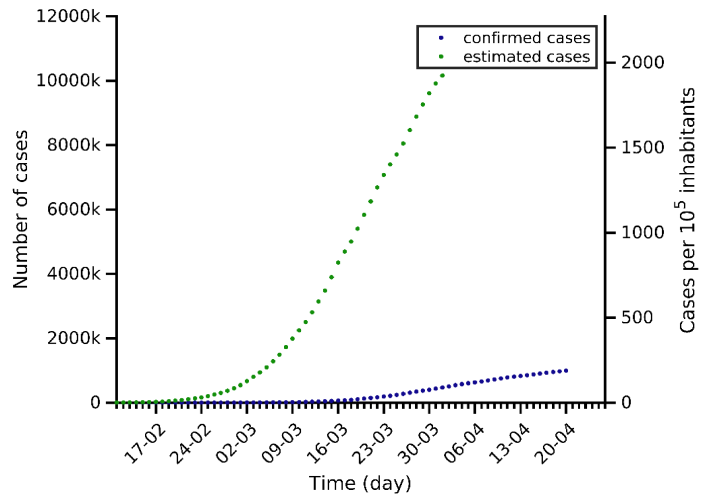
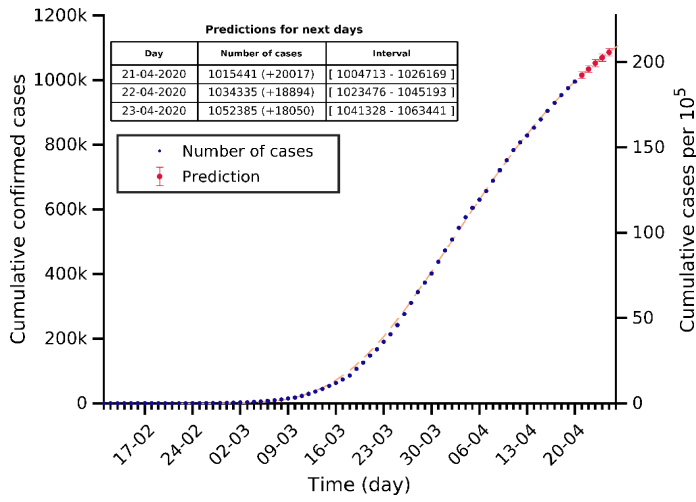
Reported deaths



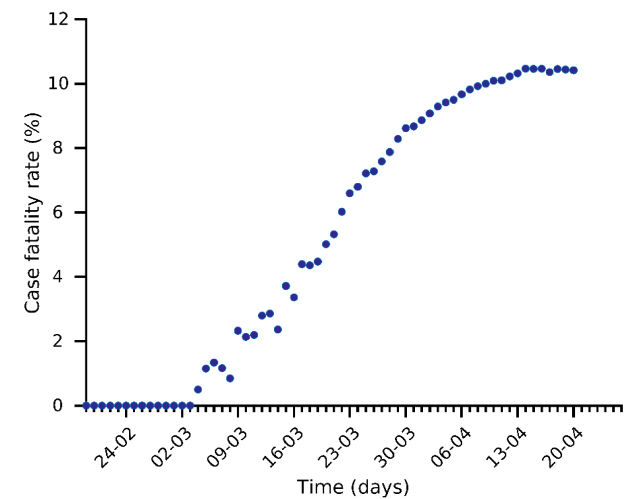
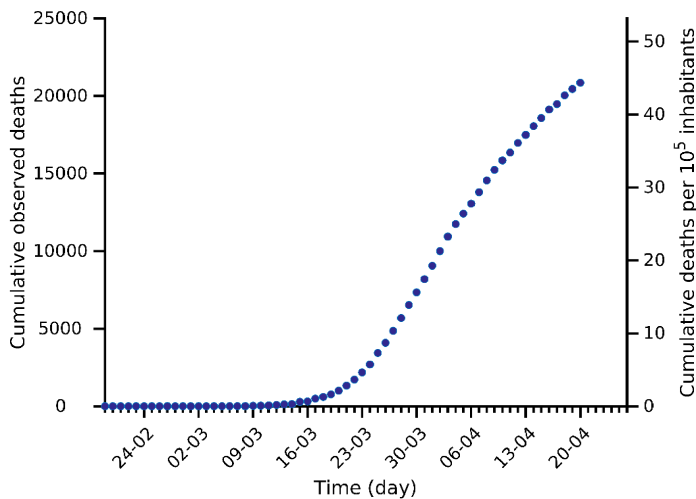
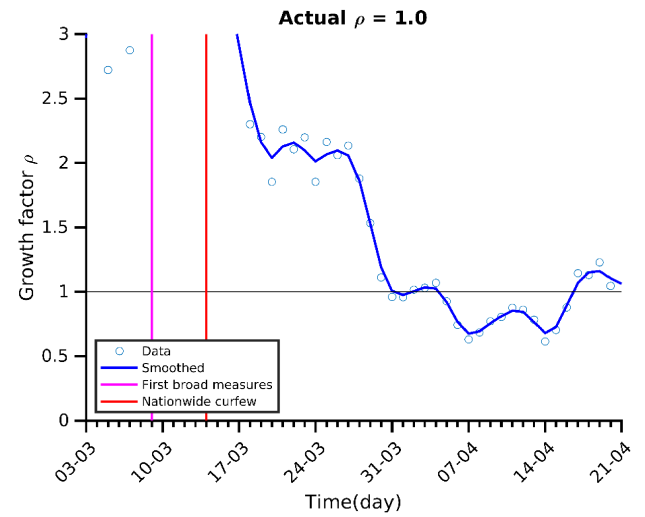
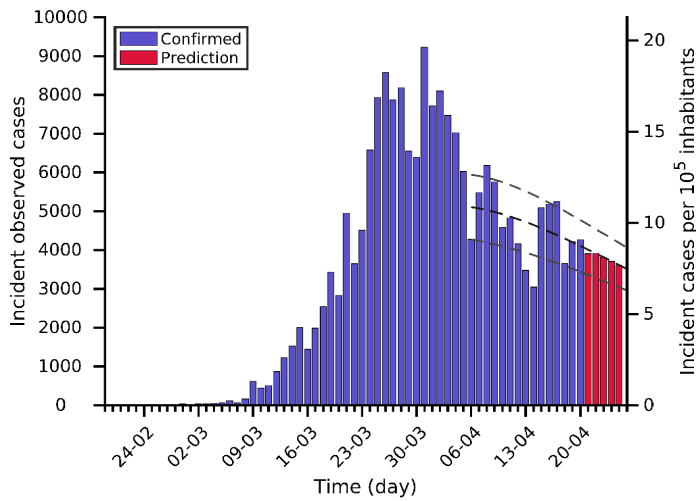
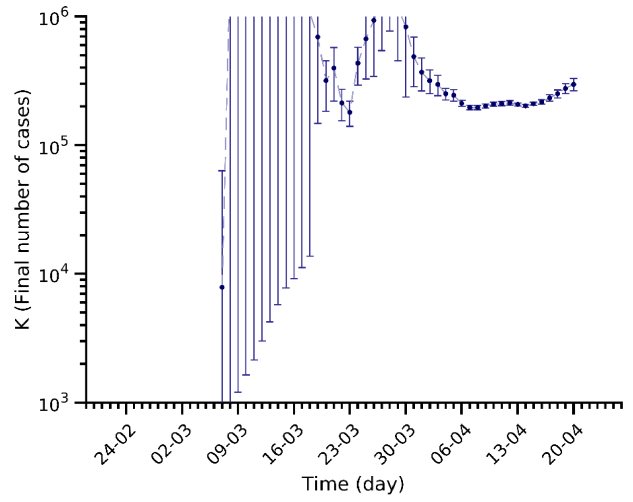
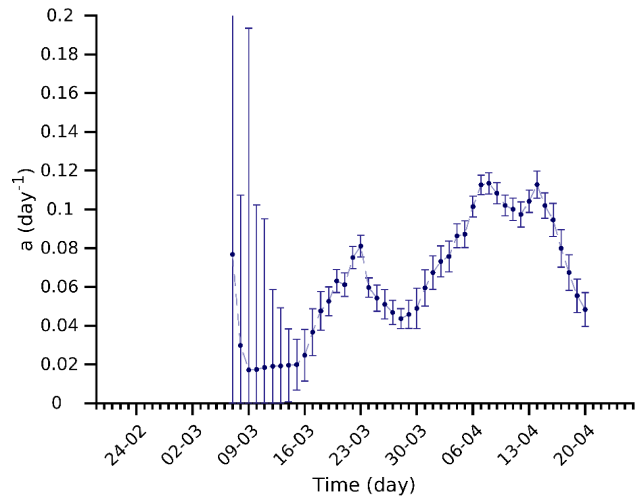
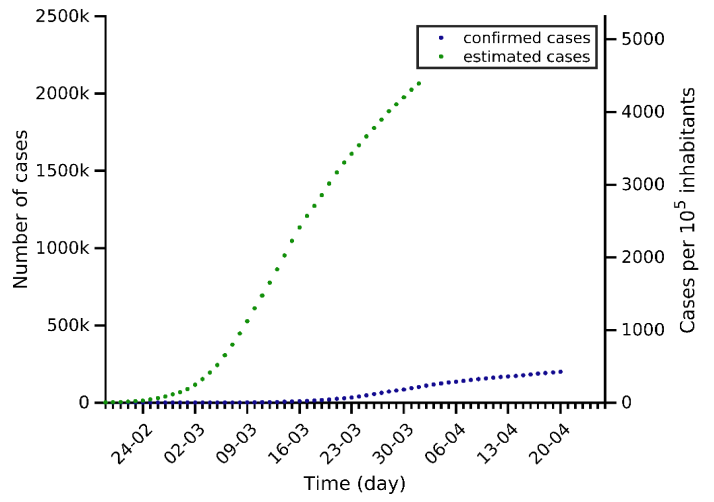
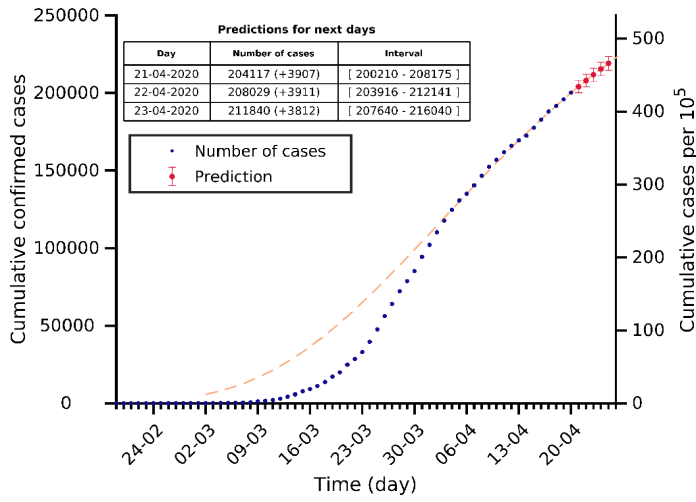
Deaths / cumulated reported cases

(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

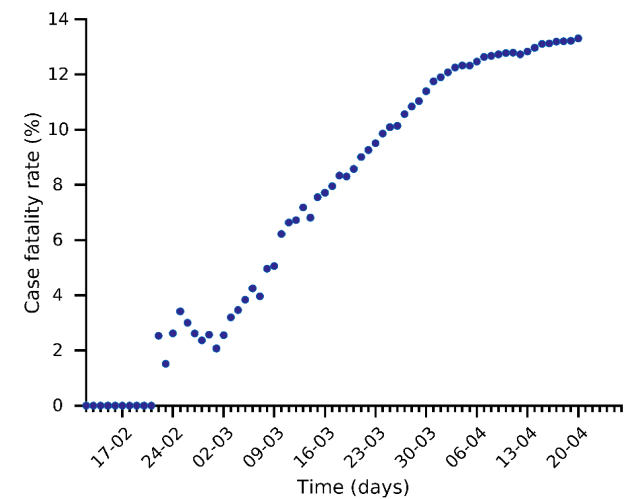
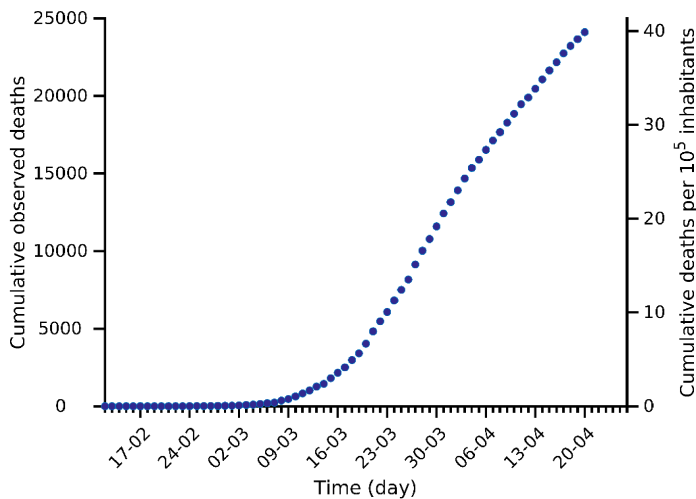
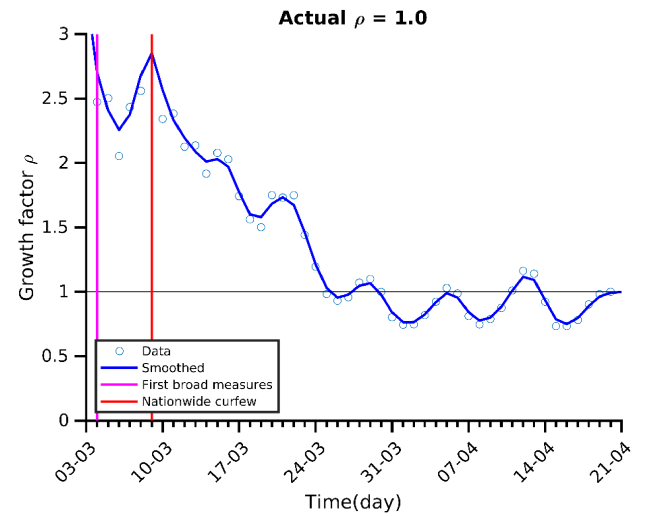
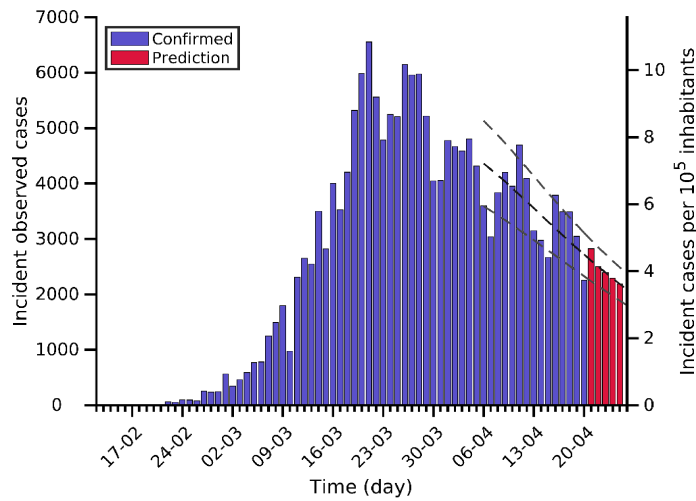
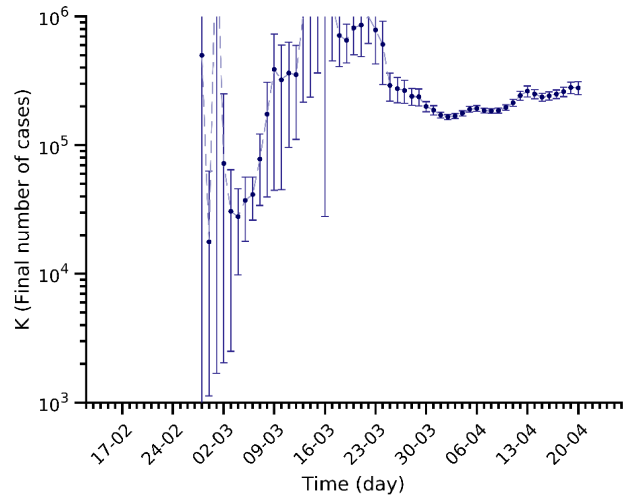
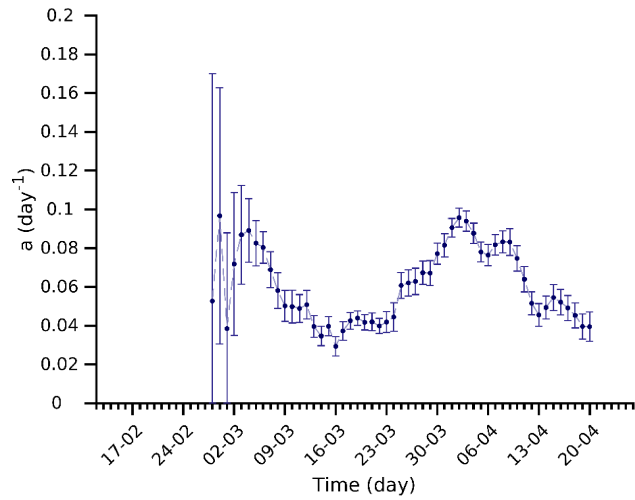
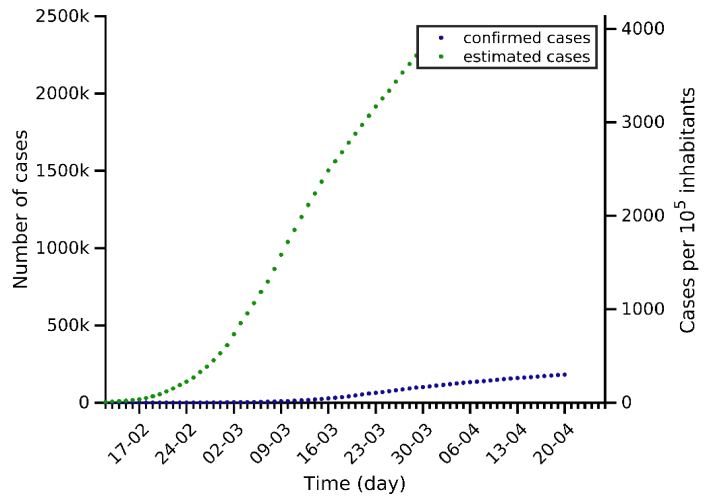
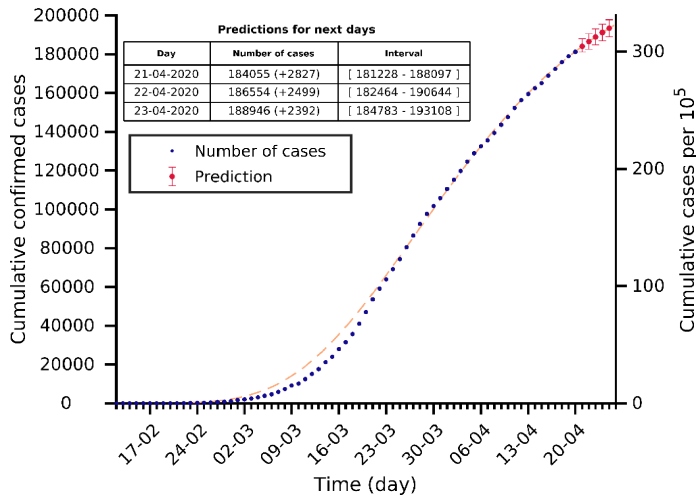
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>
<https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale> (Italy)



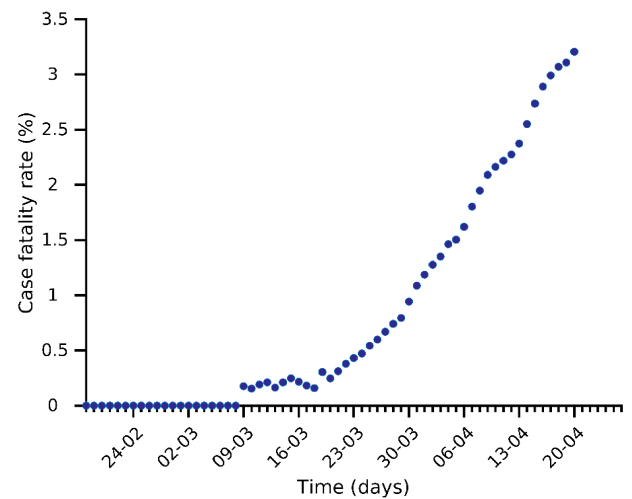
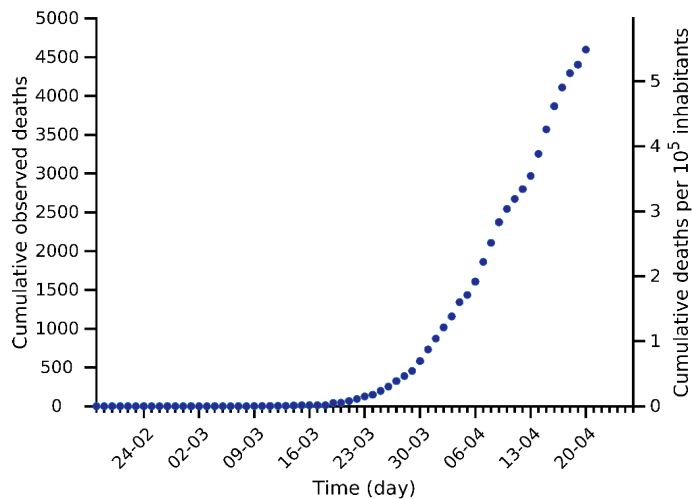
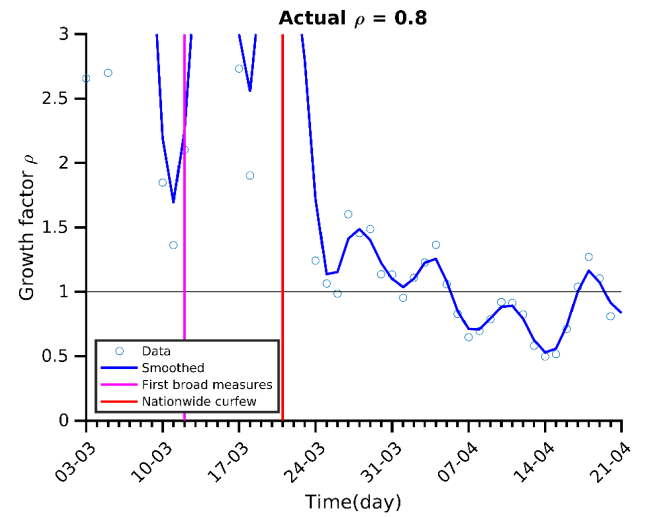
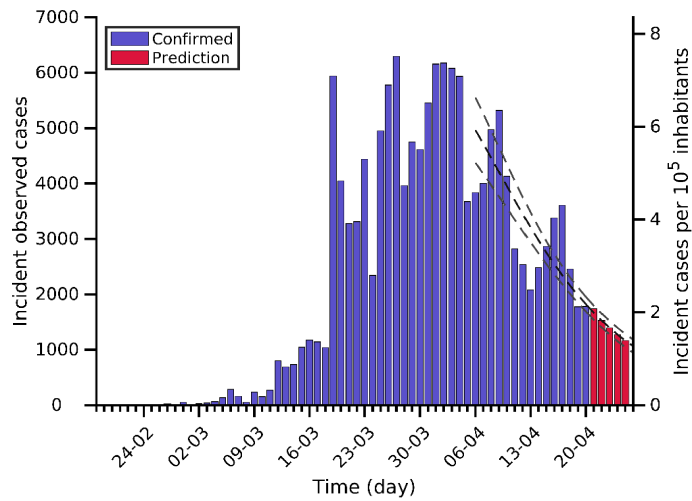
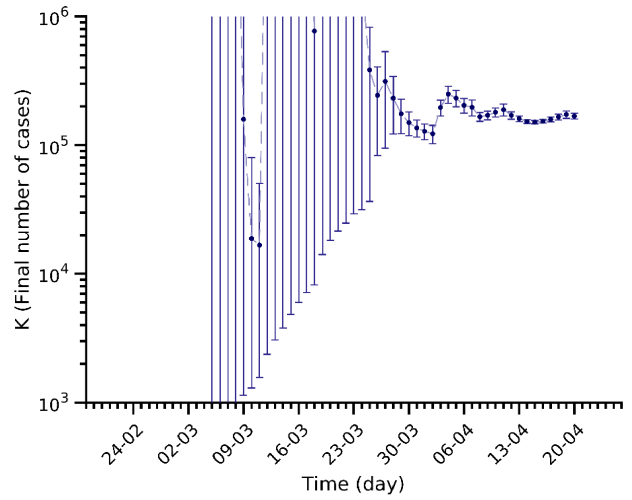
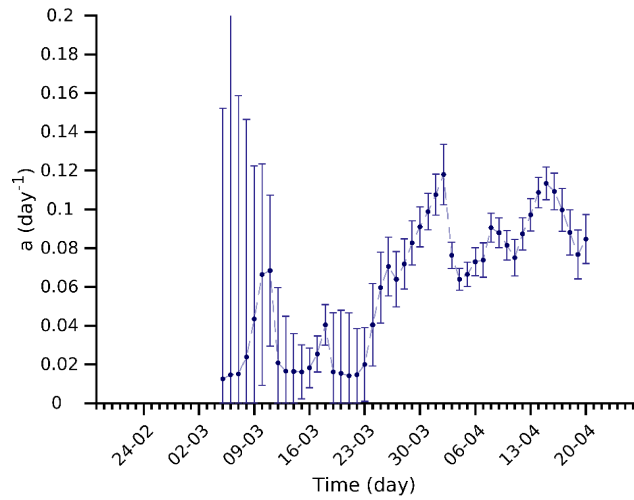
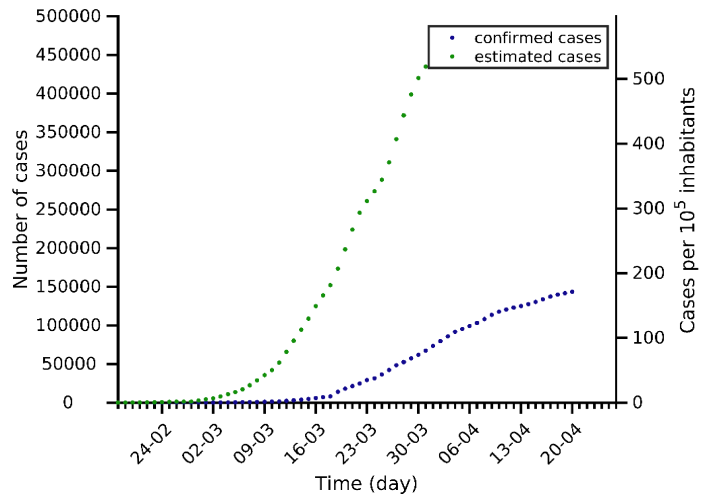
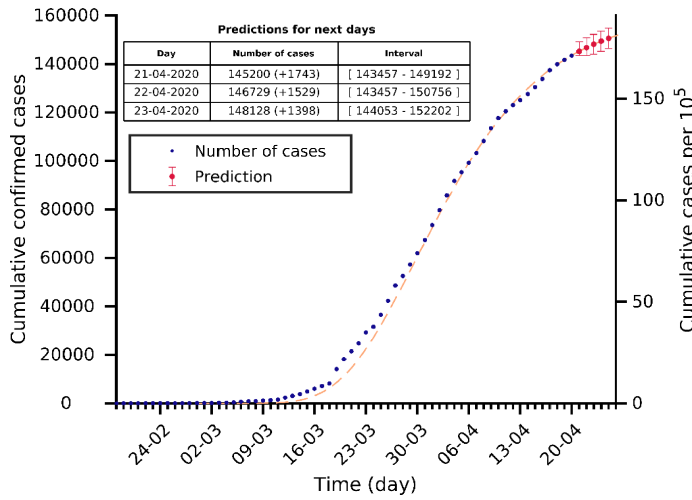
Spain 20-04-2020. Population: 47.0M. Current cumulated incidence: 426/10⁵



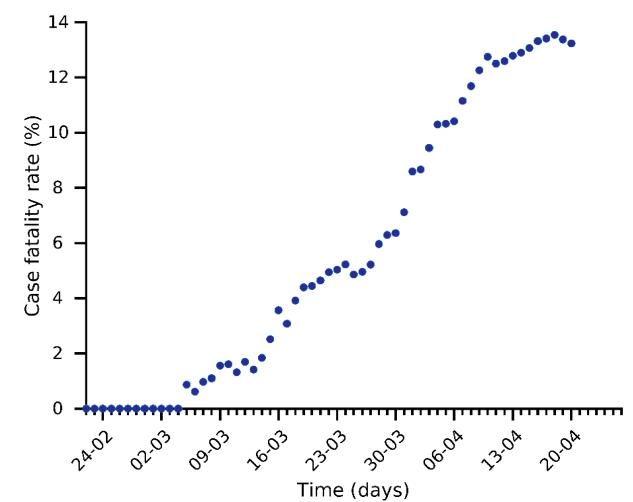
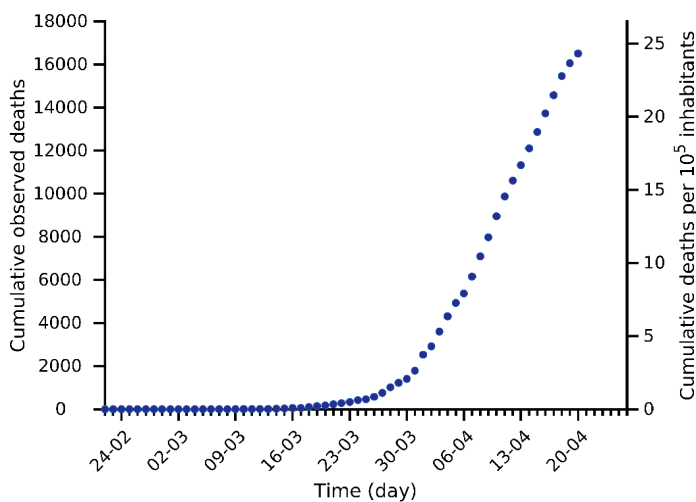
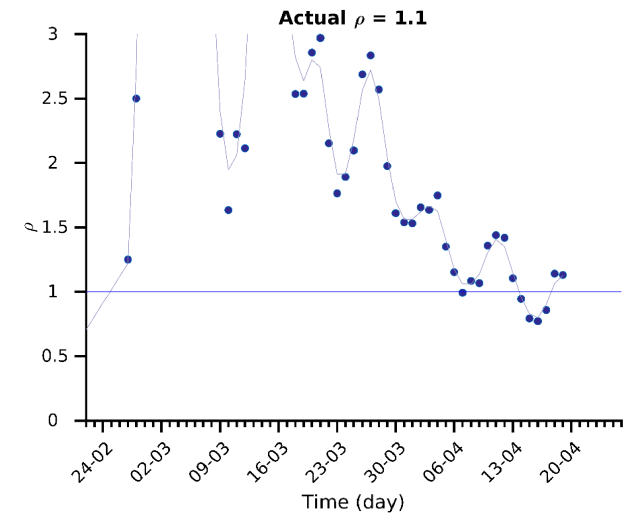
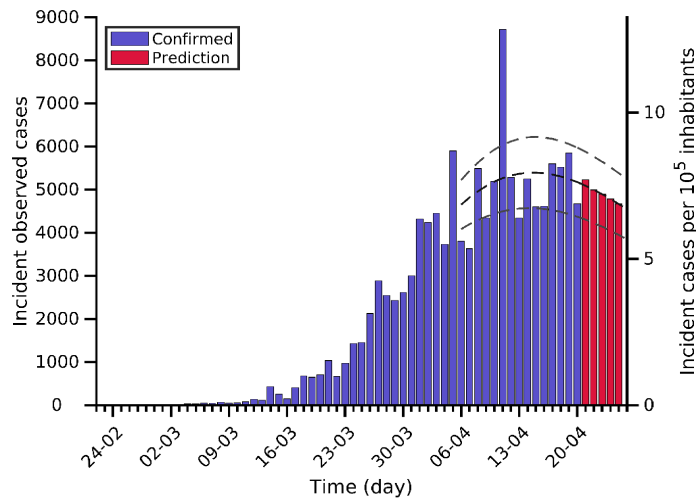
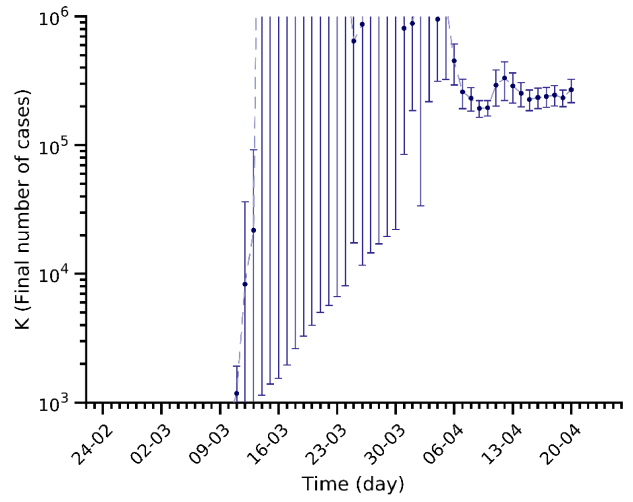
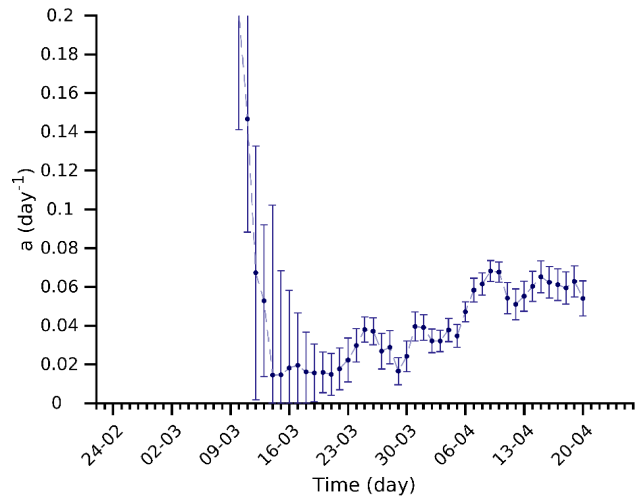
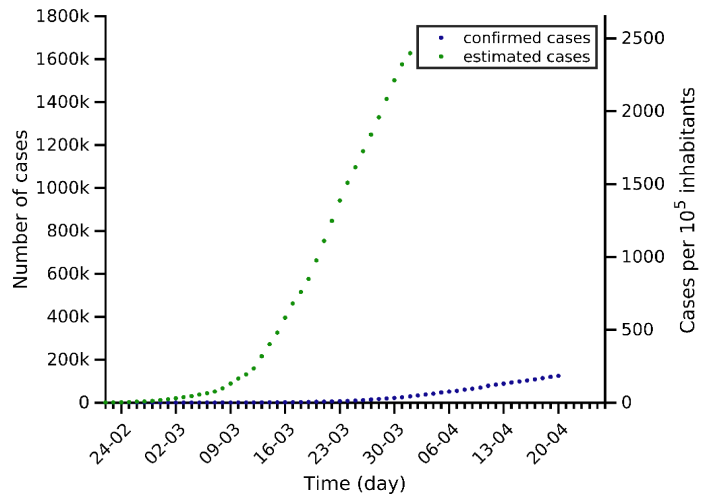
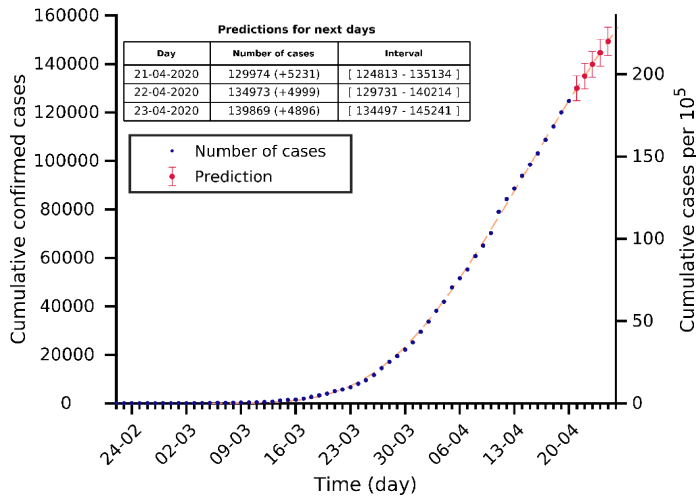
Italy 20-04-2020. Population: 60.5M. Current cumulated incidence: 300/10⁵



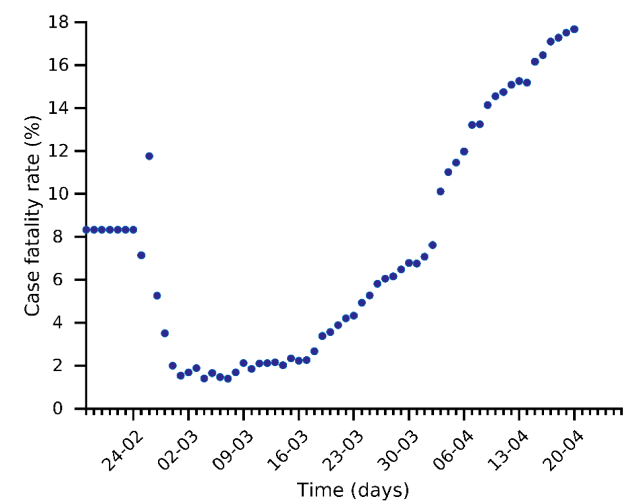
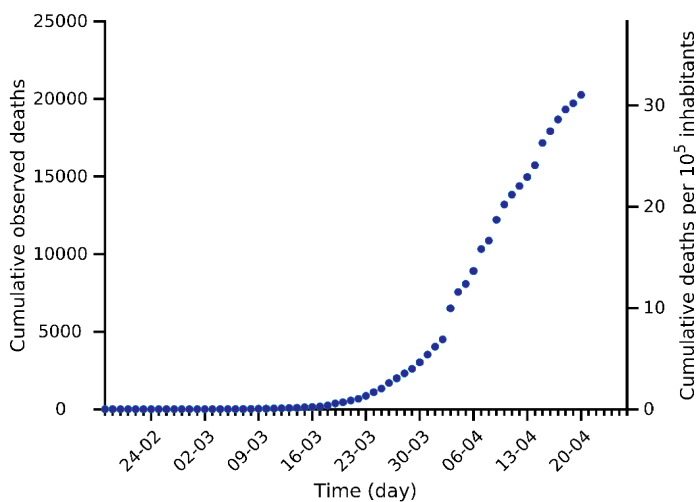
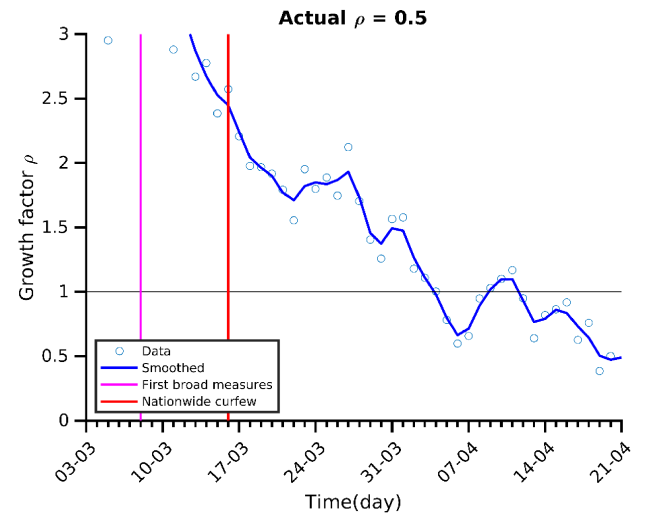
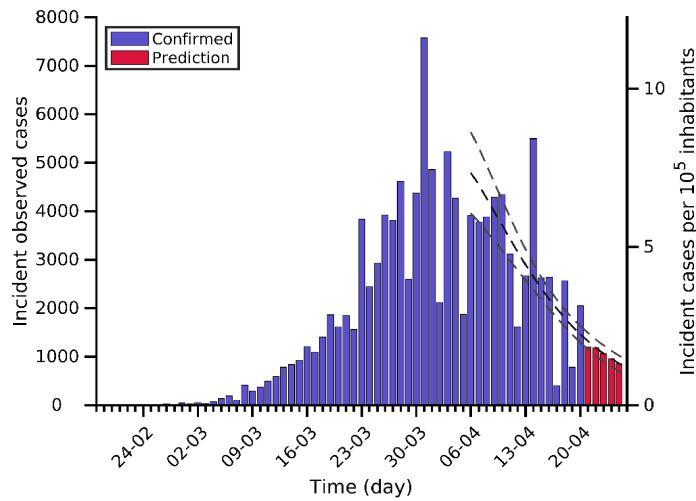
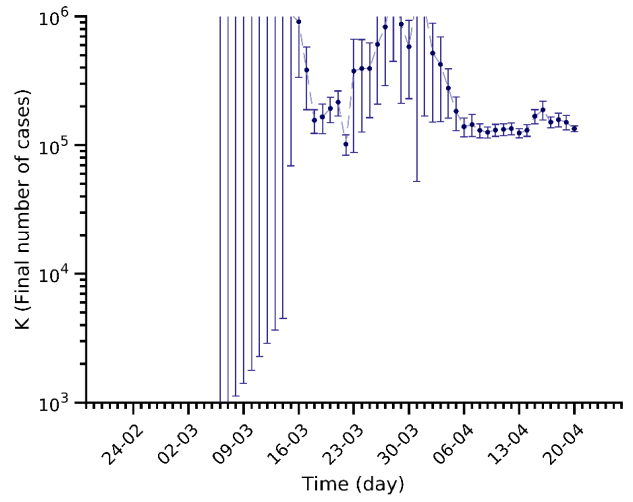
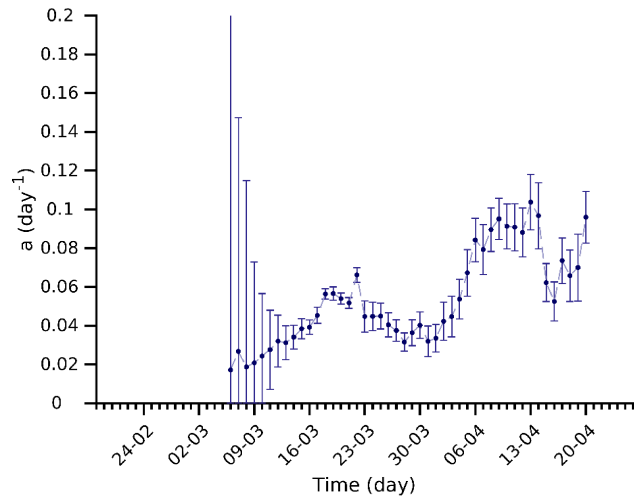
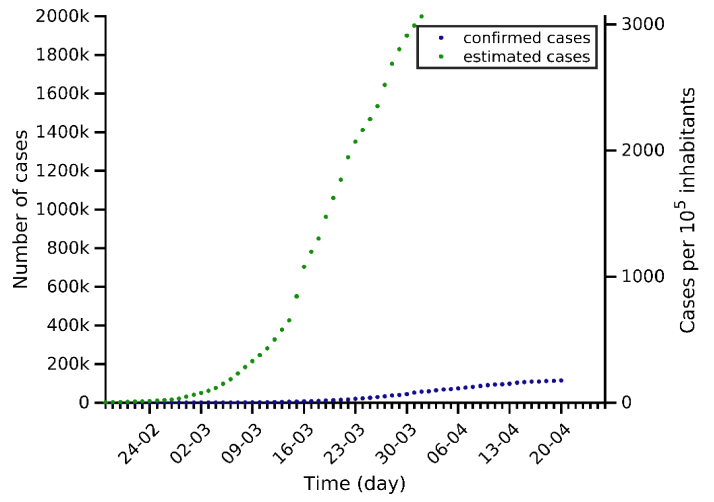
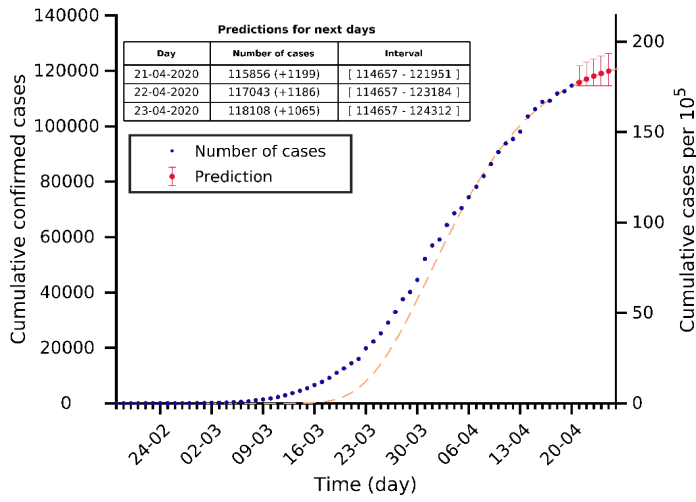
Germany 20-04-2020. Population: 83.8M. Current cumulated incidence: 171/10⁵



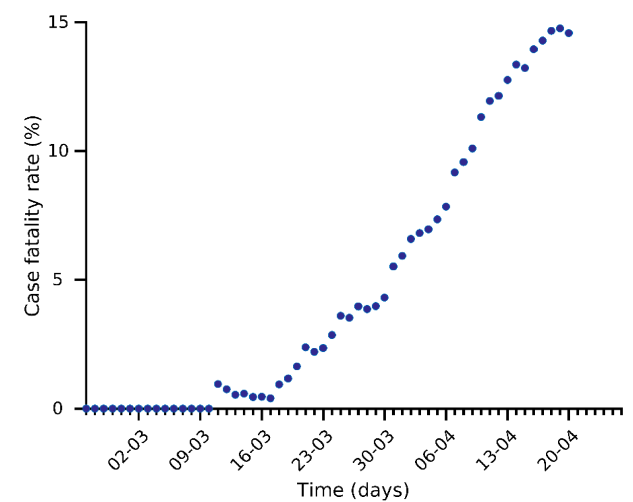
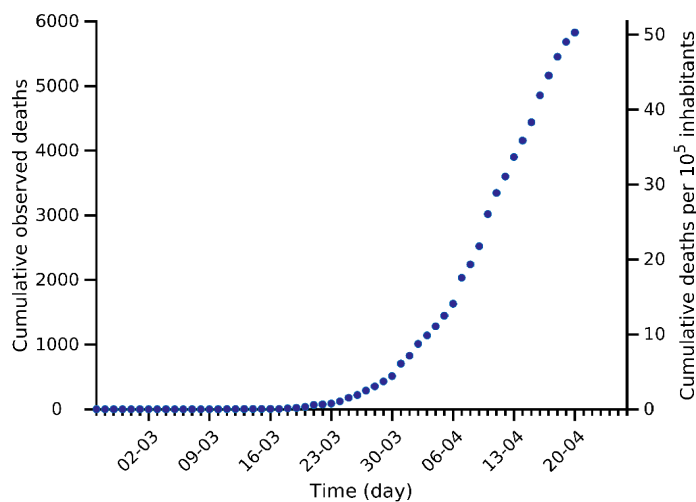
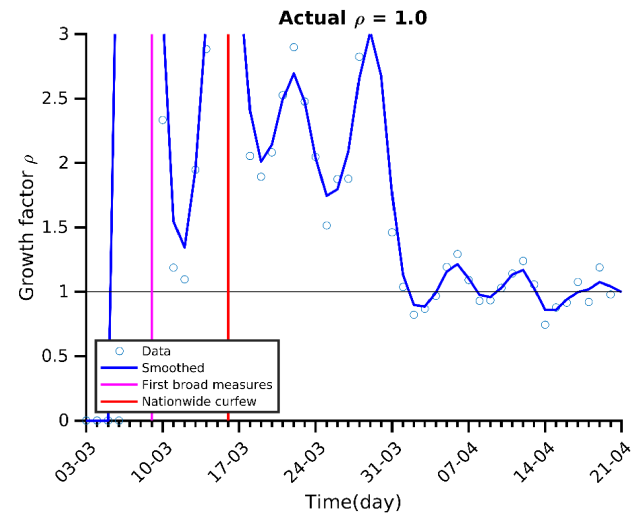
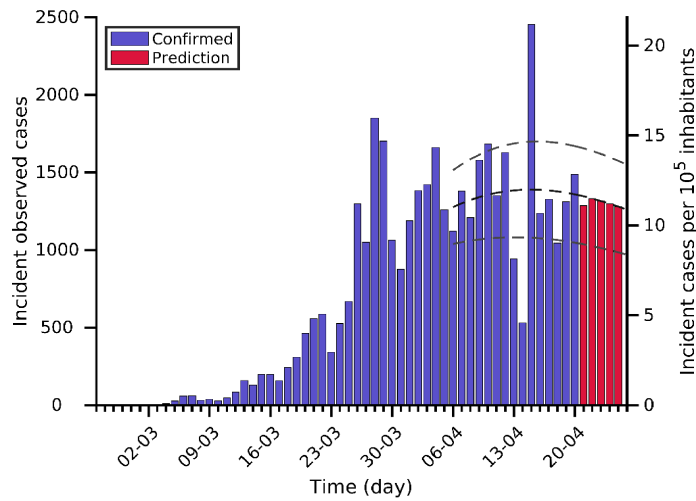
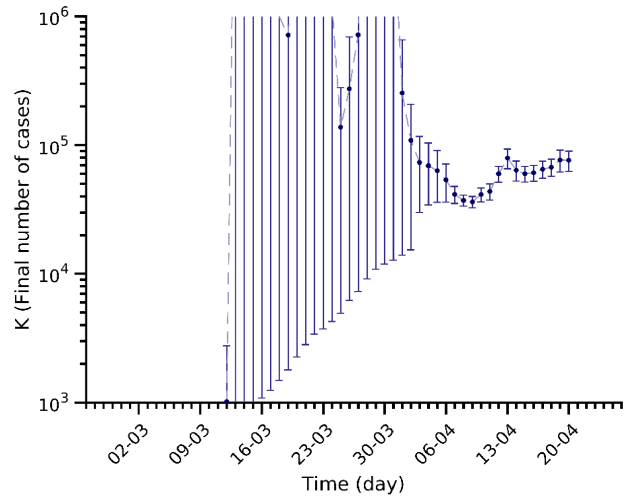
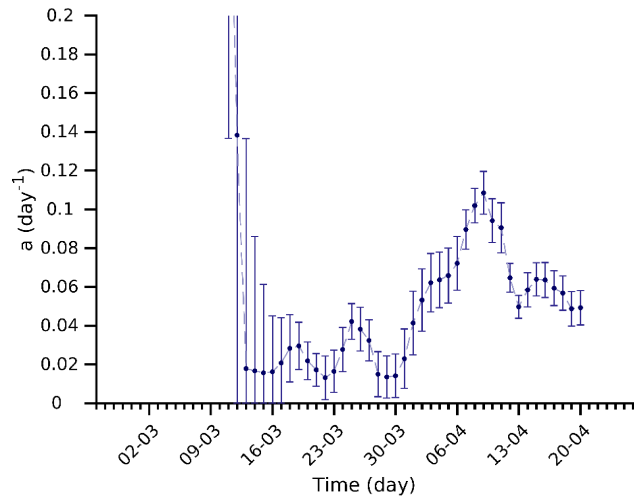
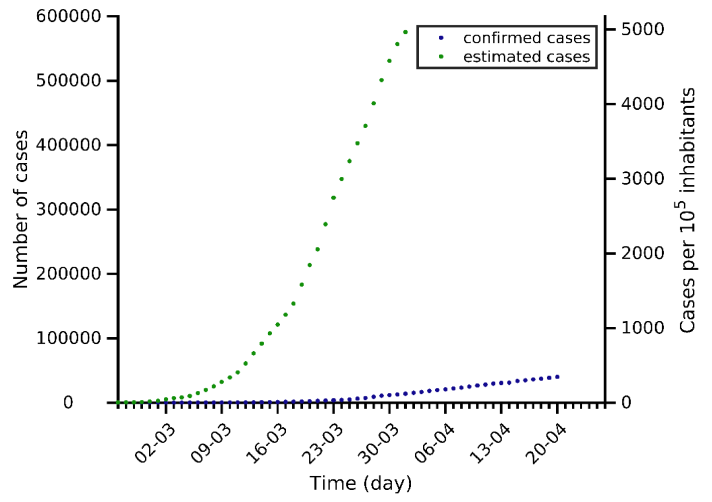
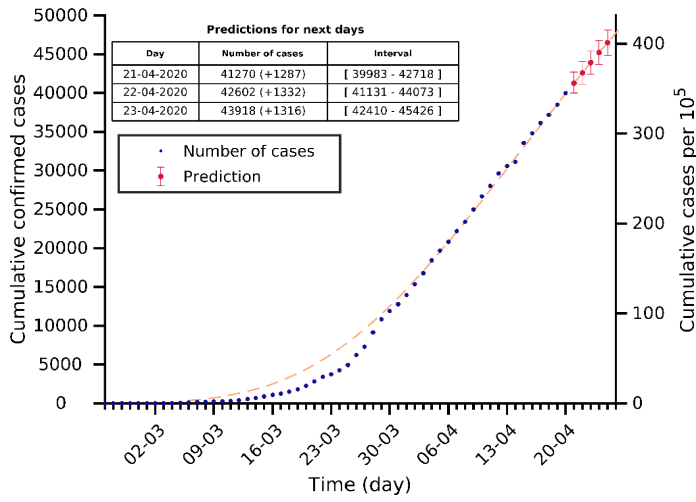
UK 20-04-2020. Population: 67.9M. Current cumulated incidence: 184/10⁵



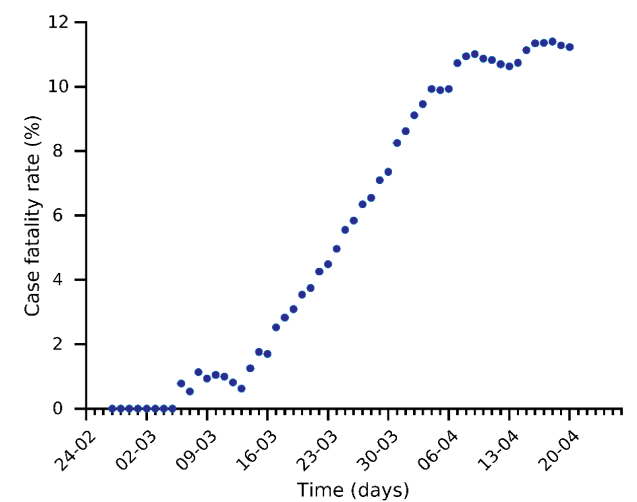
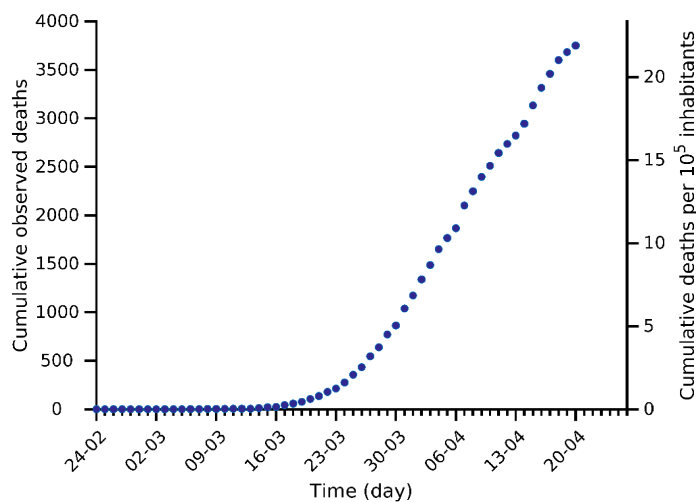
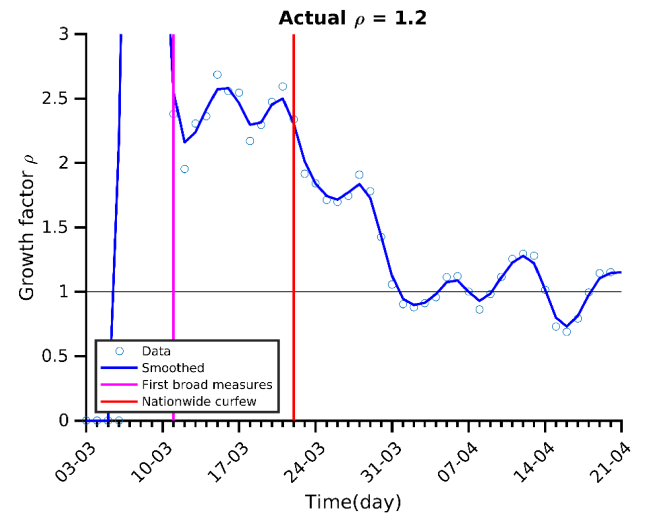
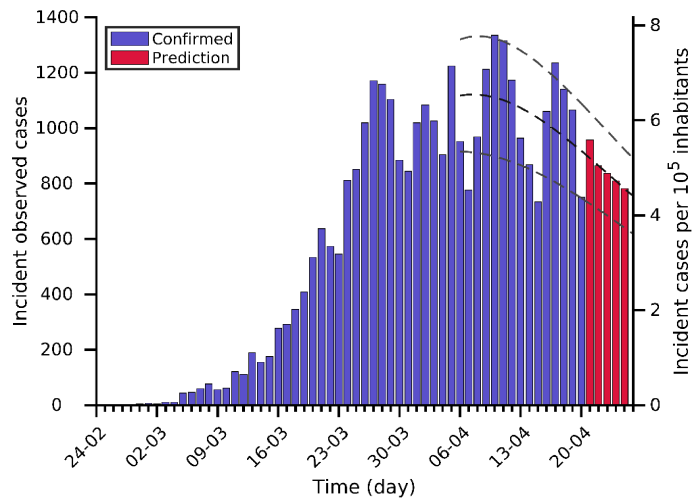
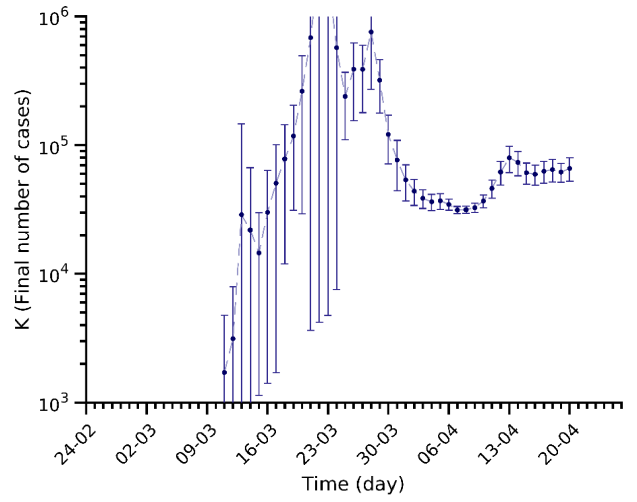
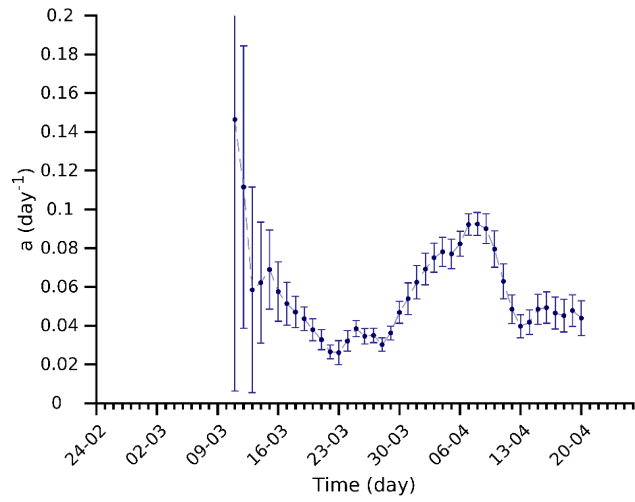
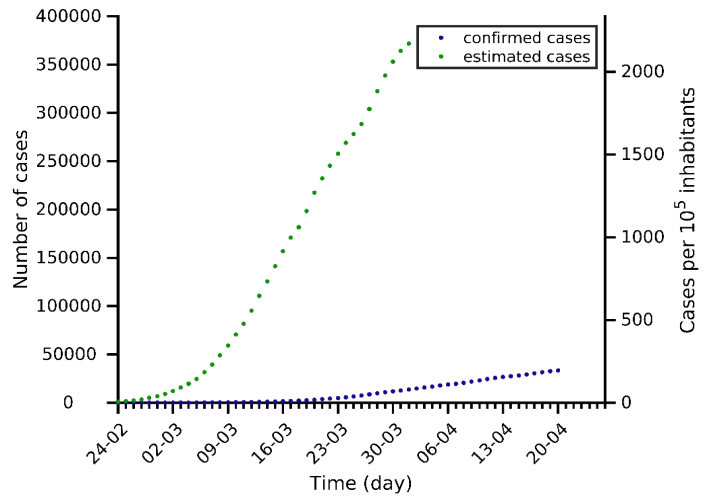
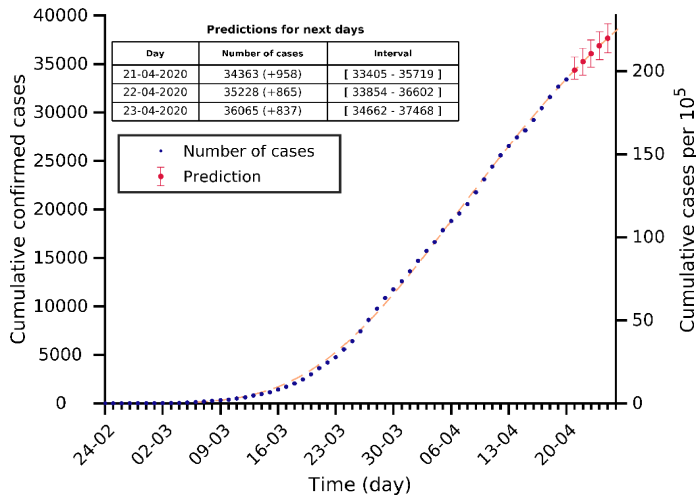
France 20-04-2020. Population: 65.3M. Current cumulated incidence: 176/10⁵



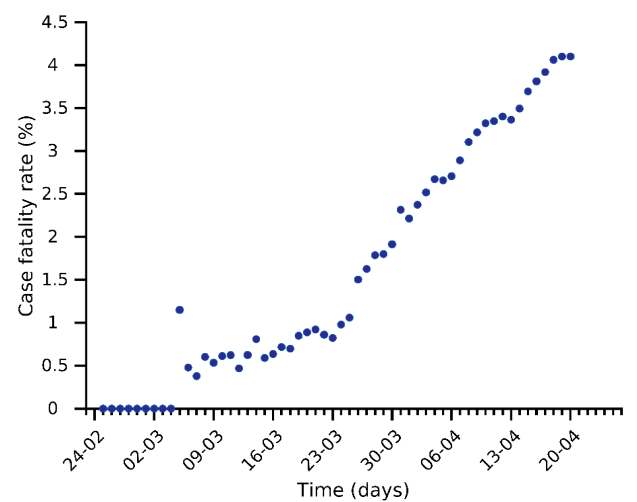
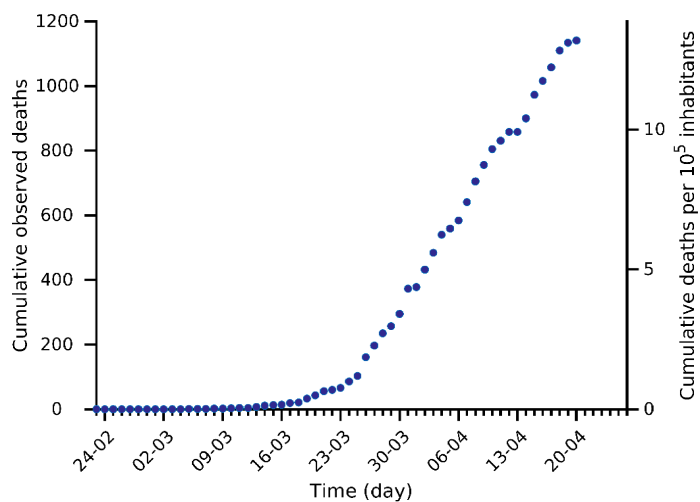
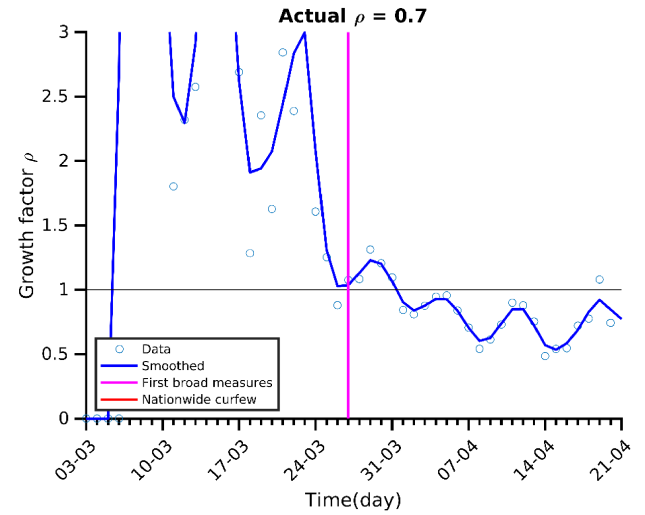
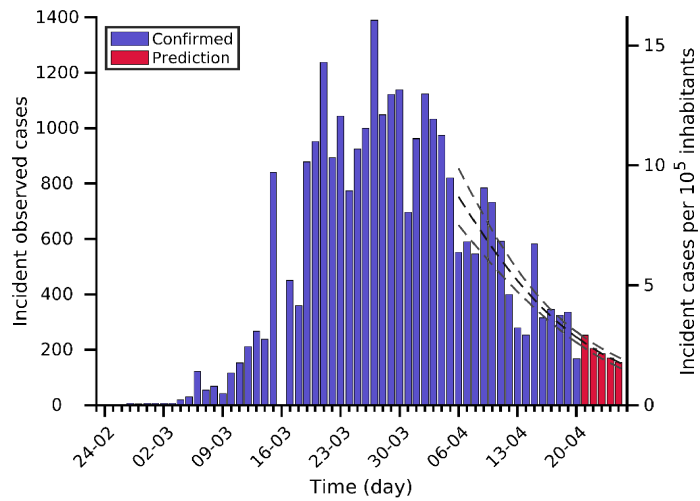
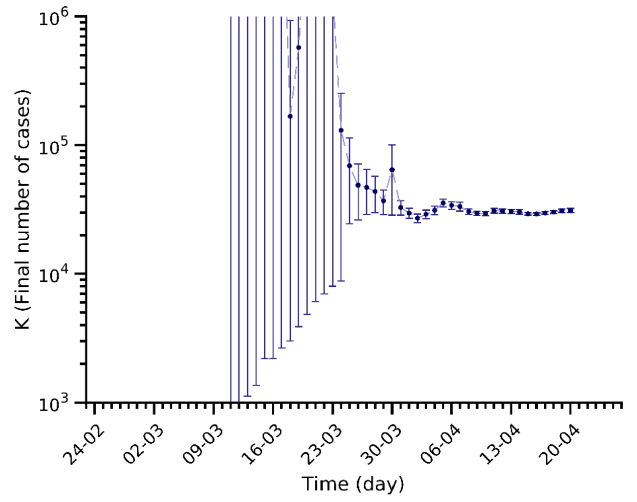
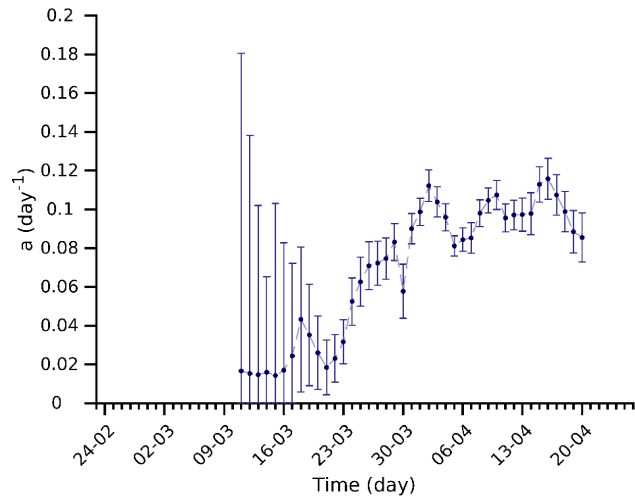
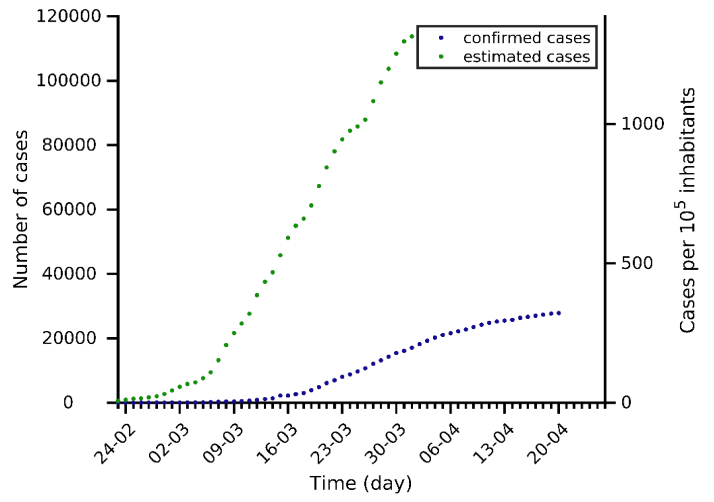
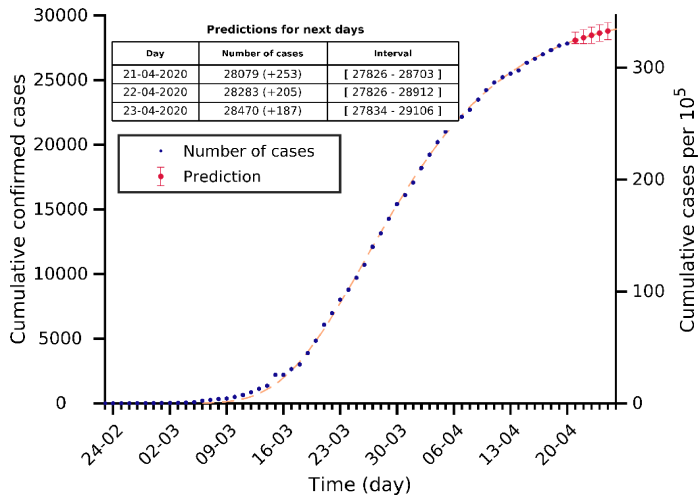
Belgium 20-04-2020. Population: 11.6M. Current cumulated incidence: 345/10⁵



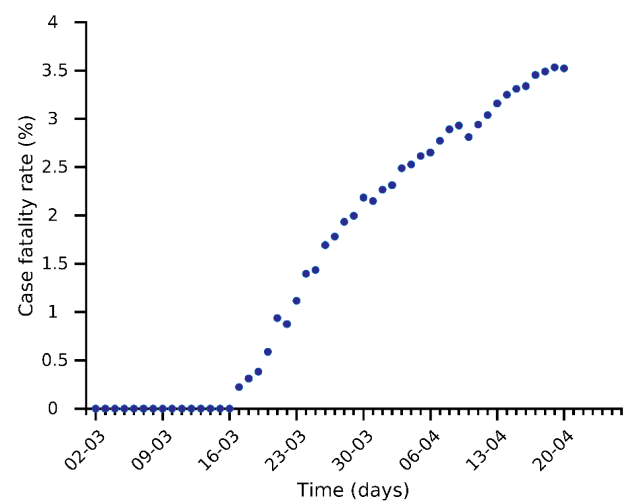
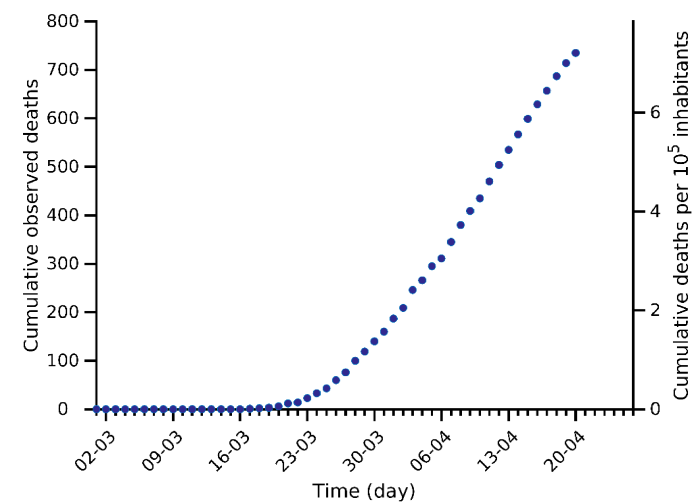
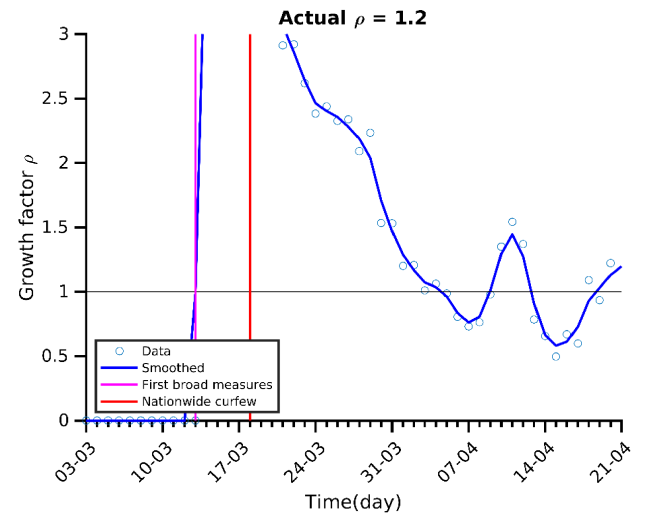
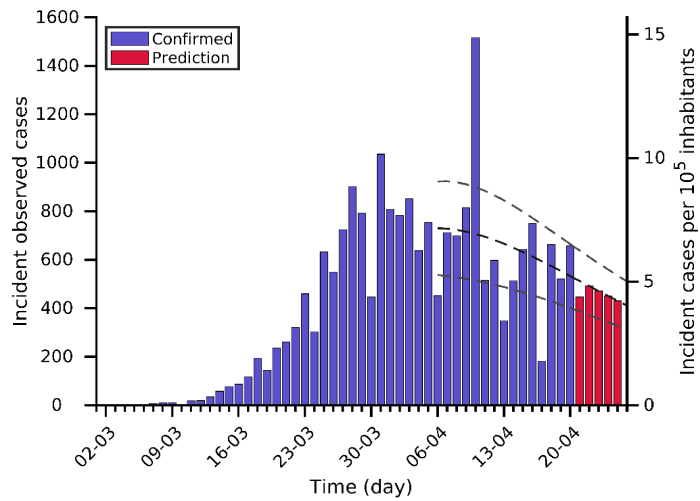
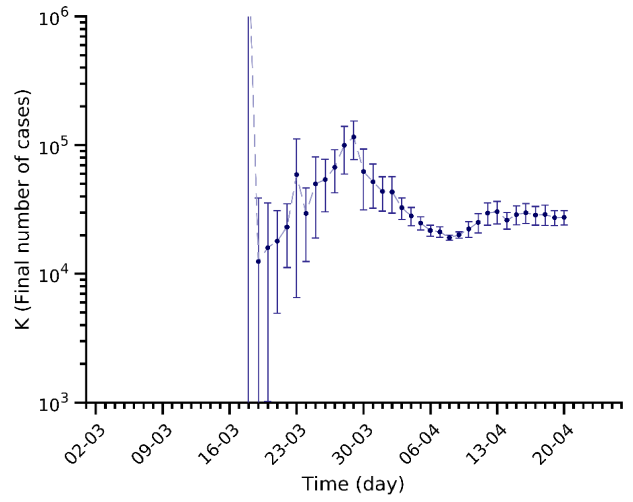
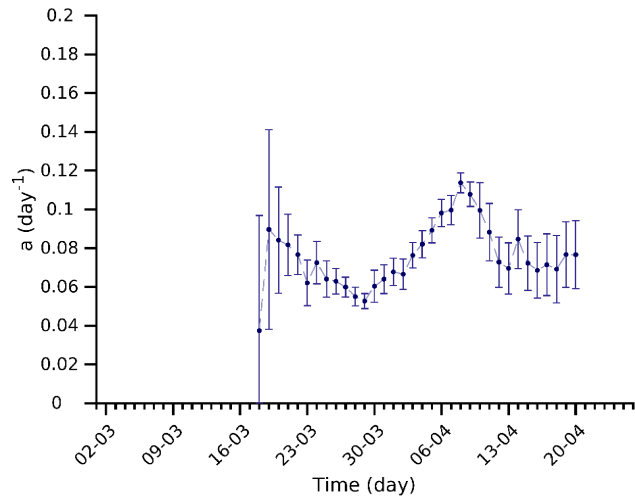
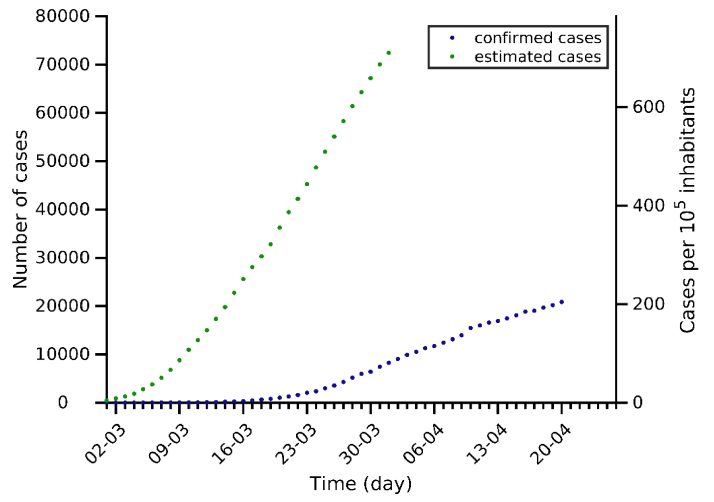
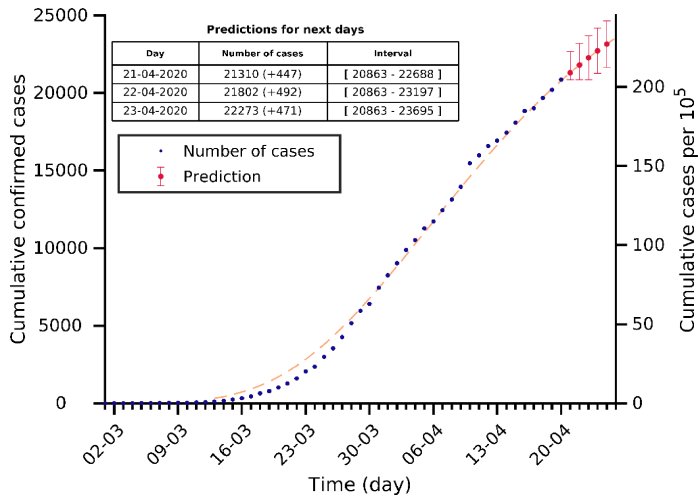
Netherlands 20-04-2020. Population: 17.1M. Current cumulated incidence: 195/10⁵



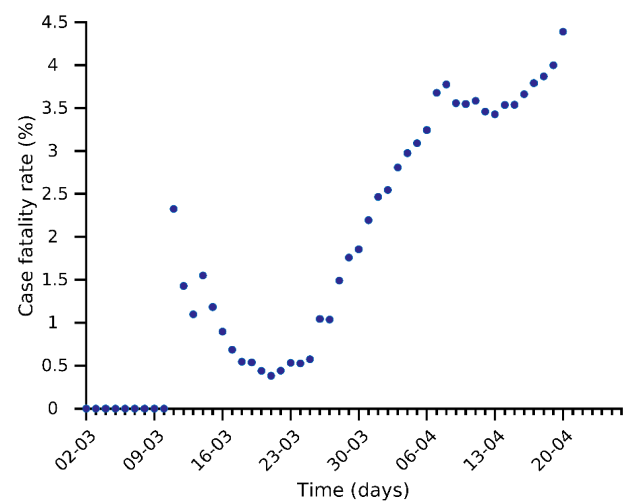
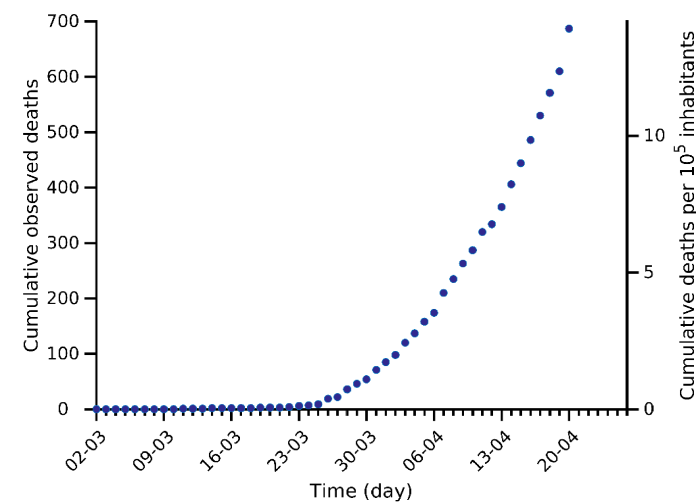
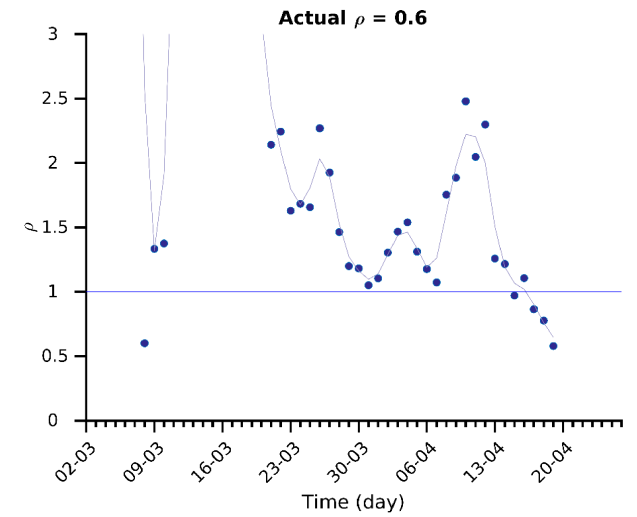
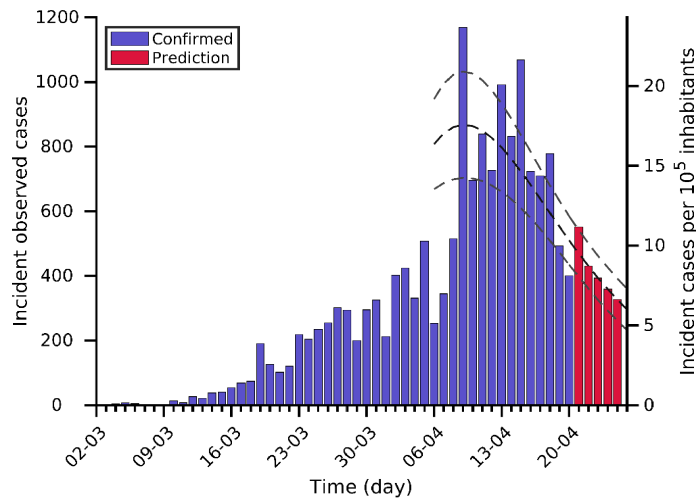
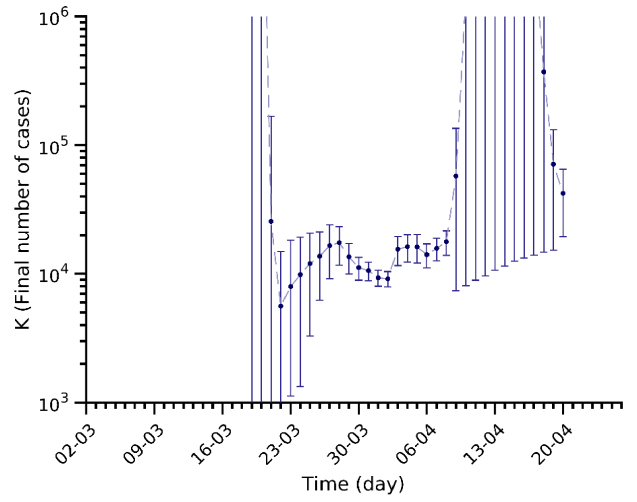
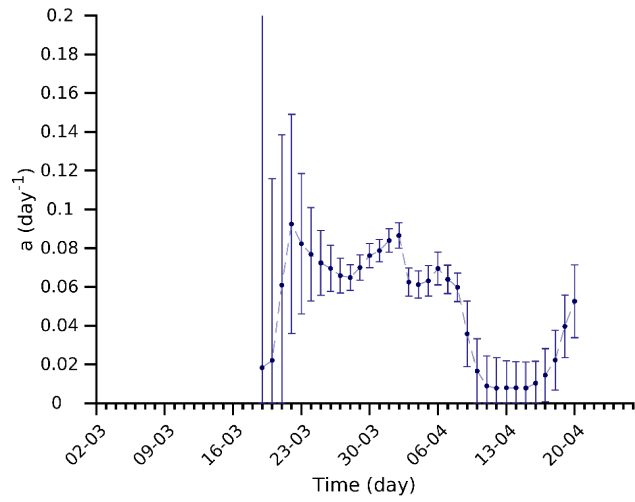
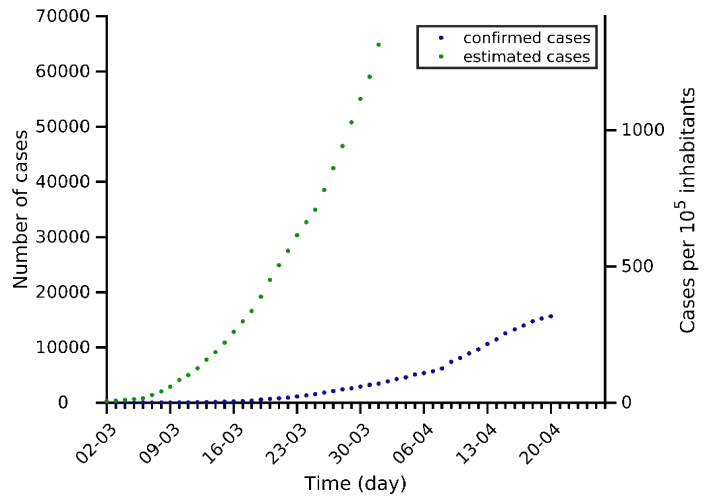
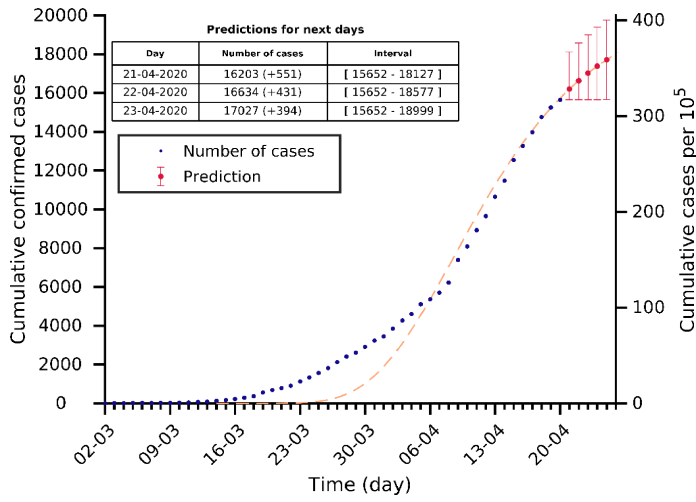
Switzerland 20-04-2020. Population: 8.7M. Current cumulated incidence: 322/10⁵



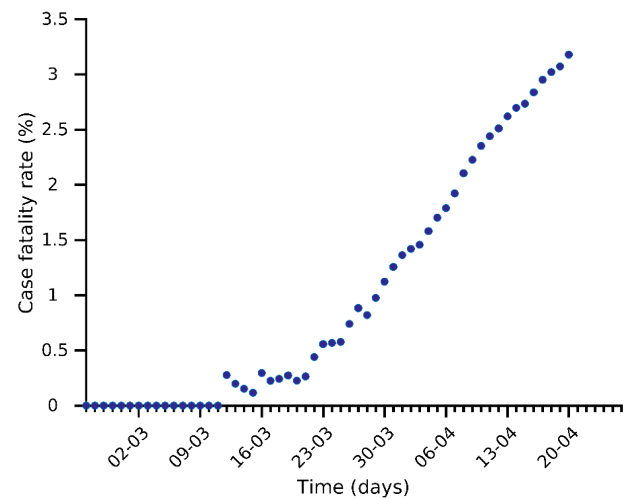
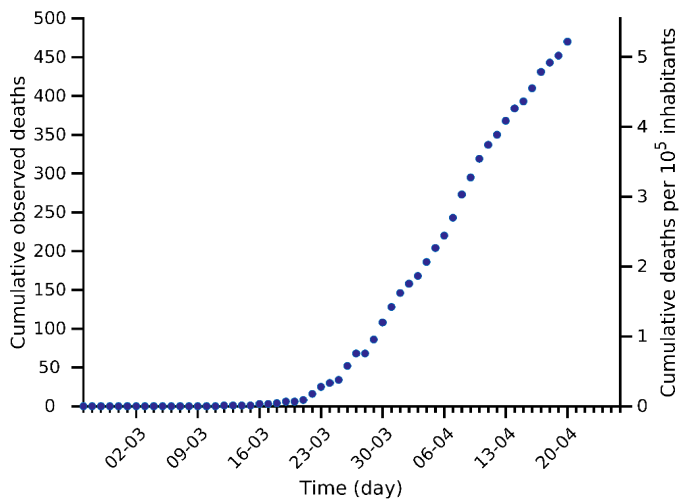
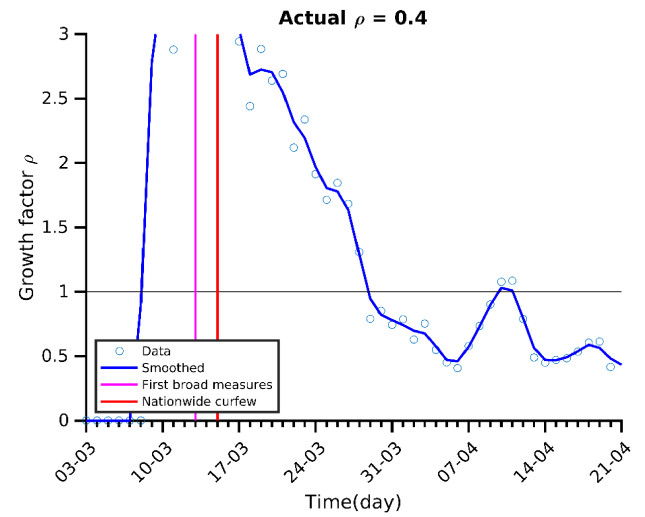
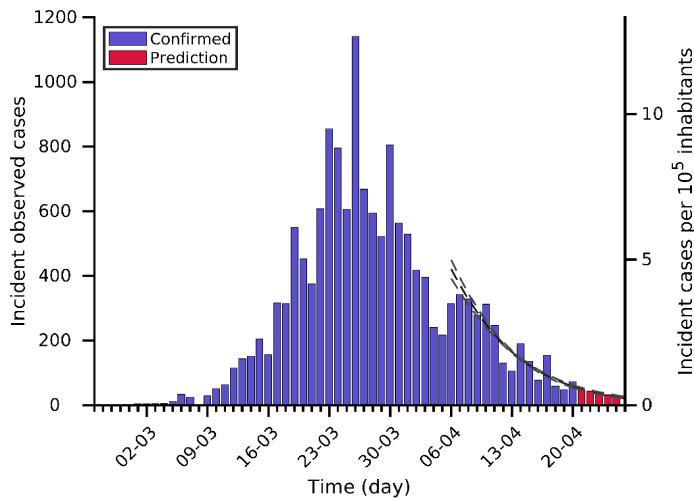
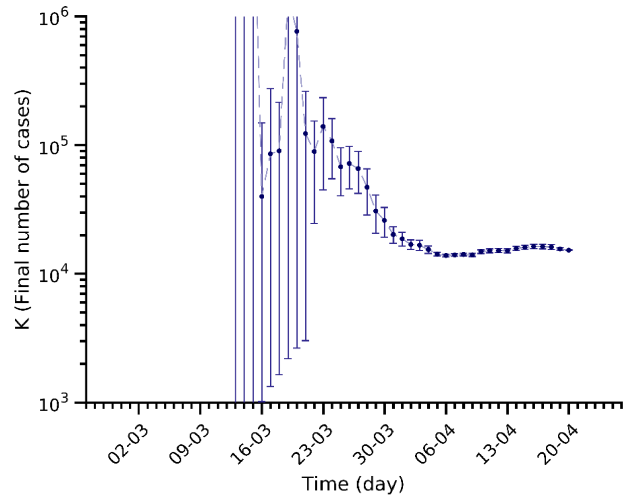
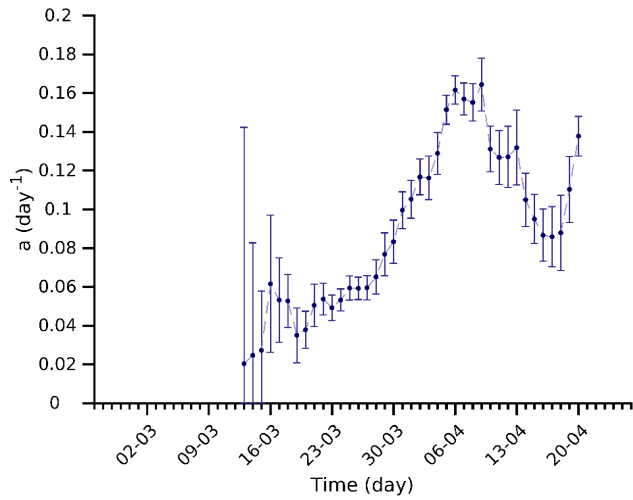
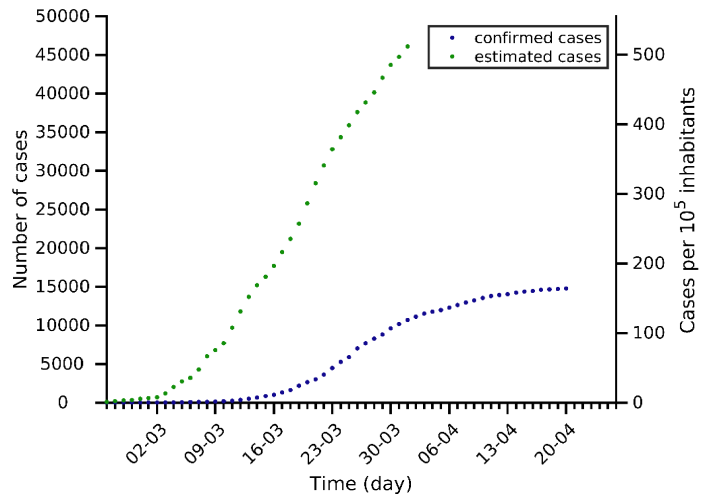
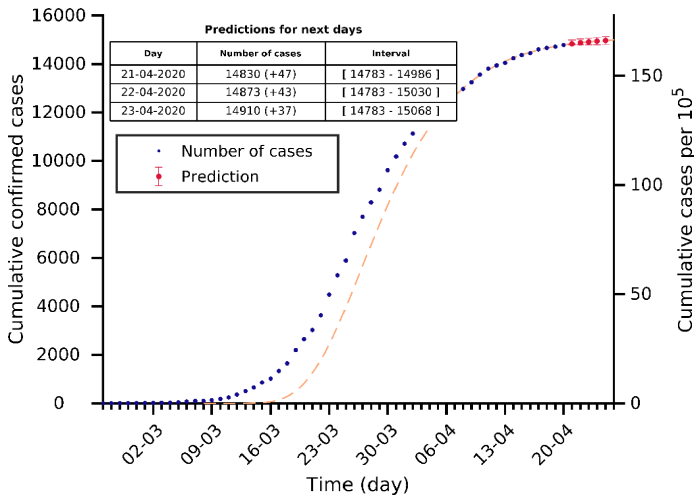
Portugal 20-04-2020. Population: 10.2M. Current cumulated incidence: 205/10⁵



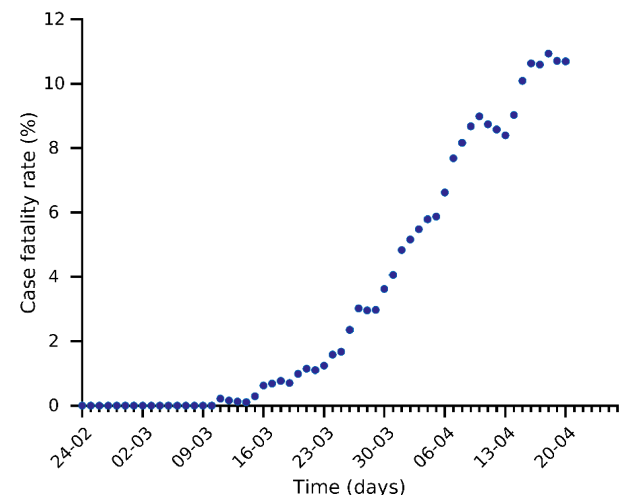
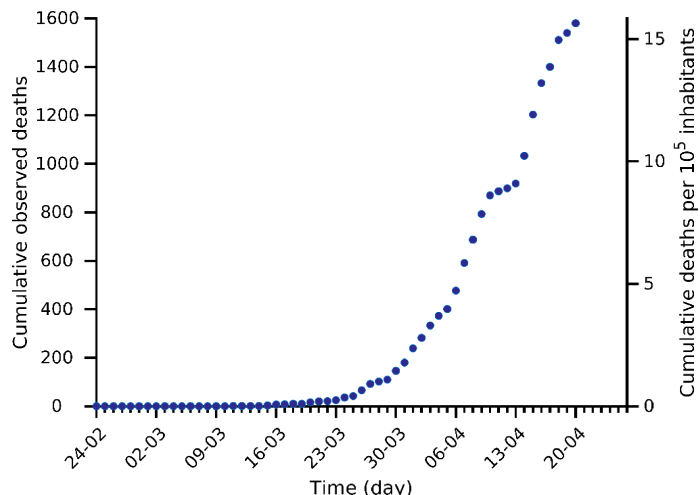
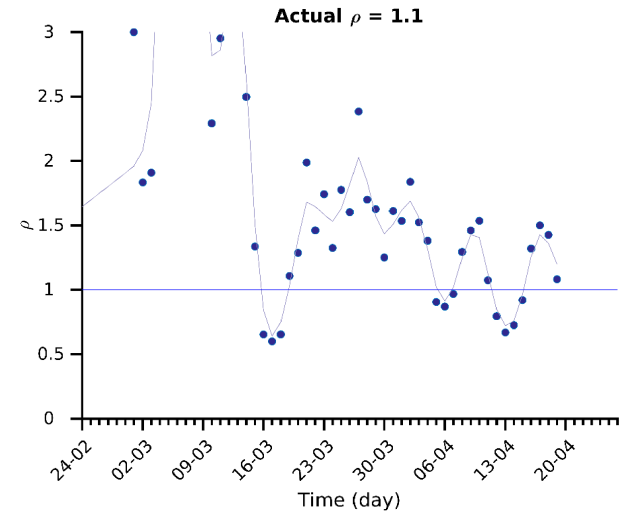
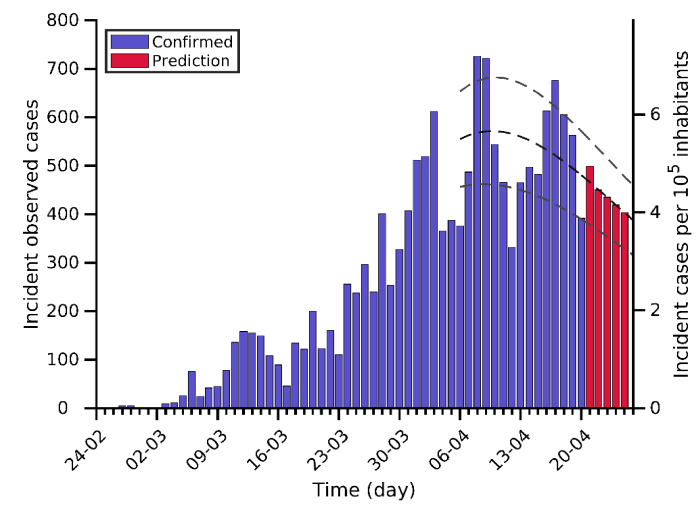
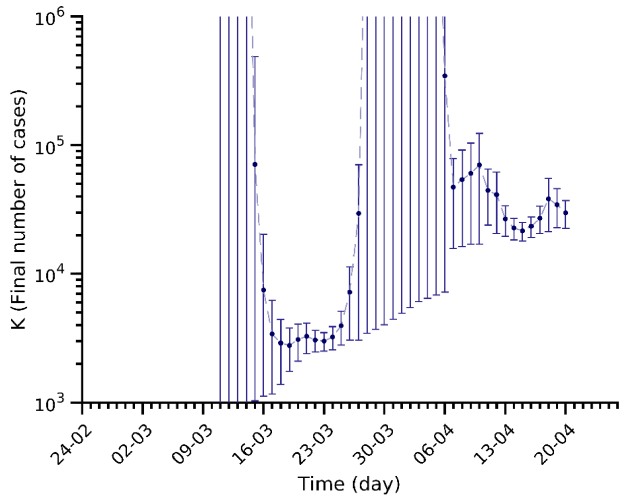
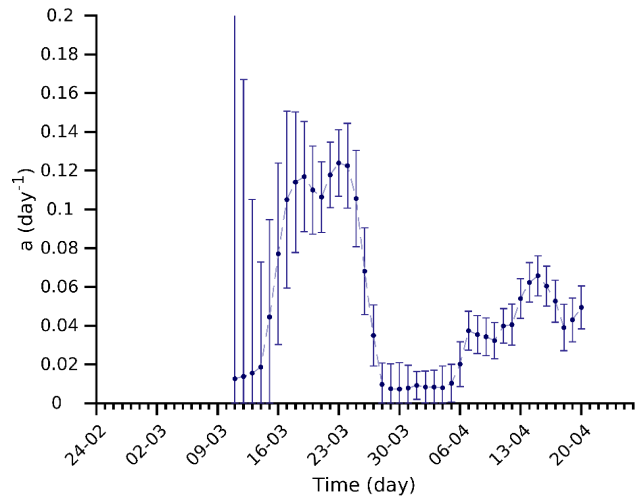
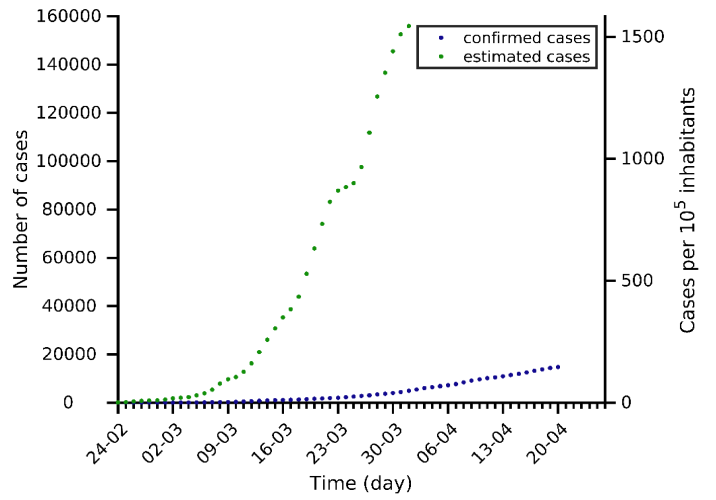
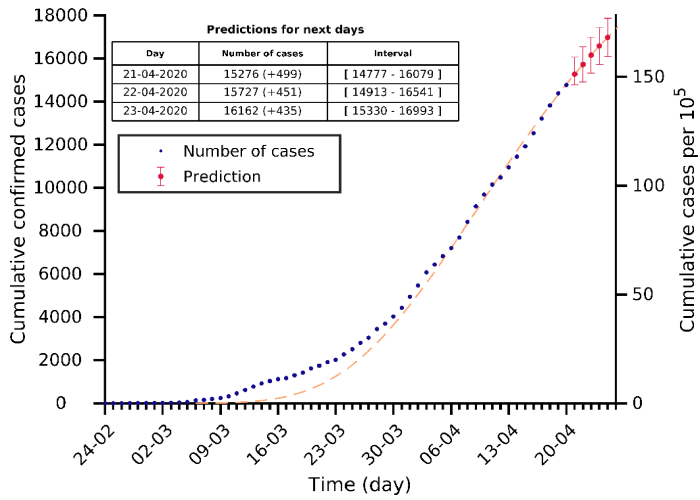
Ireland 20-04-2020. Population: 4.9M. Current cumulated incidence: 317/10⁵



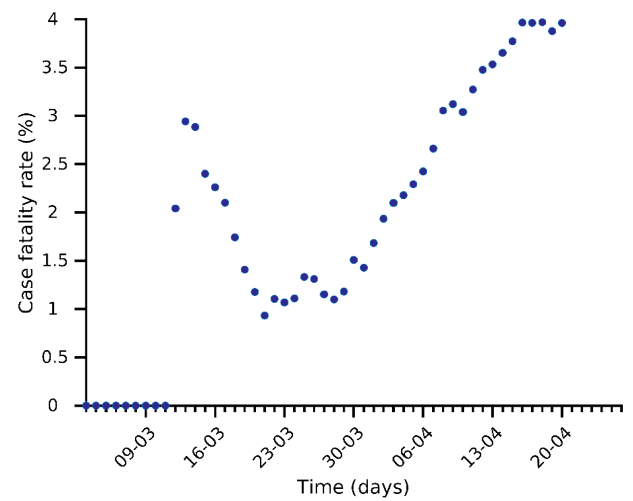
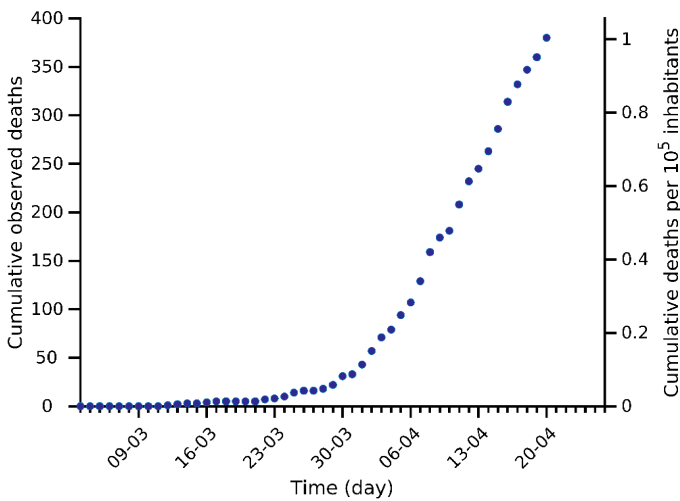
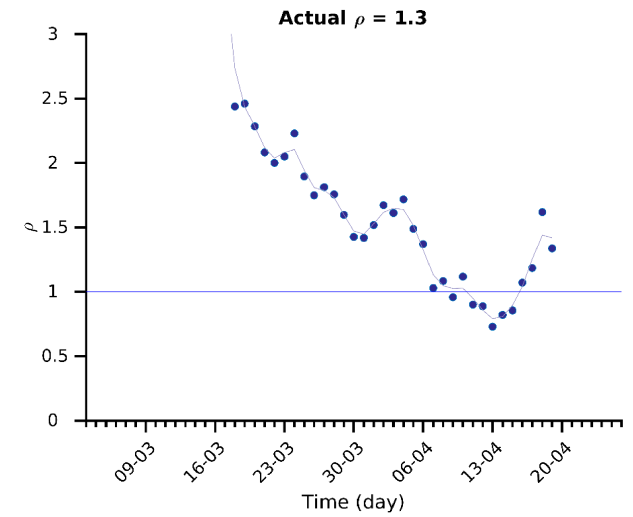
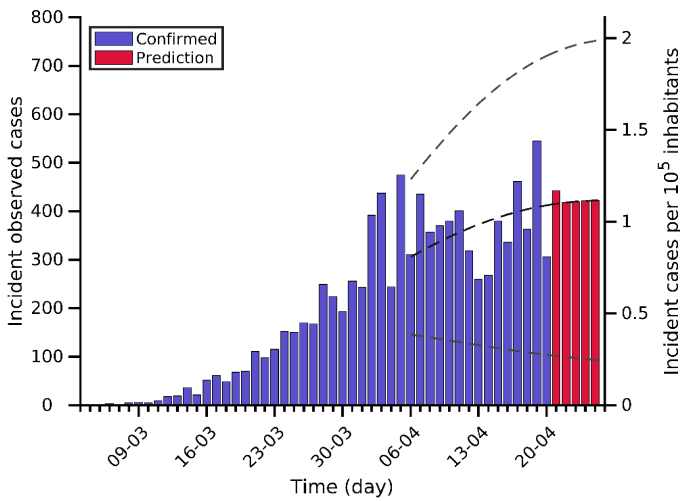
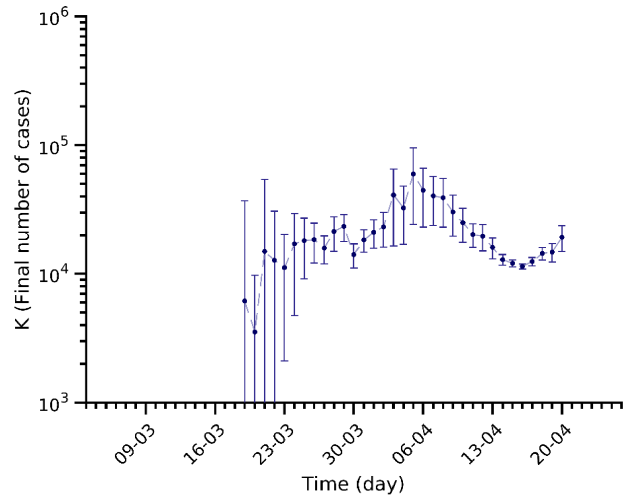
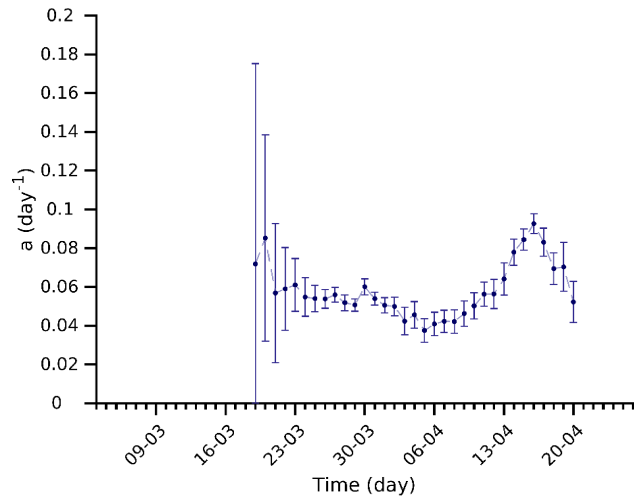
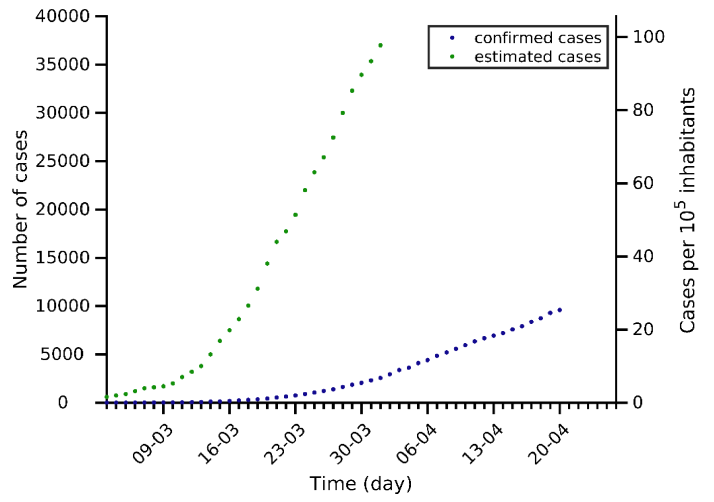
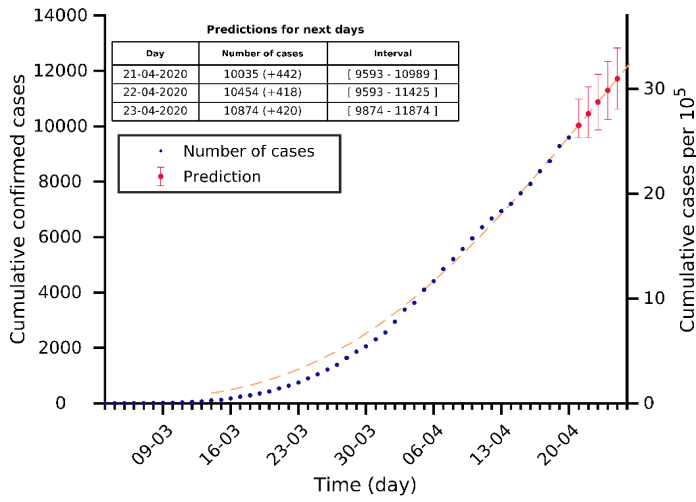
Austria 20-04-2020. Population: 9.0M. Current cumulated incidence: 164/10⁵



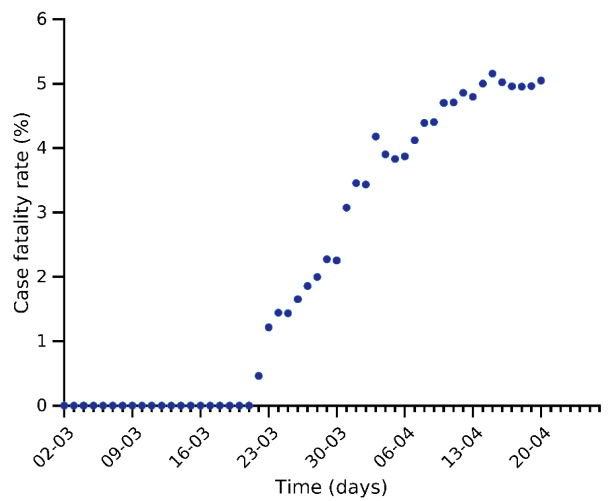
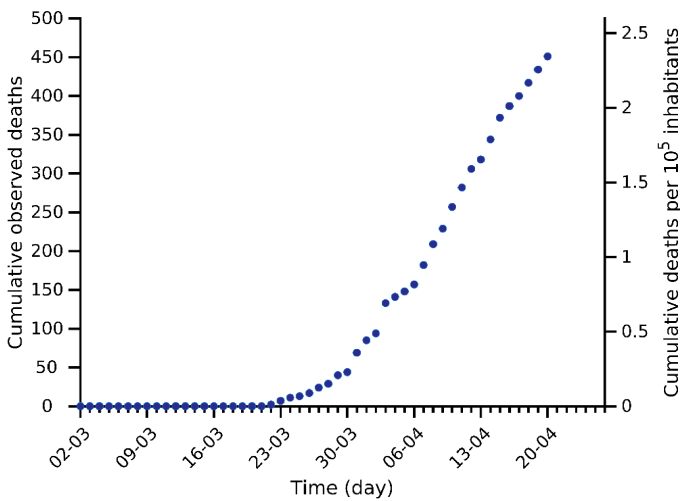
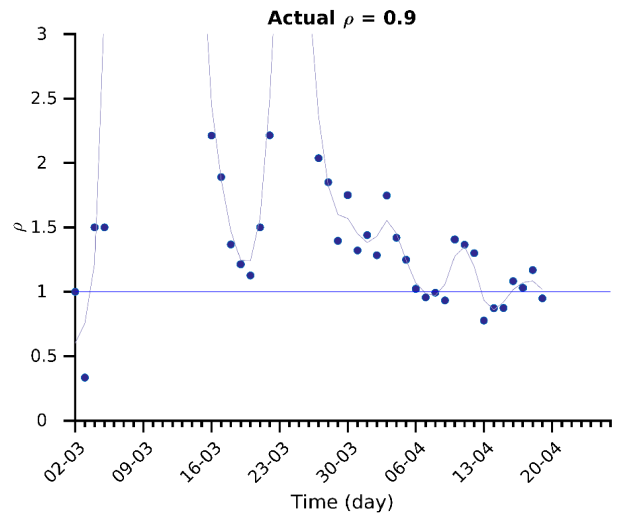
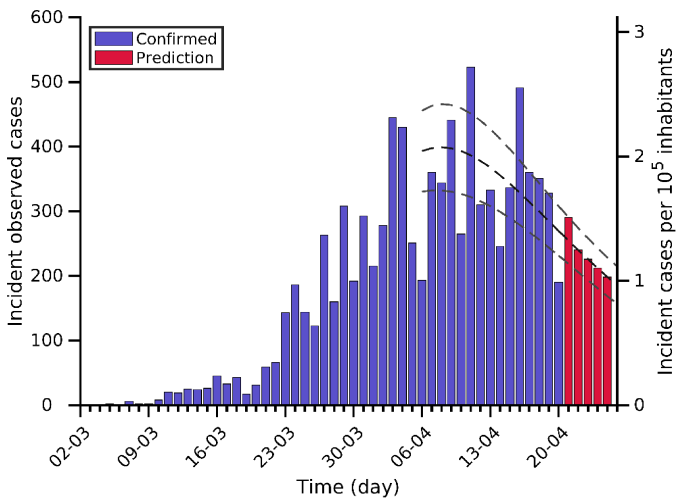
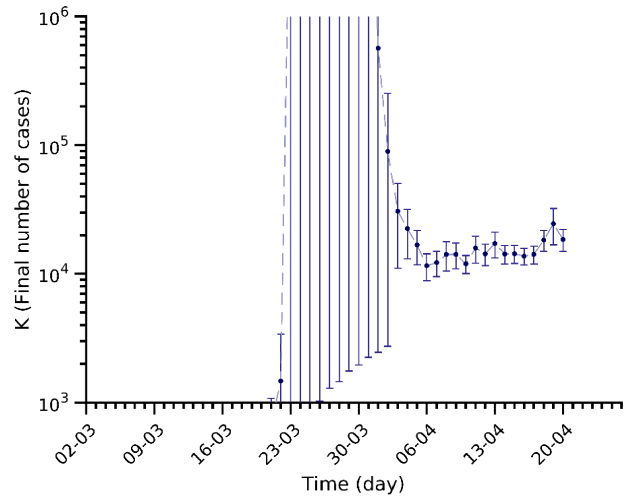
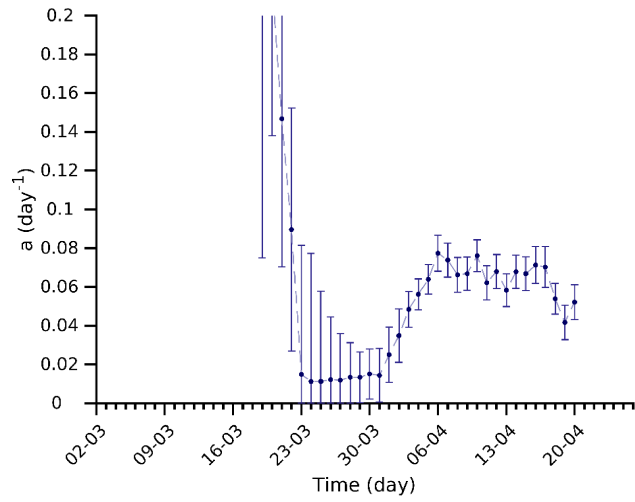
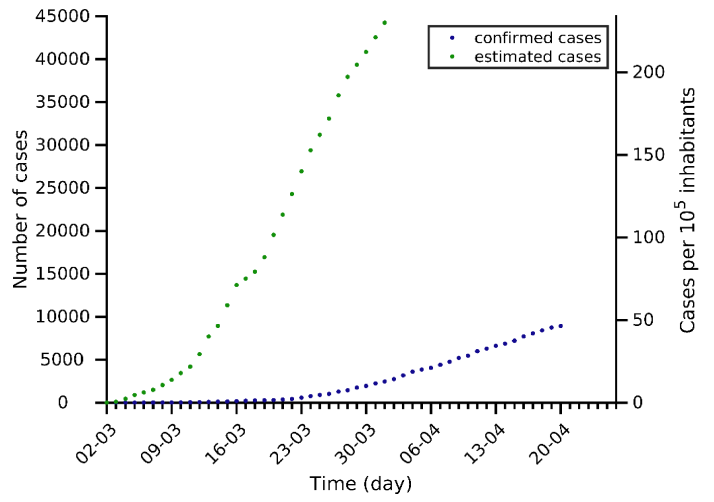
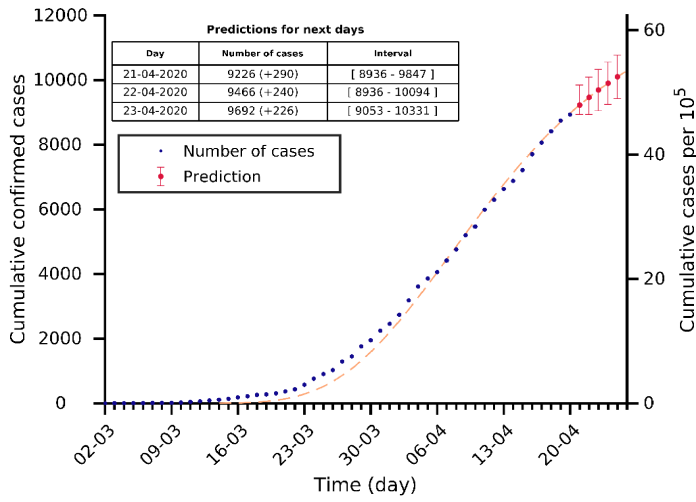
Sweden 20-04-2020. Population: 10.1M. Current cumulated incidence: 146/10⁵



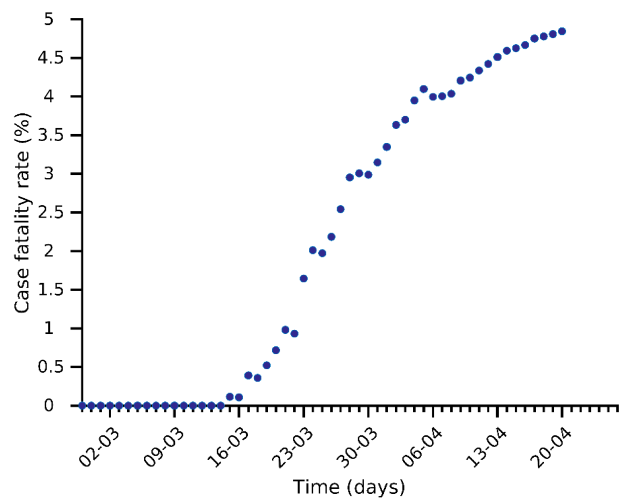
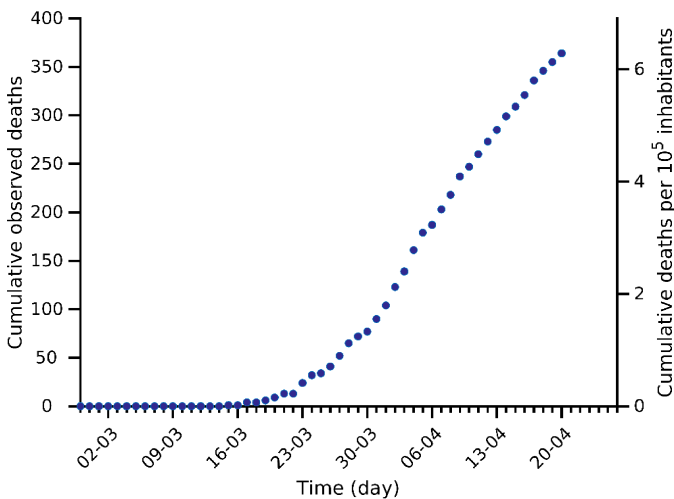
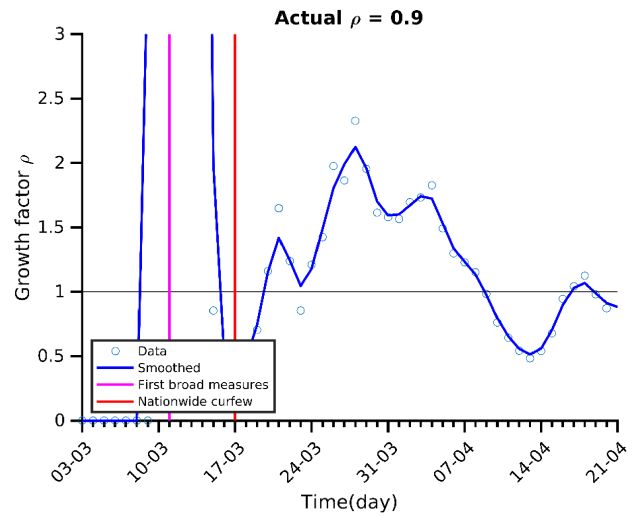
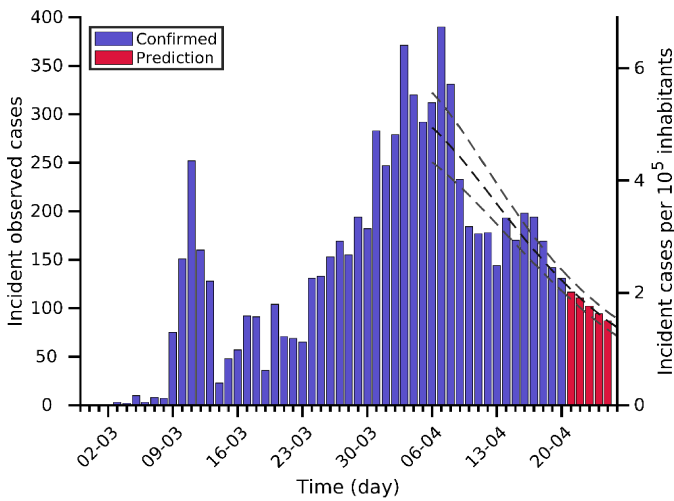
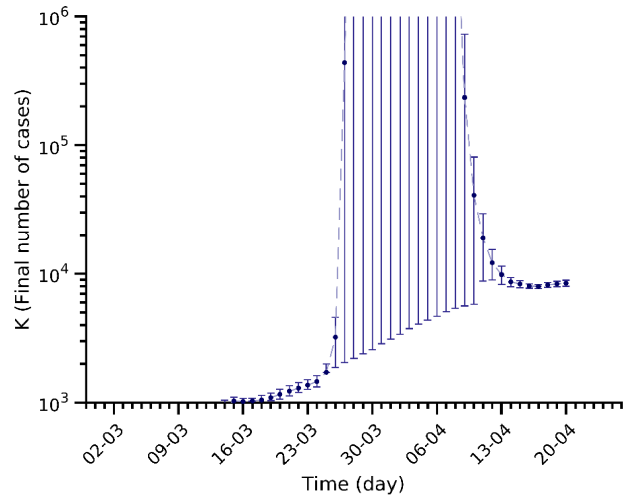
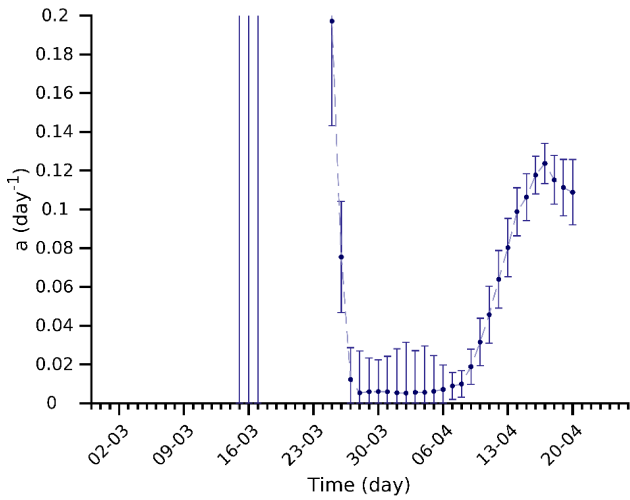
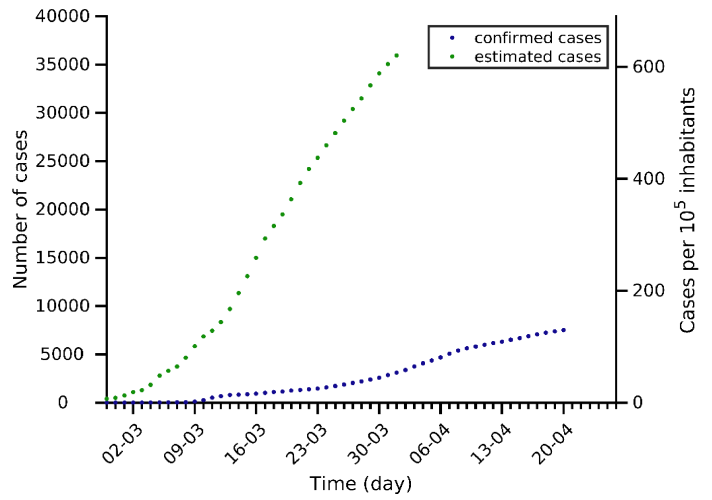
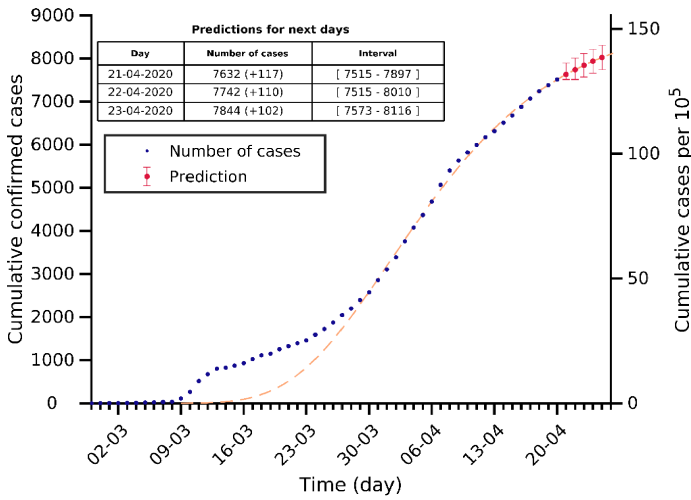
Poland 20-04-2020. Population: 37.8M. Current cumulated incidence: 25/10⁵



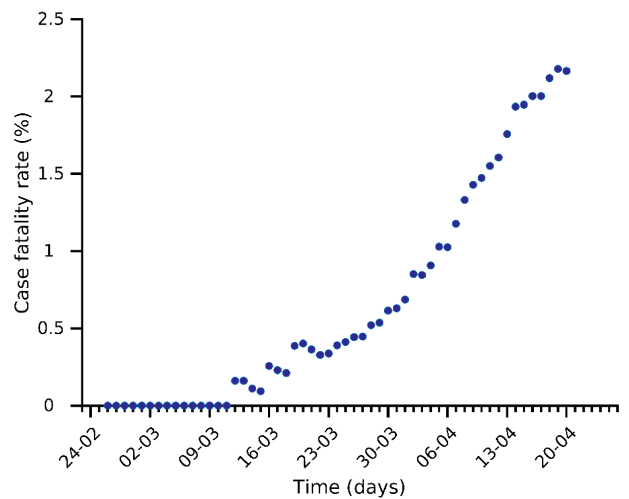
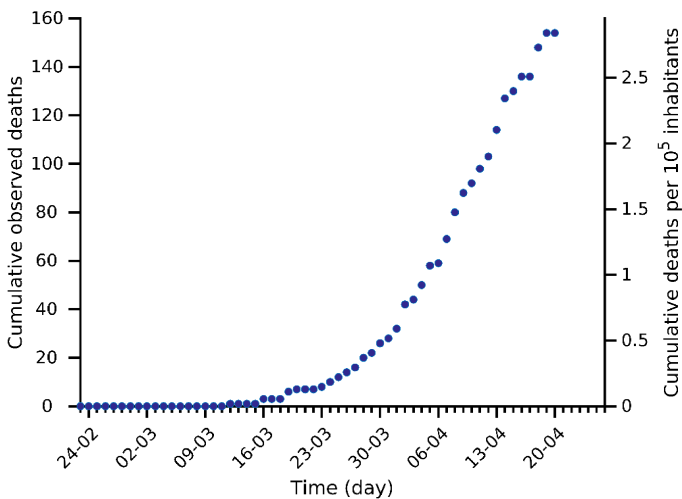
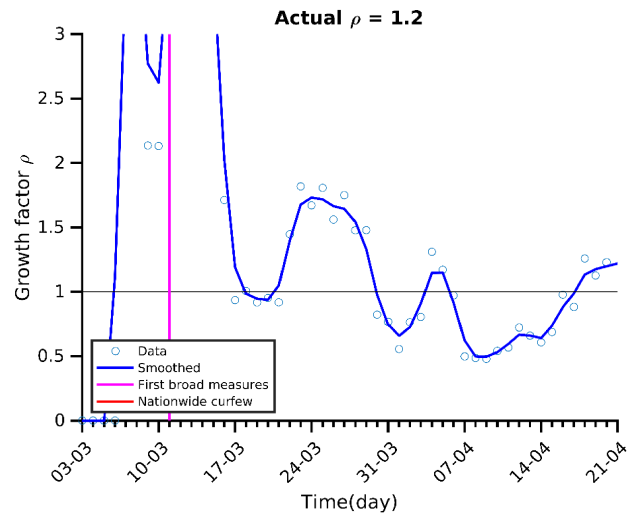
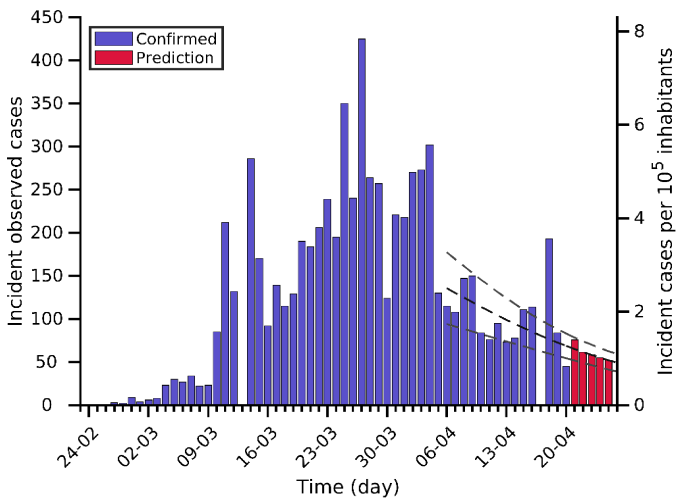
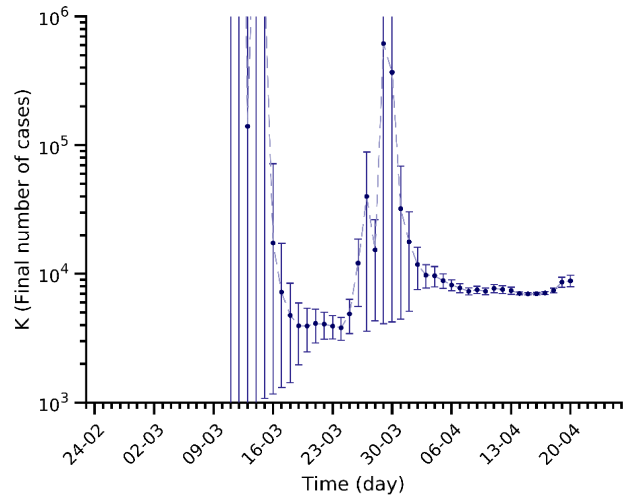
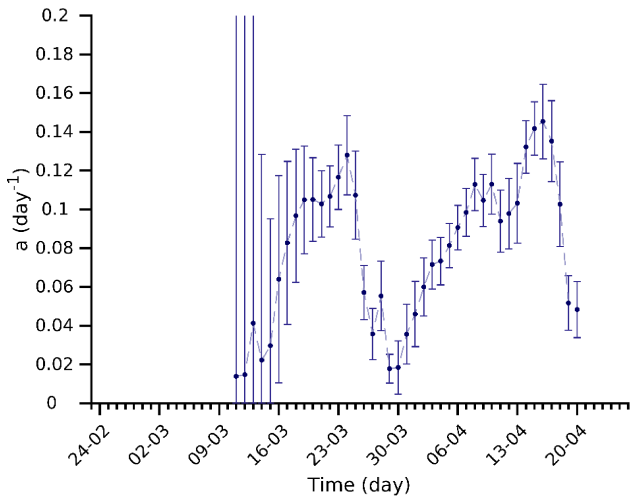
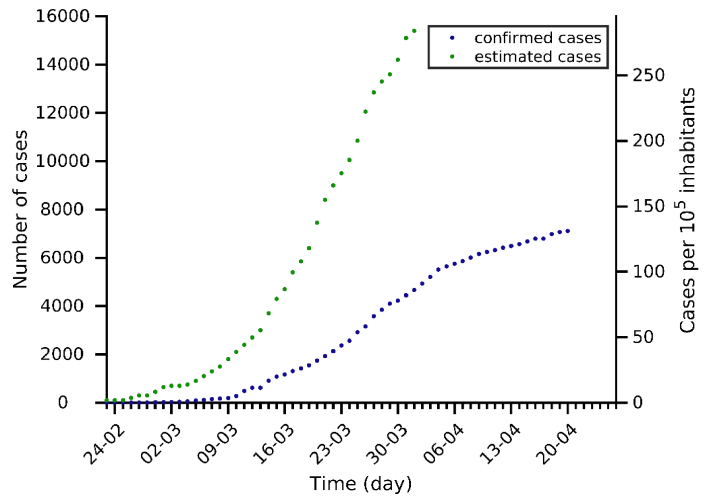
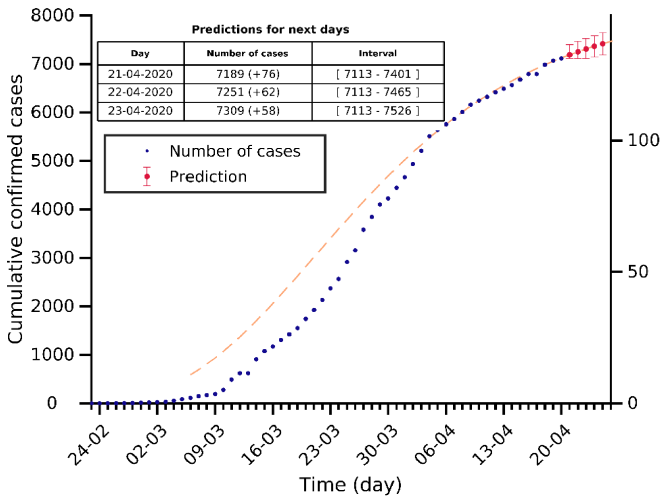
Romania 20-04-2020. Population: 19.2M. Current cumulated incidence: 46/10⁵



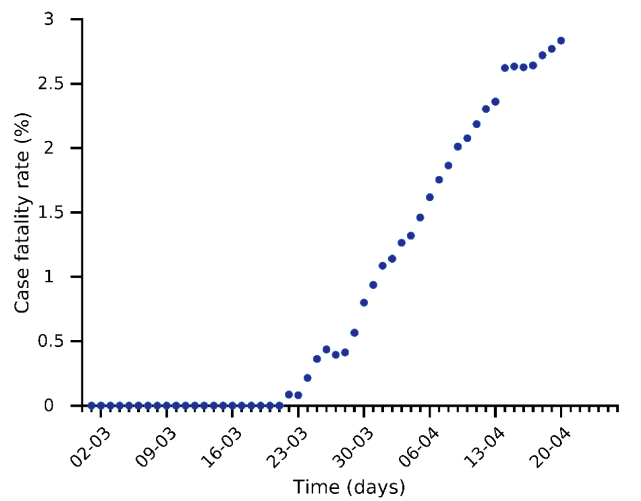
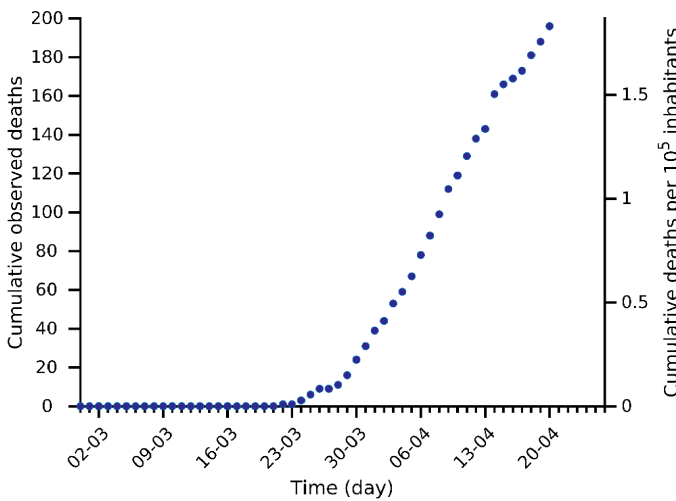
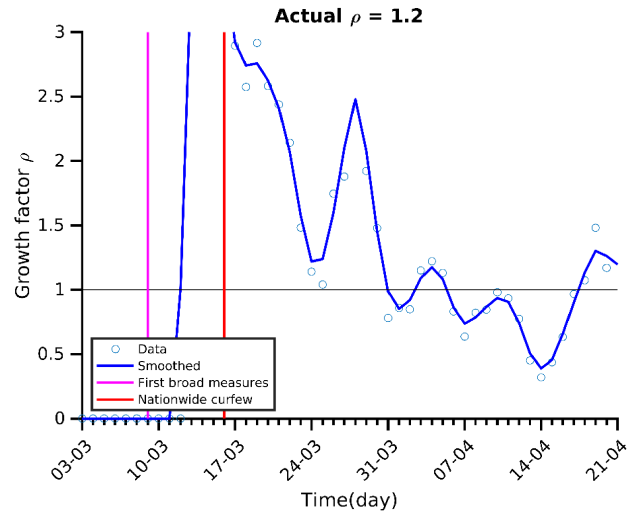
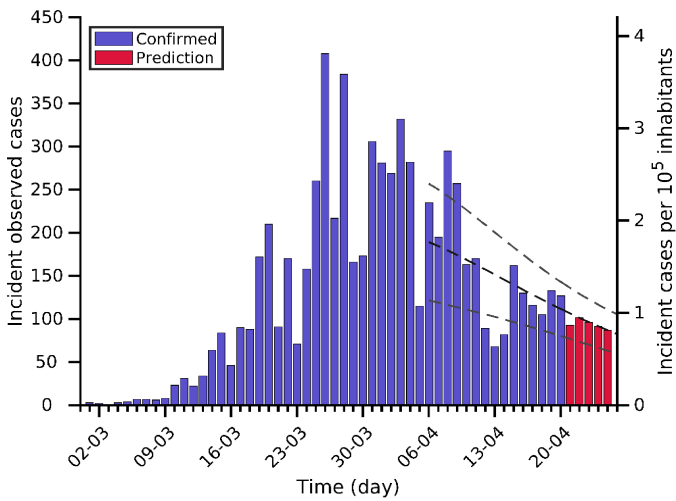
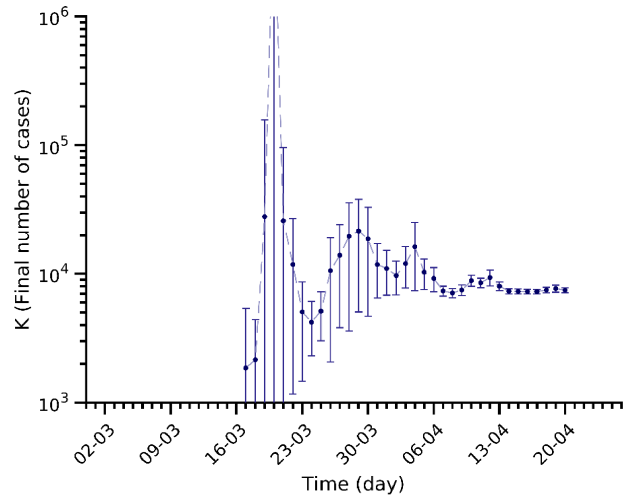
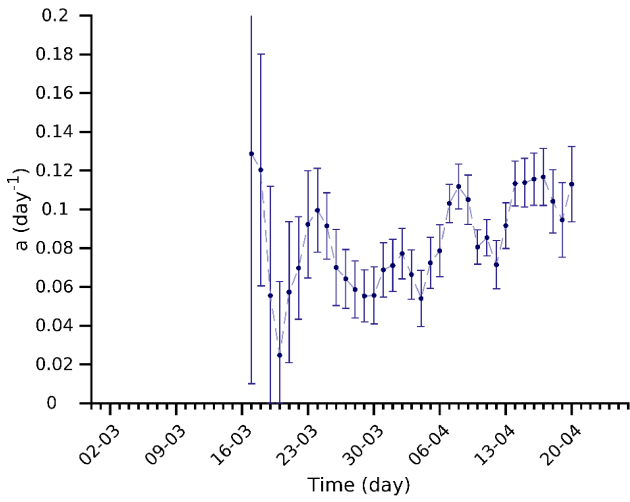
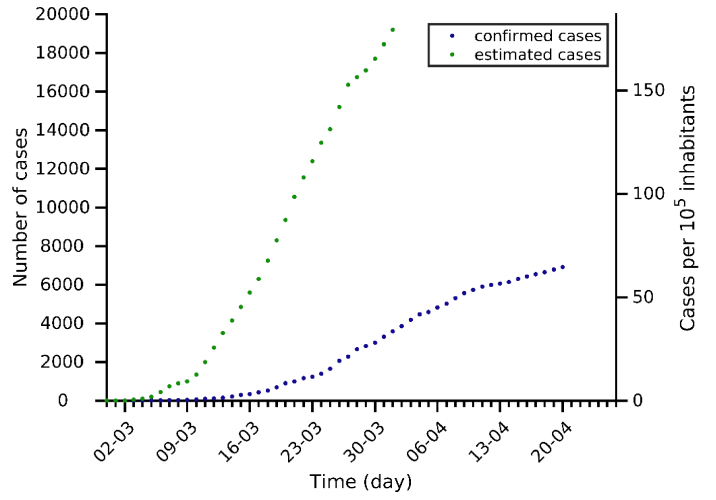
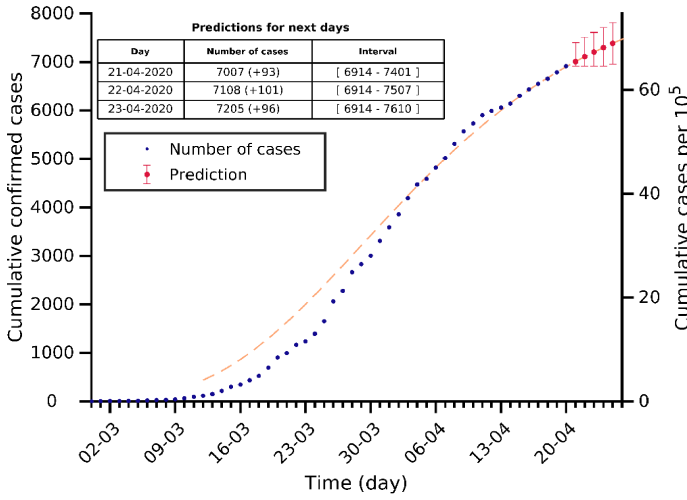
Denmark 20-04-2020. Population: 5.8M. Current cumulated incidence: 130/10⁵



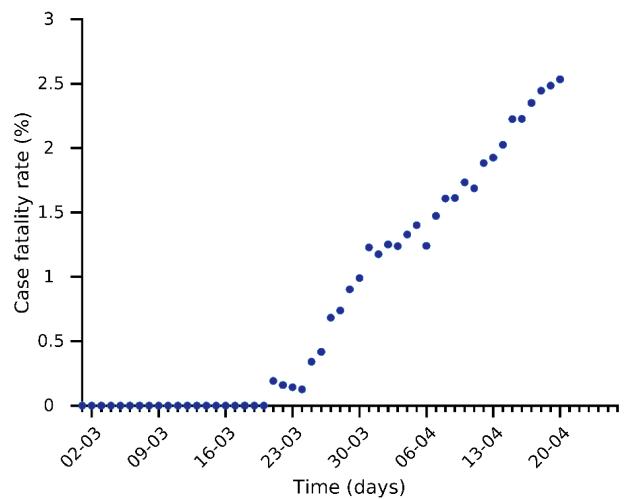
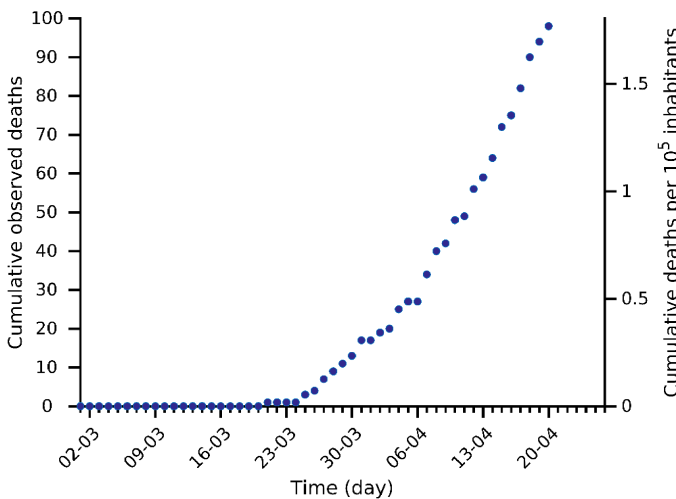
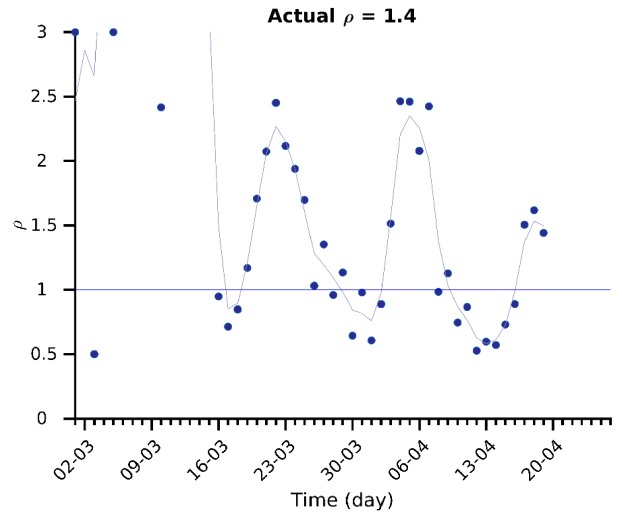
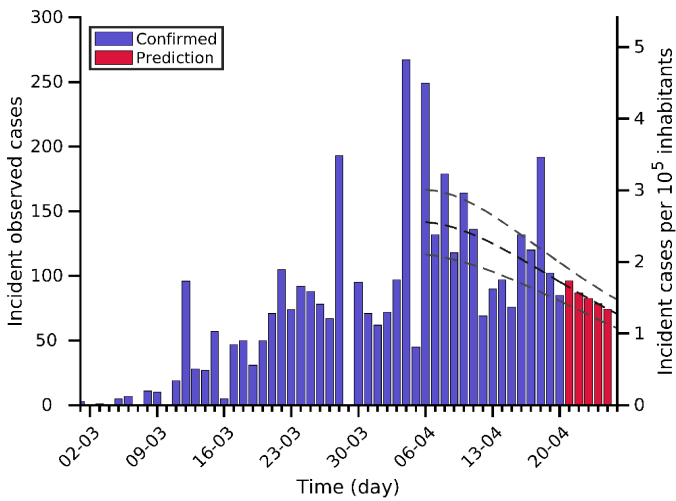
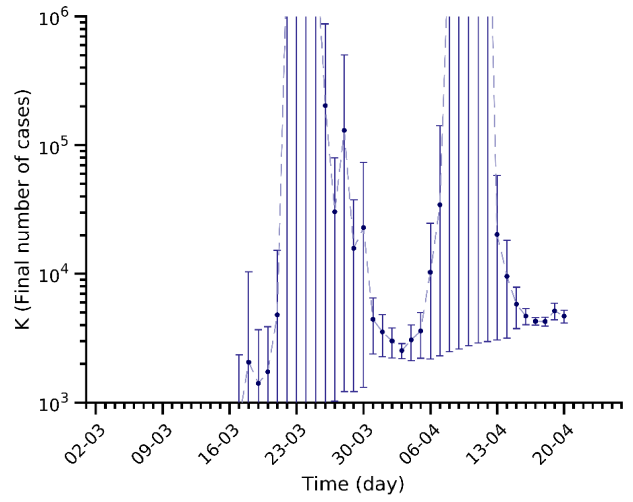
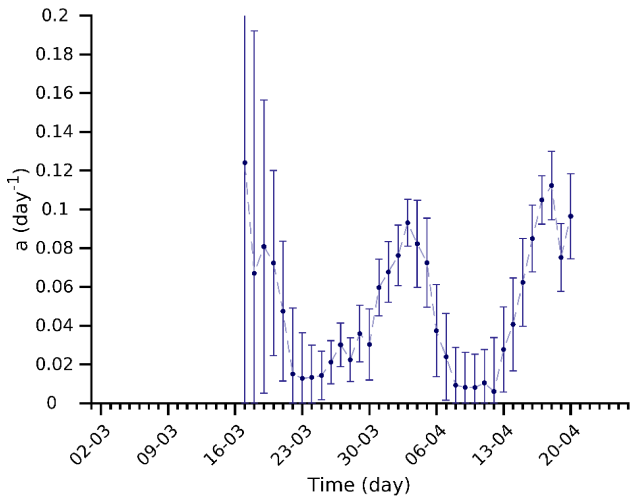
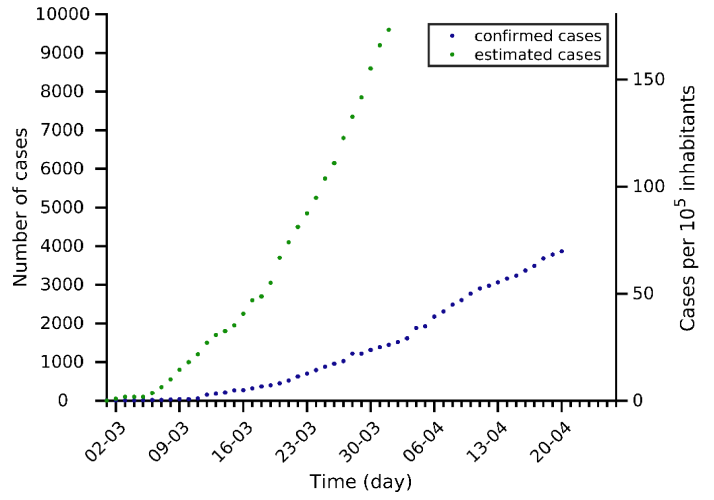
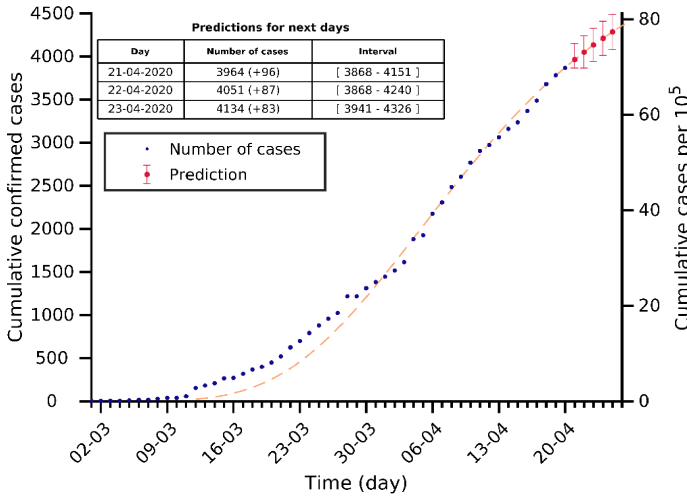
Norway 20-04-2020. Population: 5.4M. Current cumulated incidence: 131/10⁵



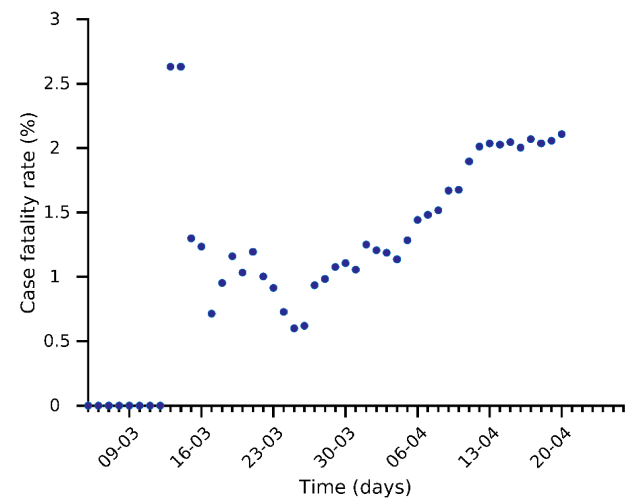
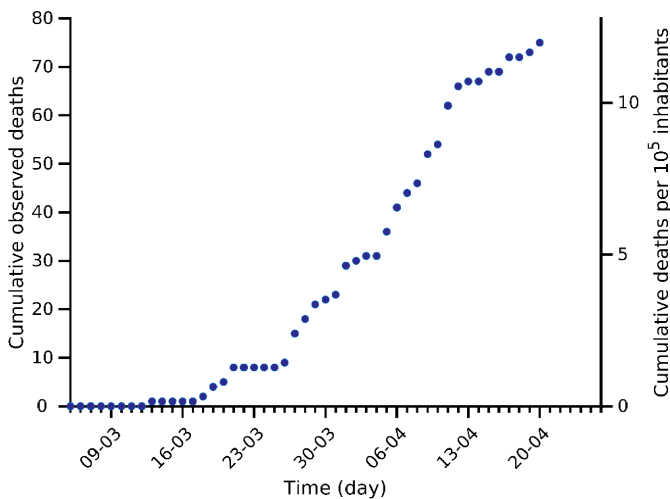
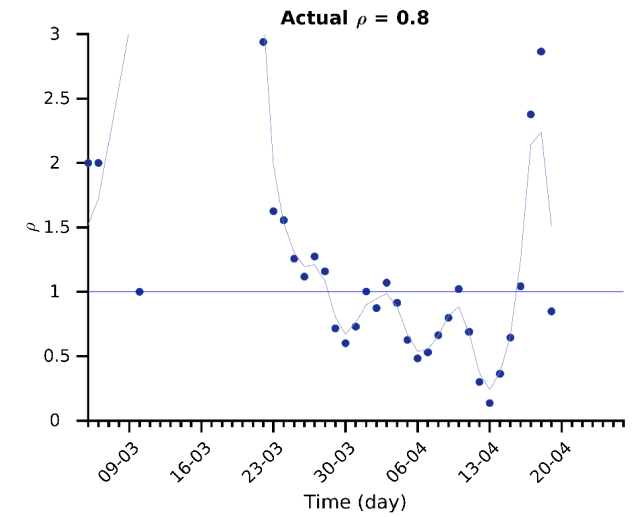
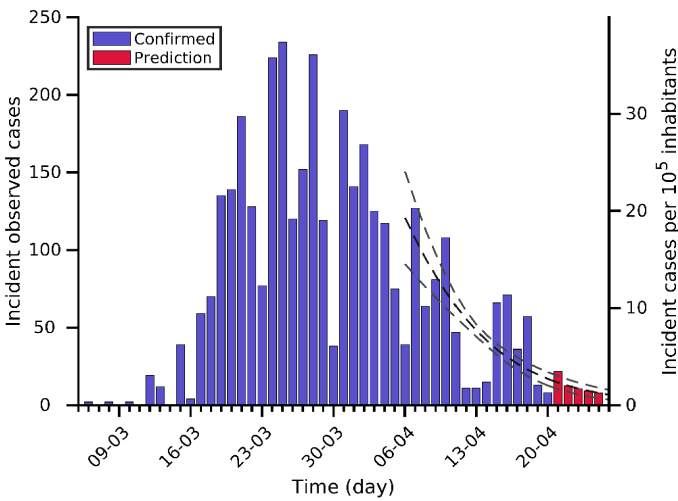
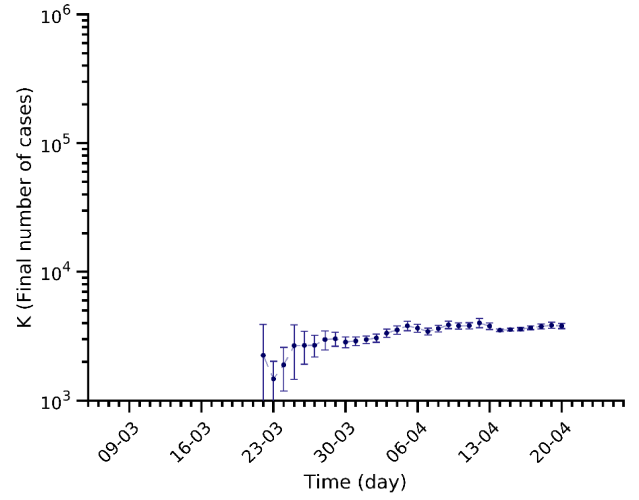
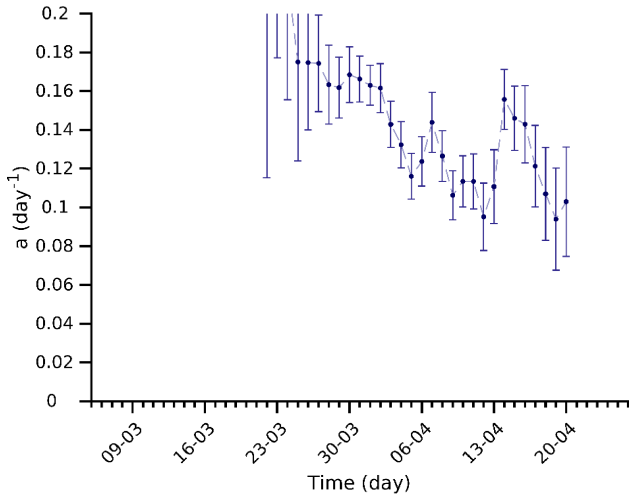
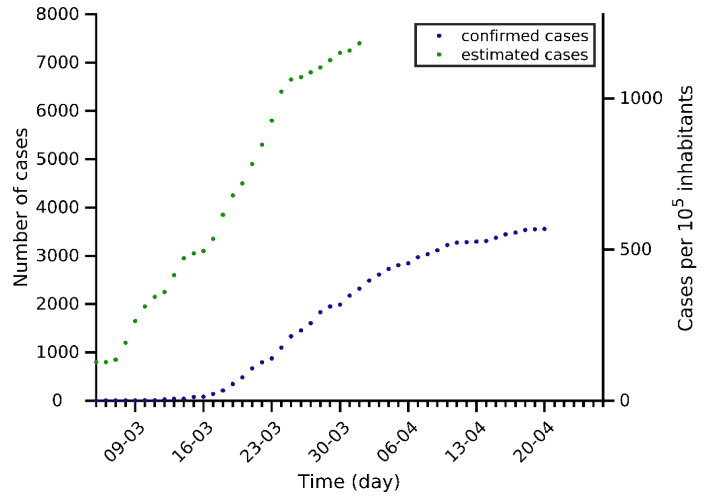
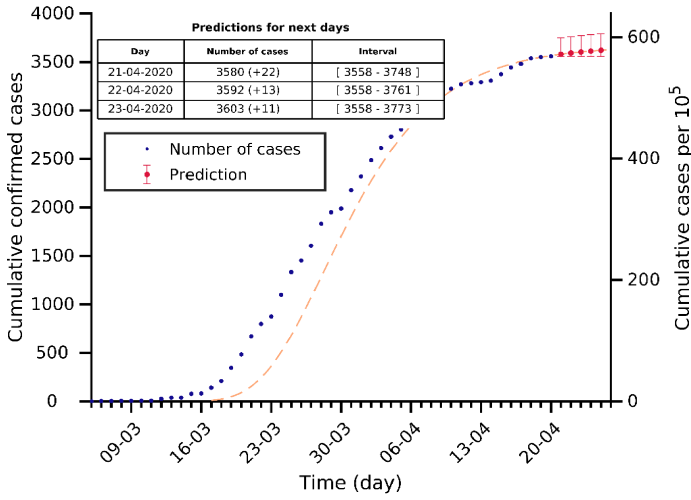
Czech Rep 20-04-2020. Population: 10.7M. Current cumulated incidence: 65/10⁵



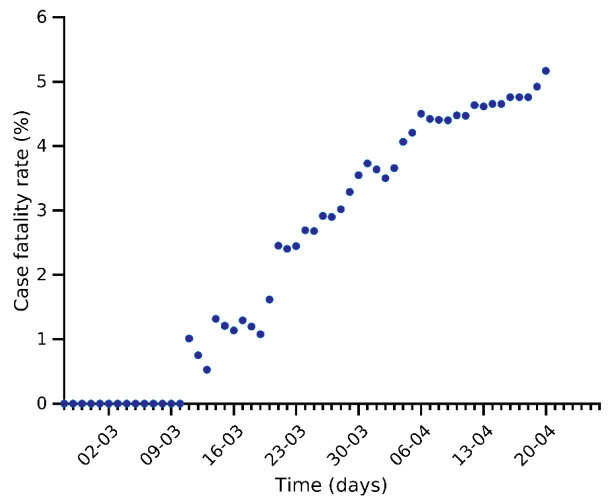
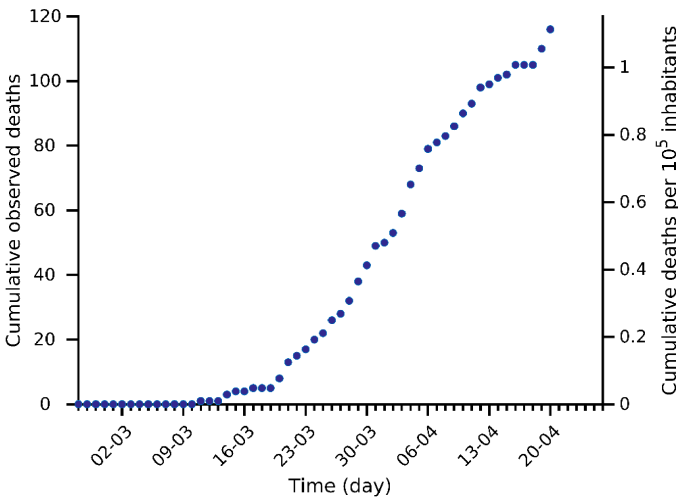
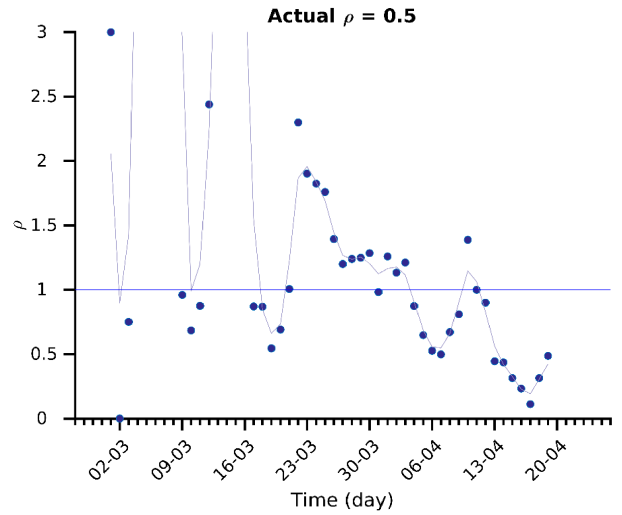
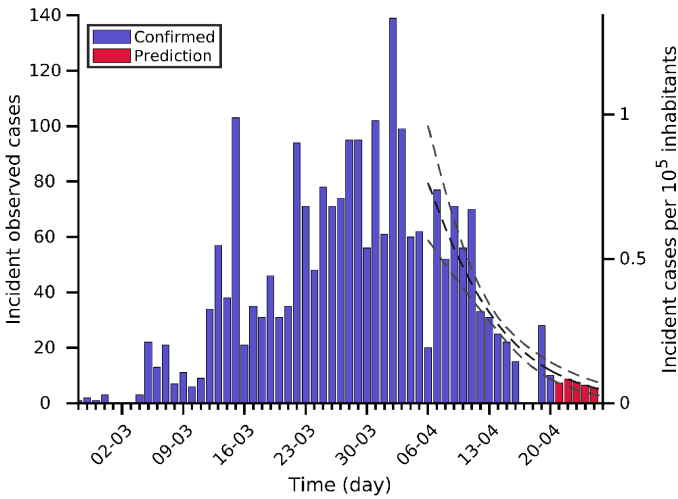
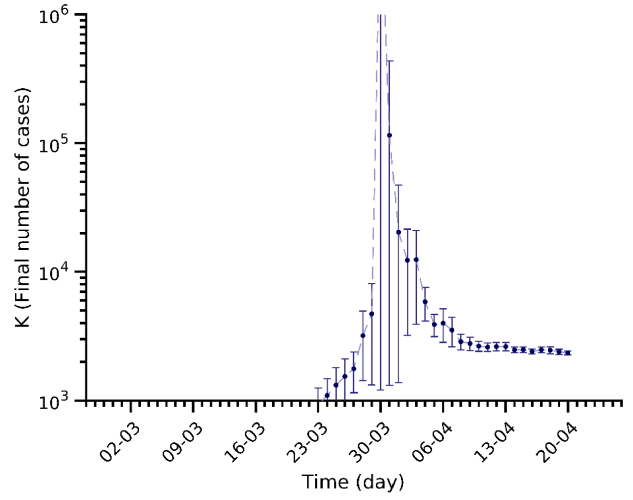
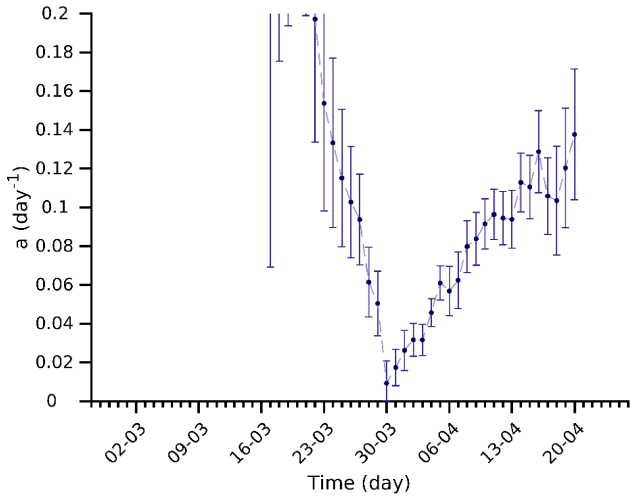
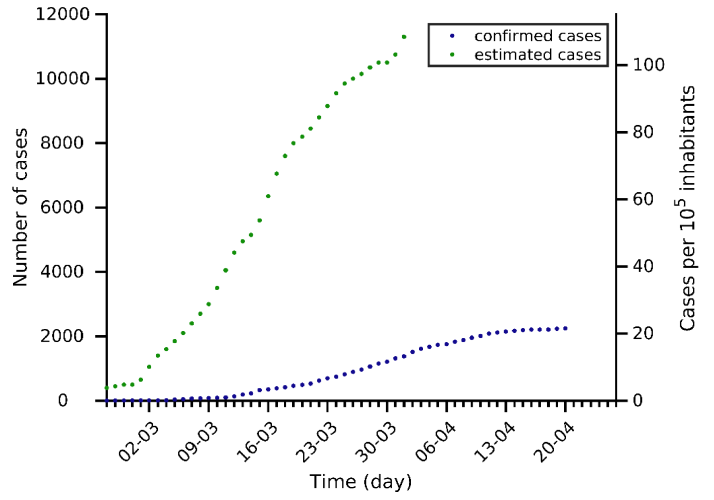
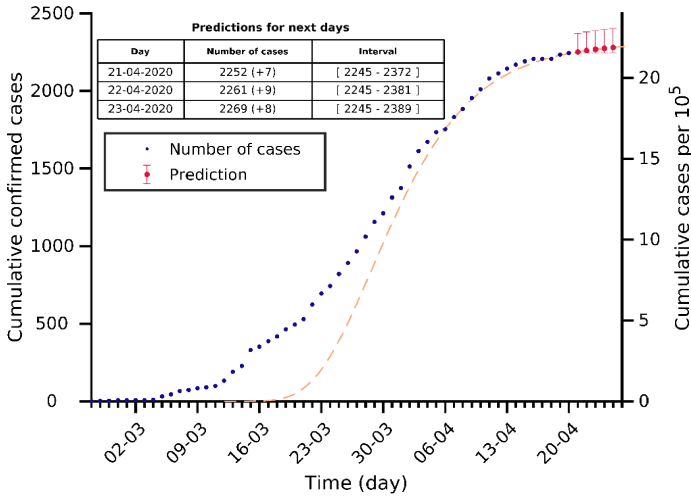
Finland 20-04-2020. Population: 5.5M. Current cumulated incidence: 70/10⁵



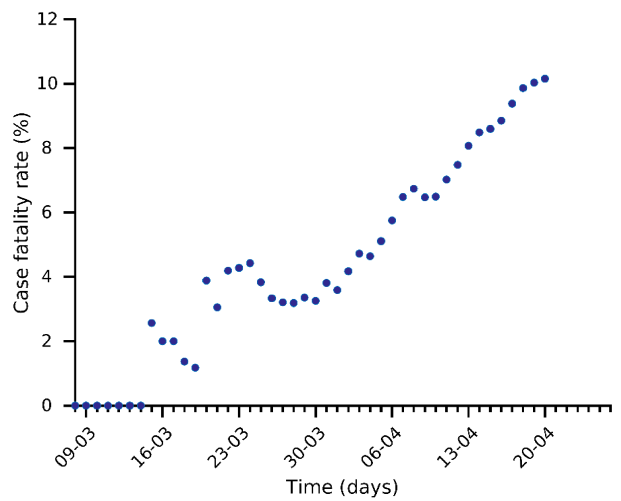
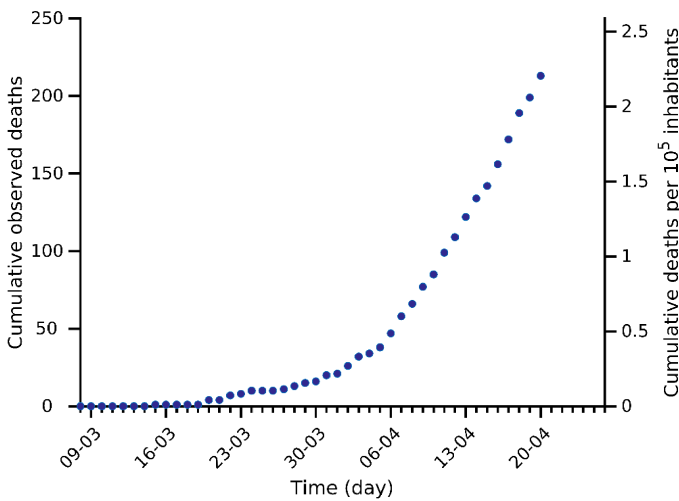
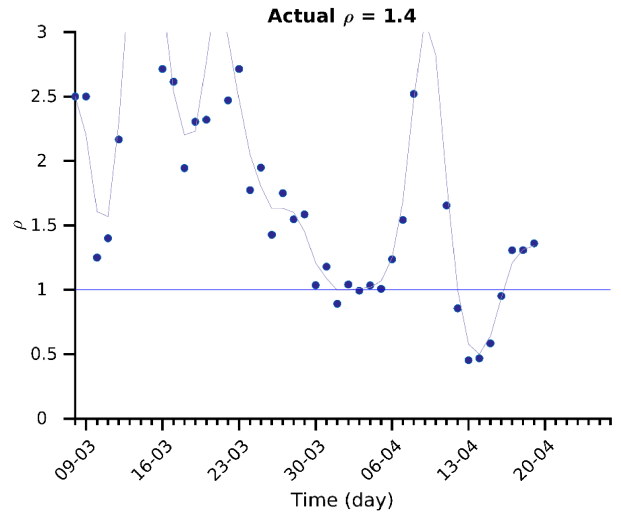
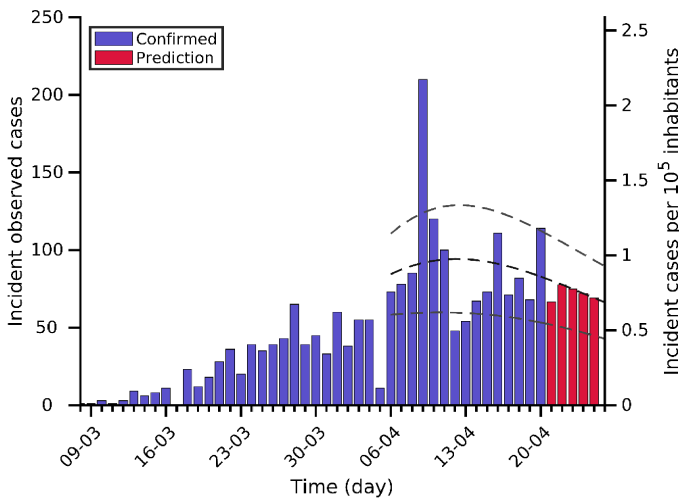
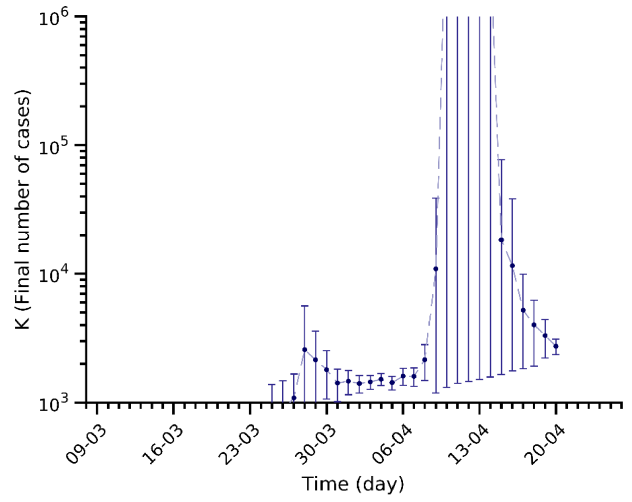
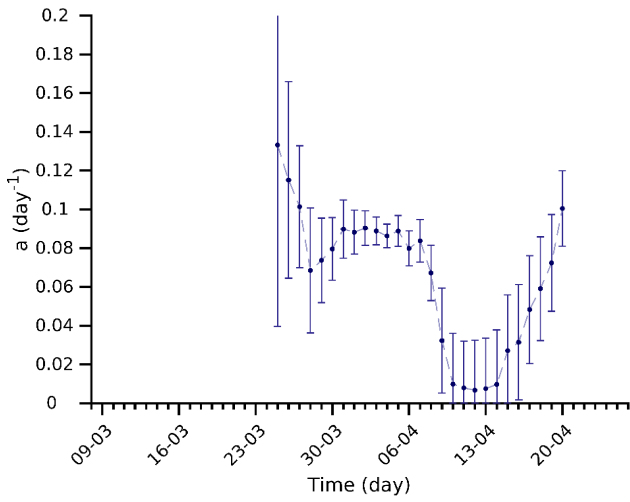
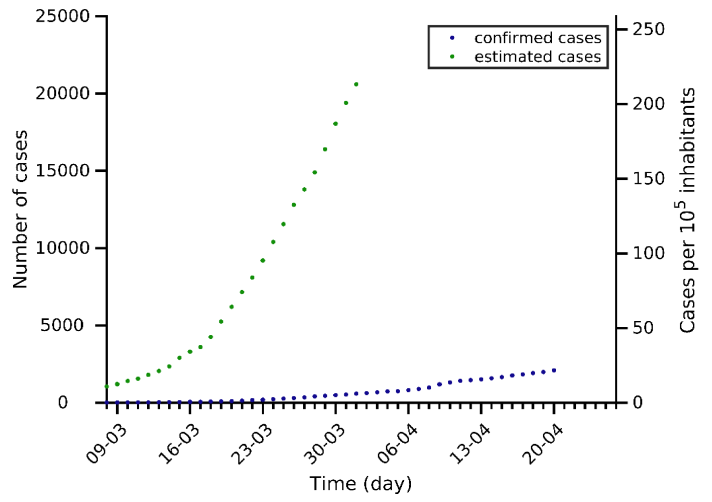
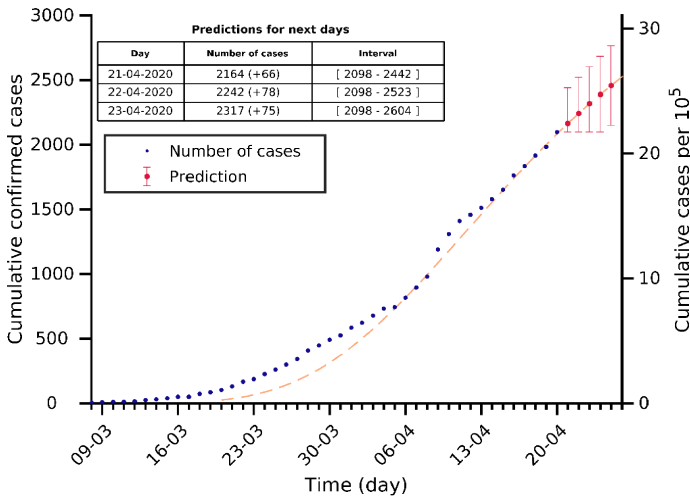
Luxembourg 20-04-2020. Population: 0.6M. Current cumulated incidence: 568/10⁵



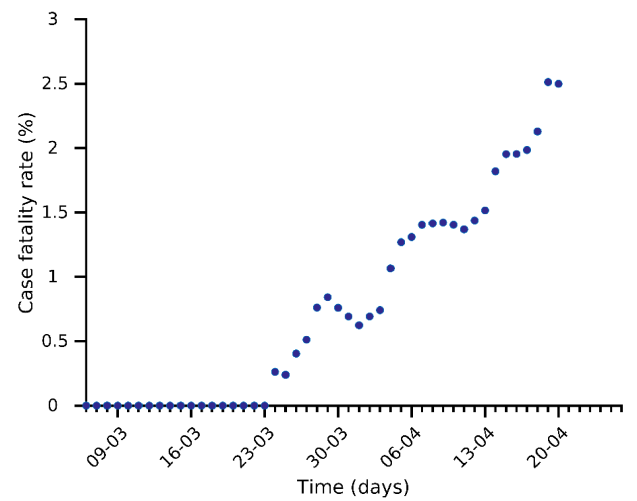
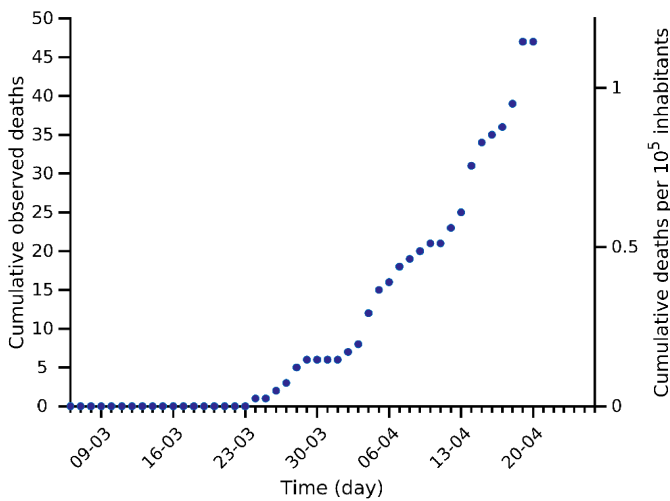
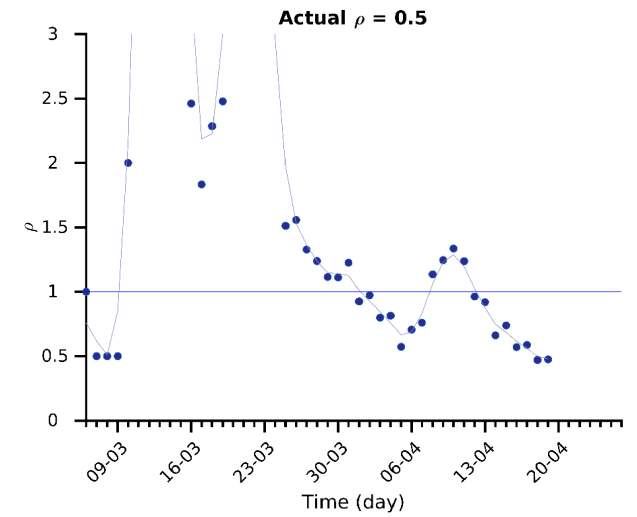
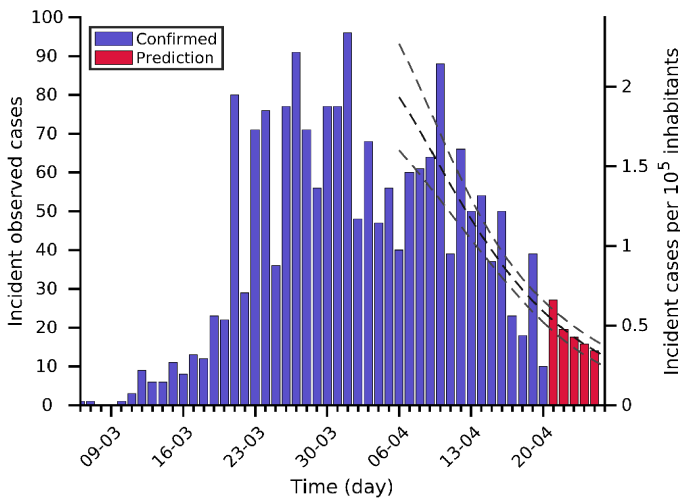
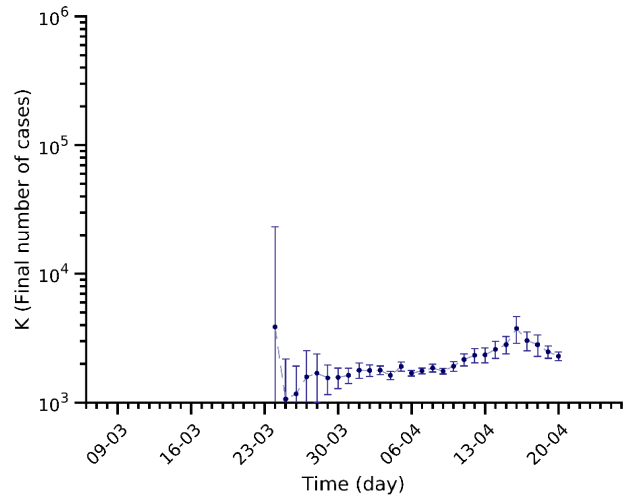
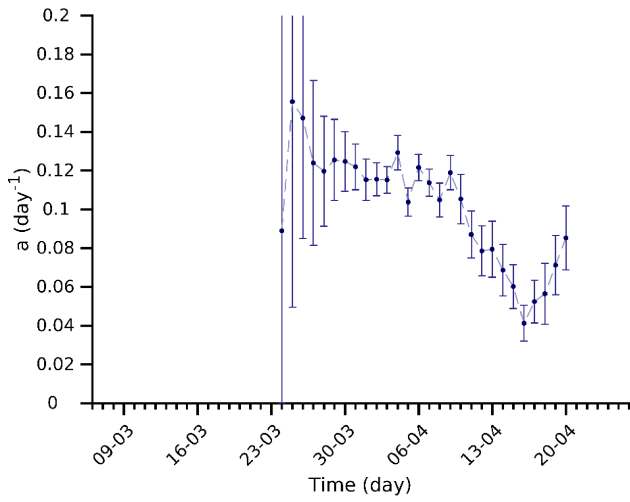
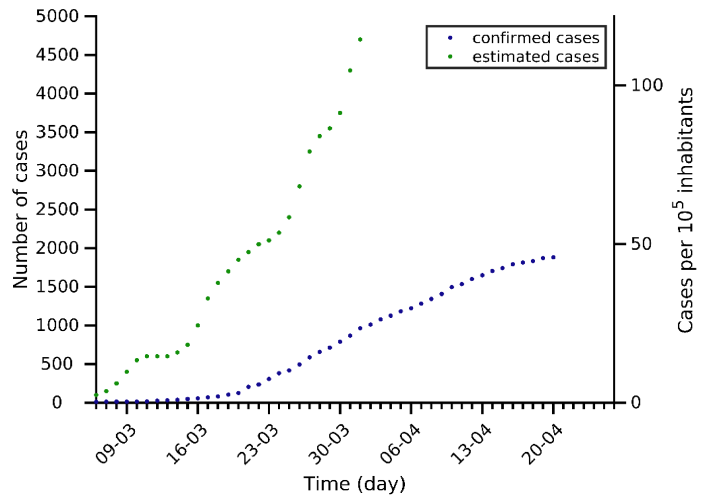
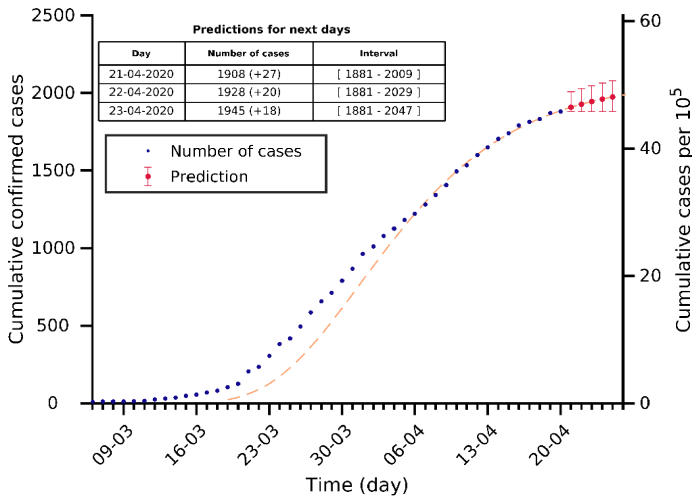
Greece 20-04-2020. Population: 10.4M. Current cumulated incidence: 22/10⁵



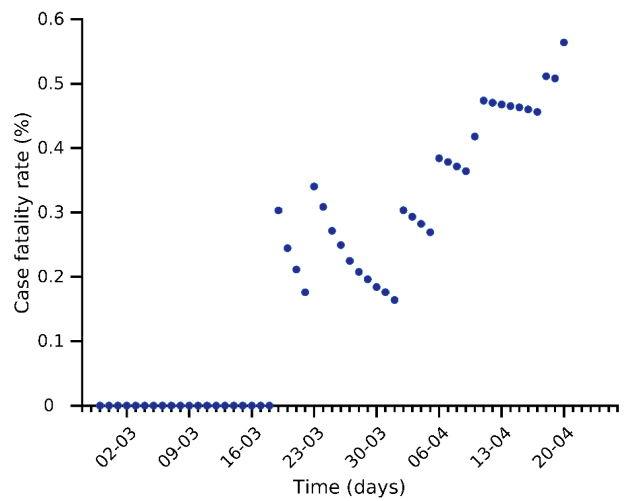
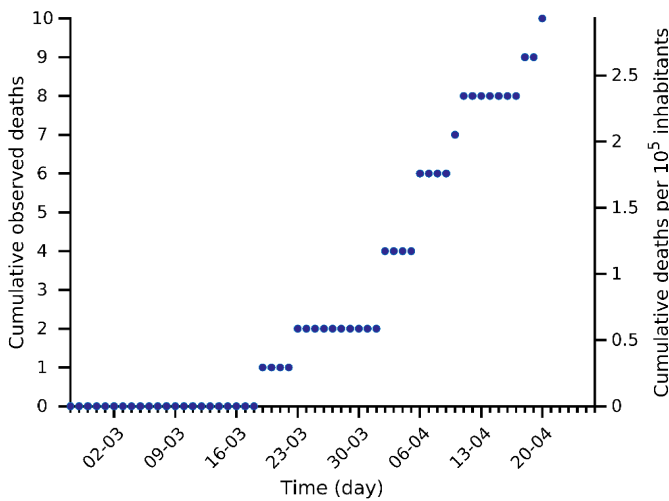
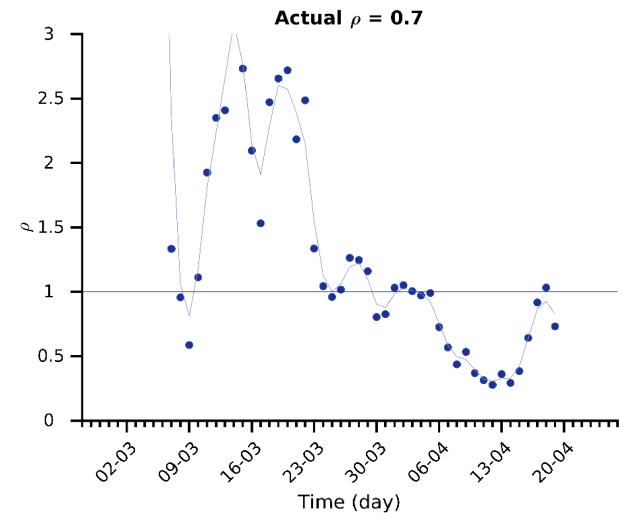
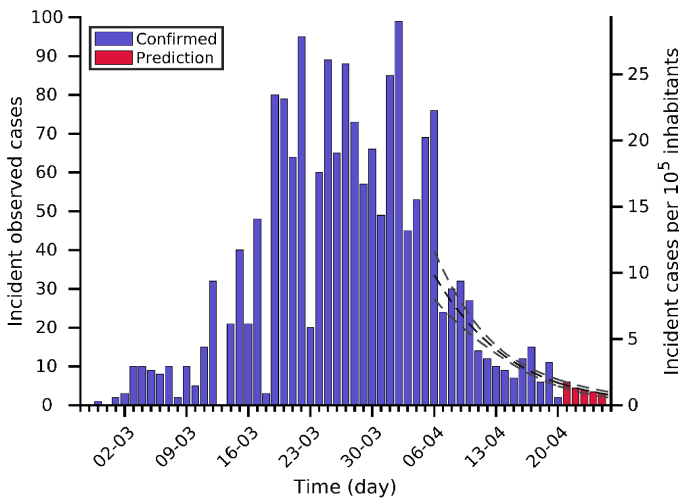
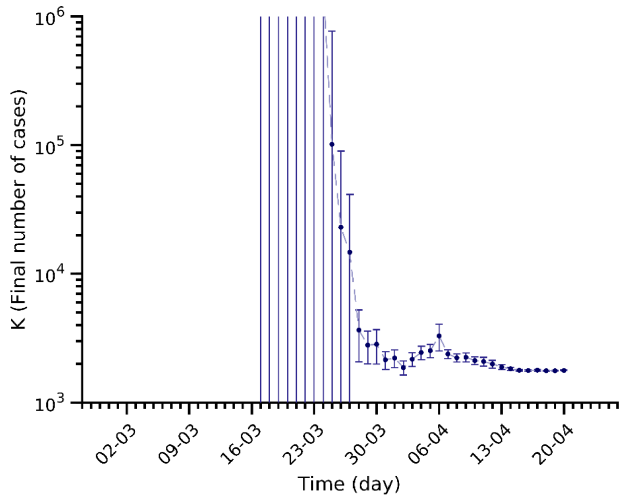
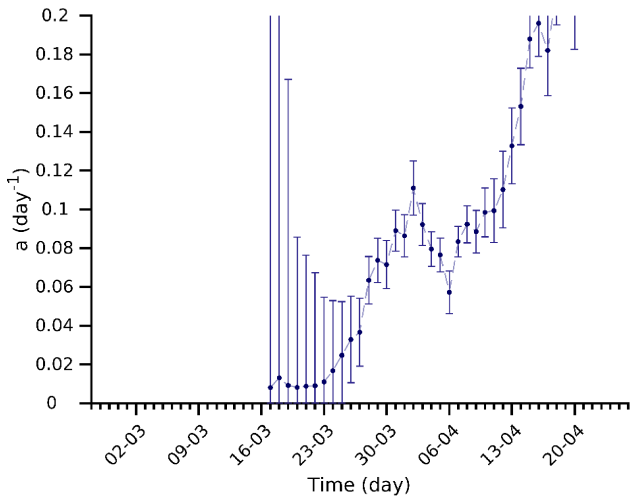
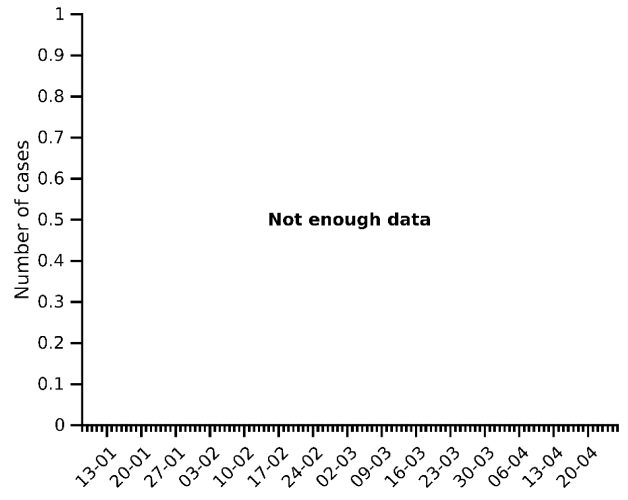
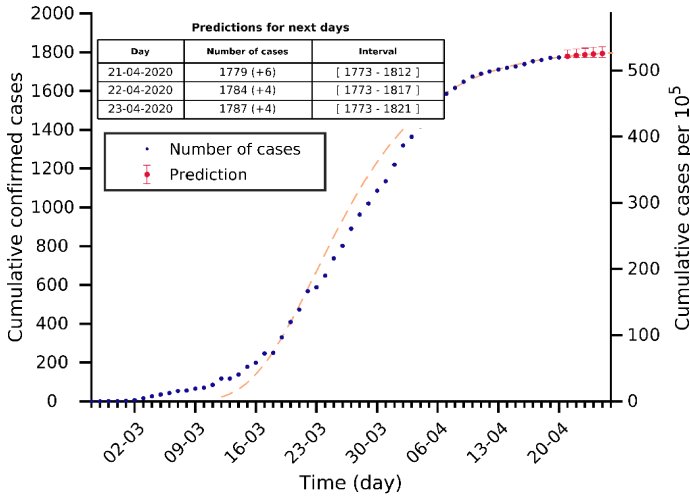
Hungary 20-04-2020. Population: 9.7M. Current cumulated incidence: 22/10⁵



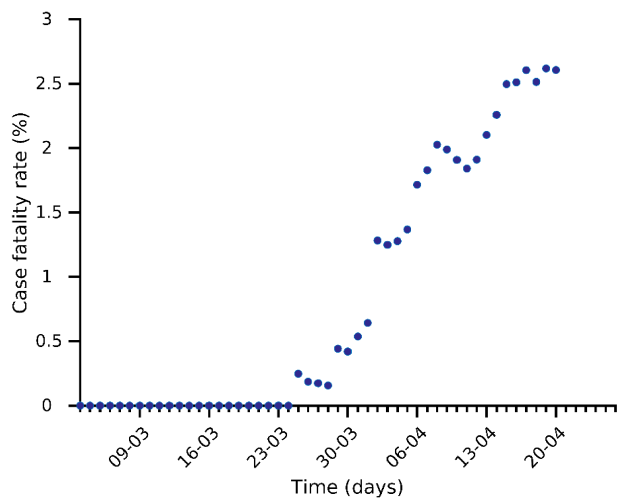
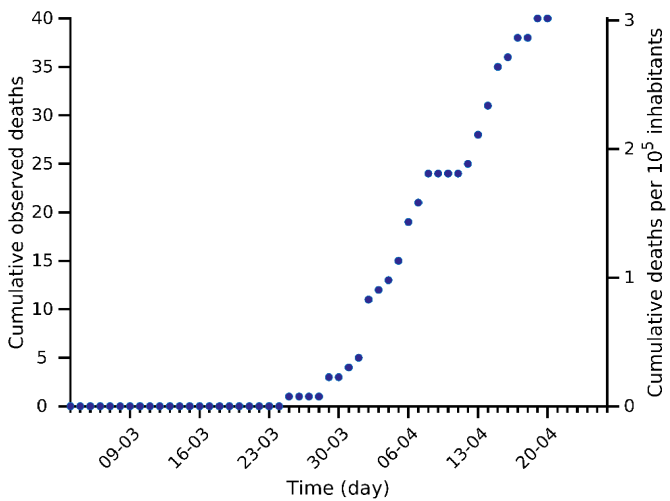
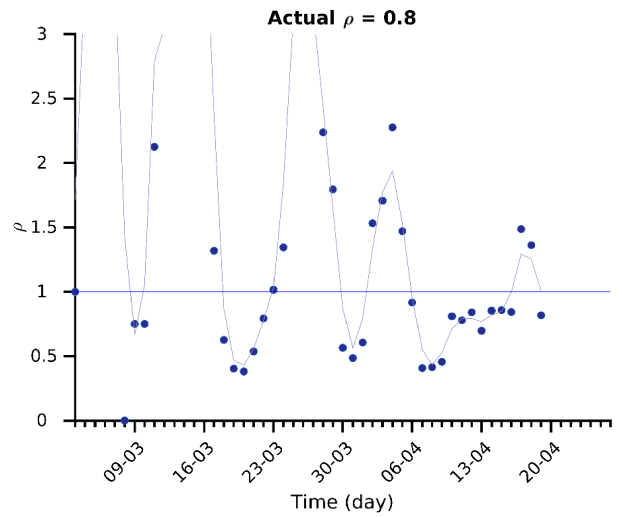
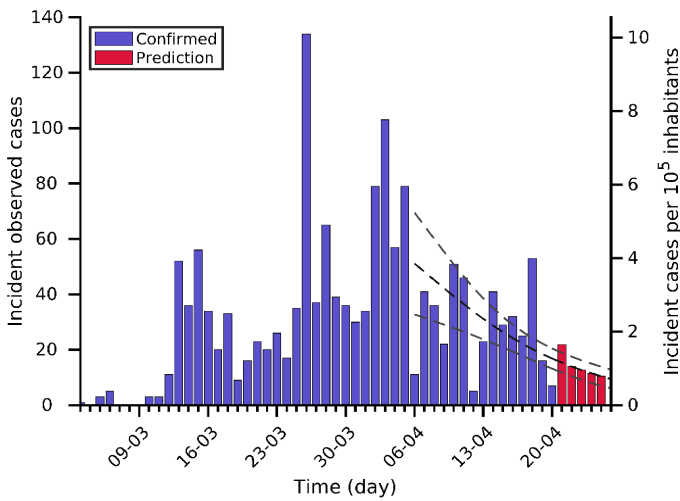
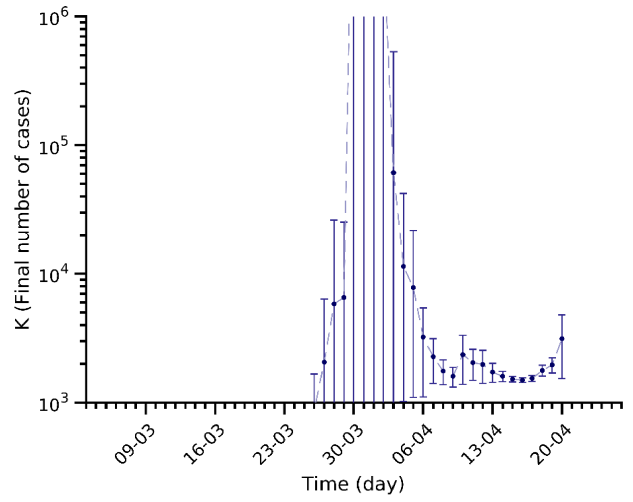
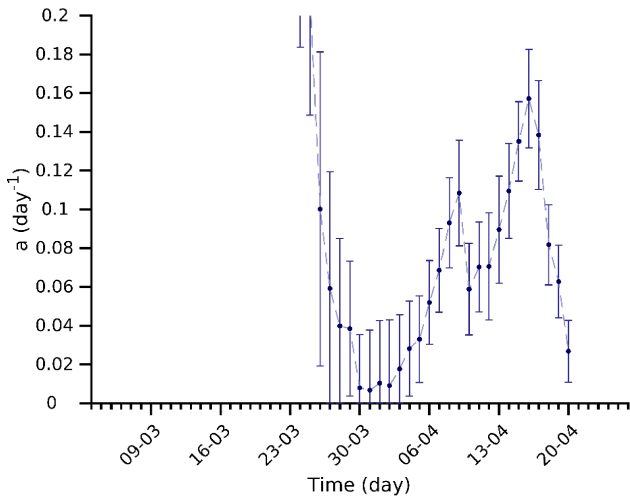
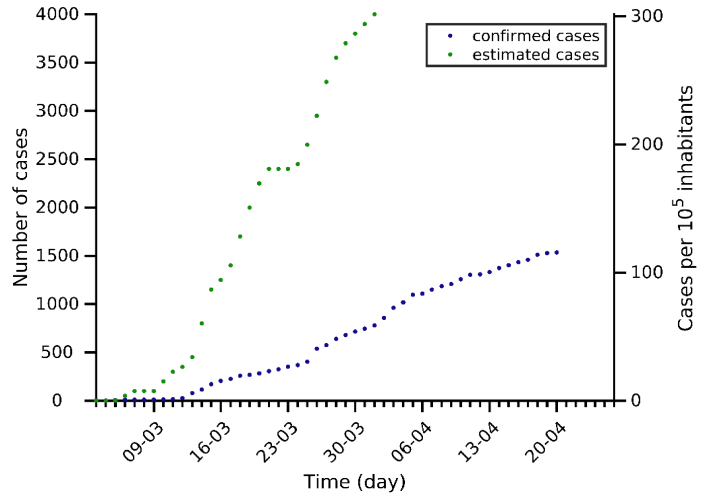
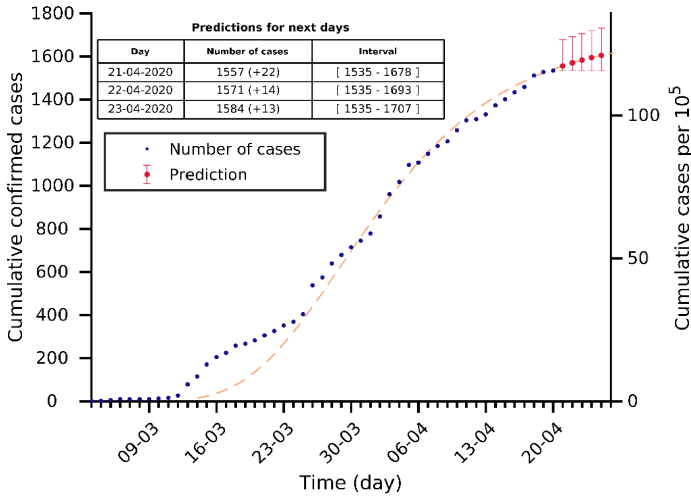
Croatia 20-04-2020. Population: 4.1M. Current cumulated incidence: 46/10⁵



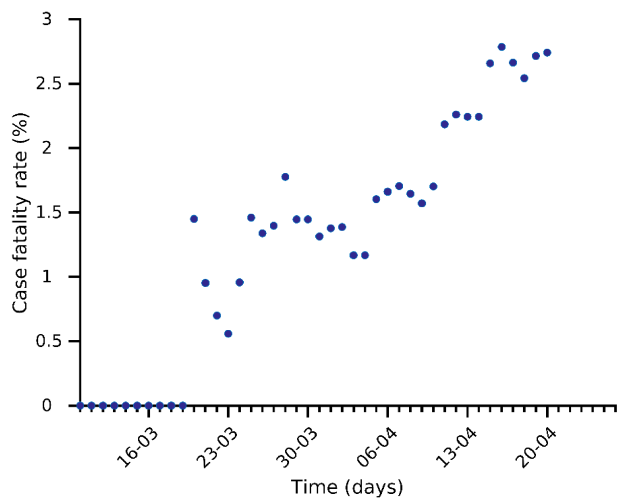
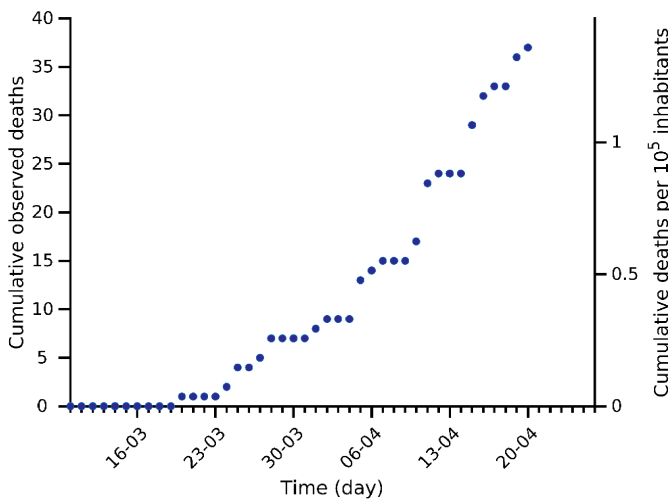
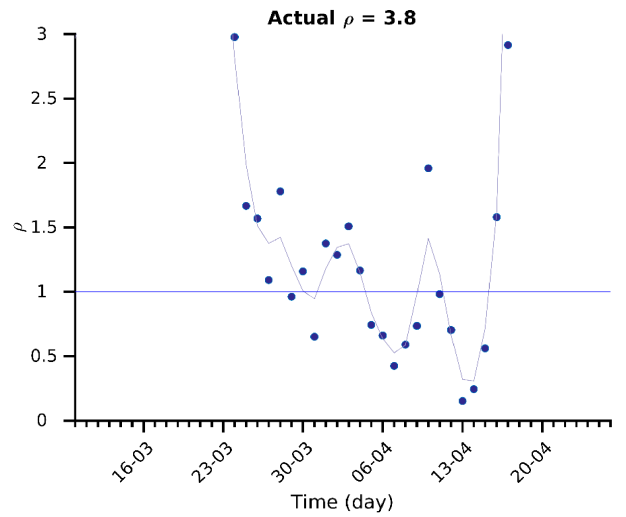
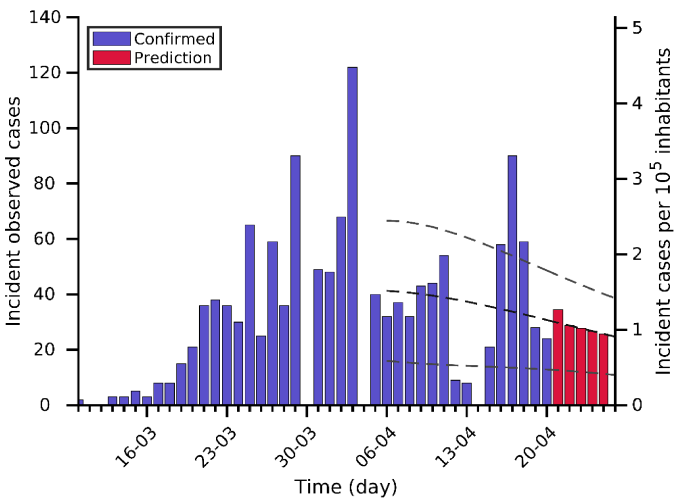
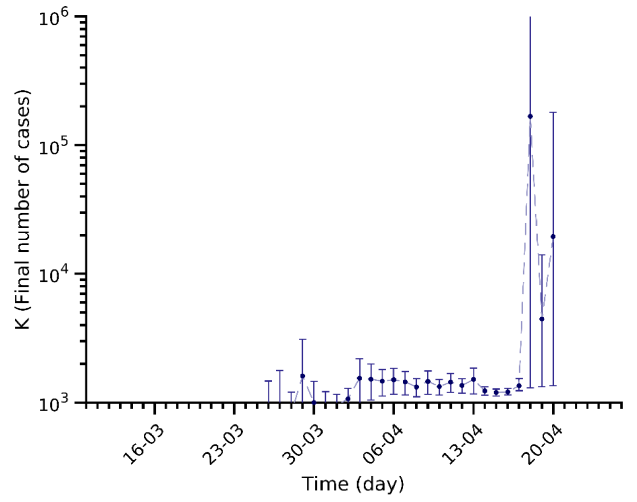
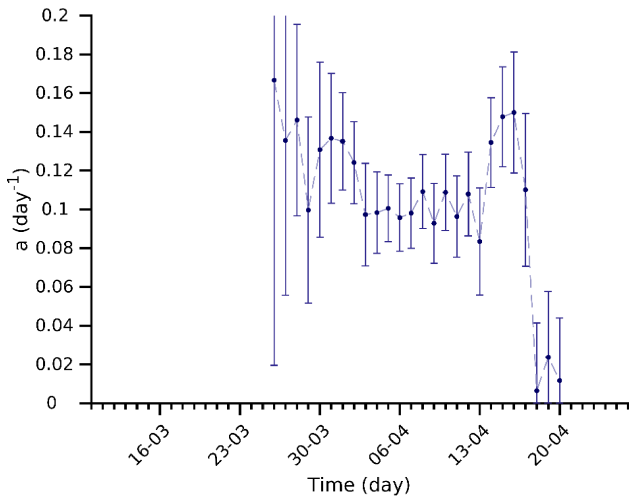
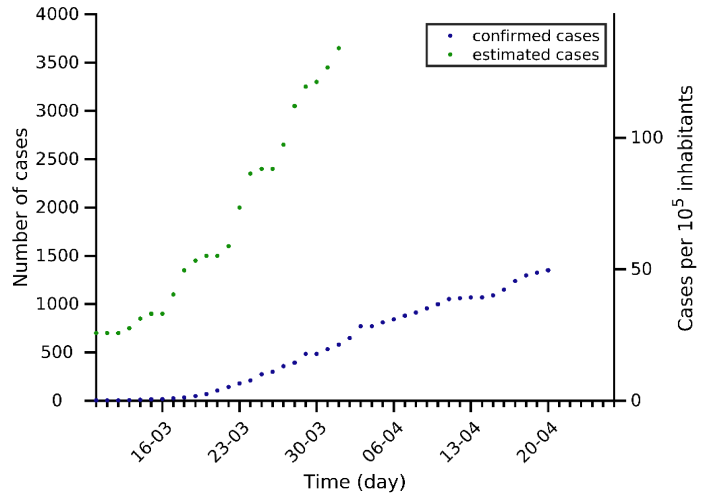
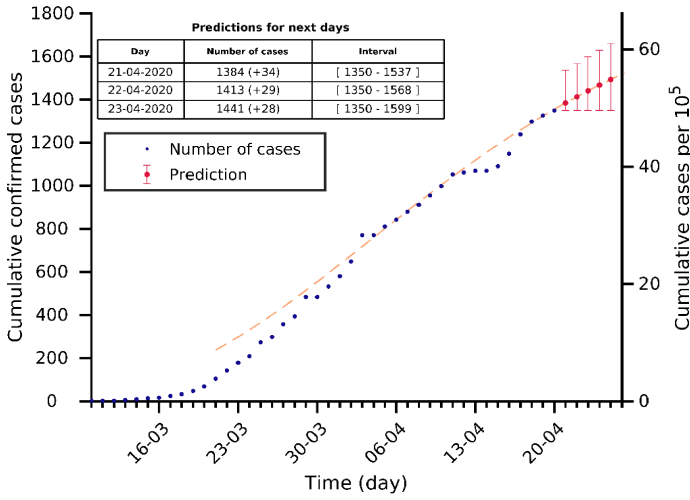
Iceland 20-04-2020. Population: 0.3M. Current cumulated incidence: 520/10⁵



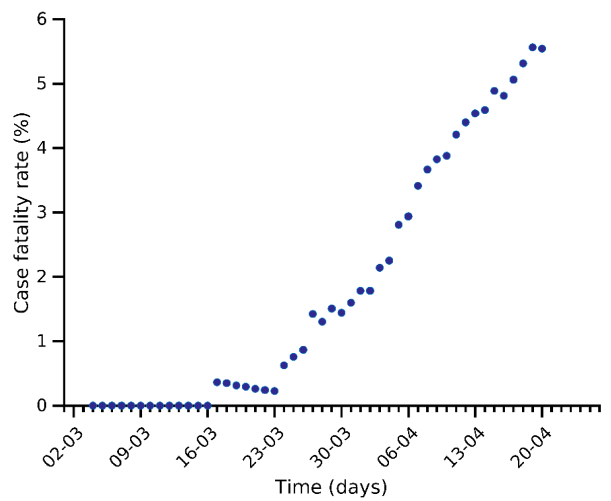
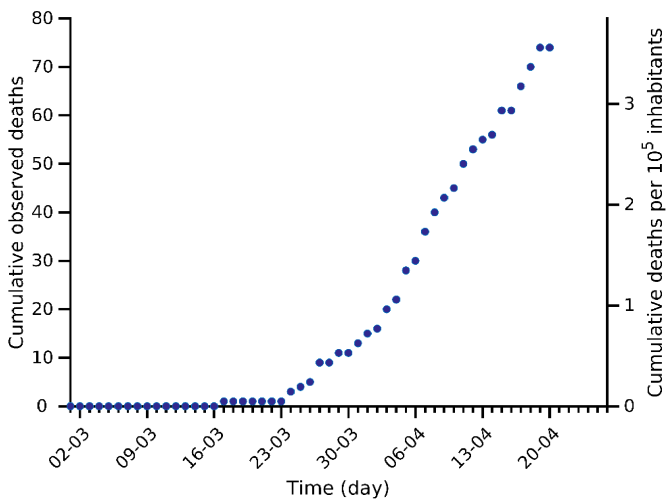
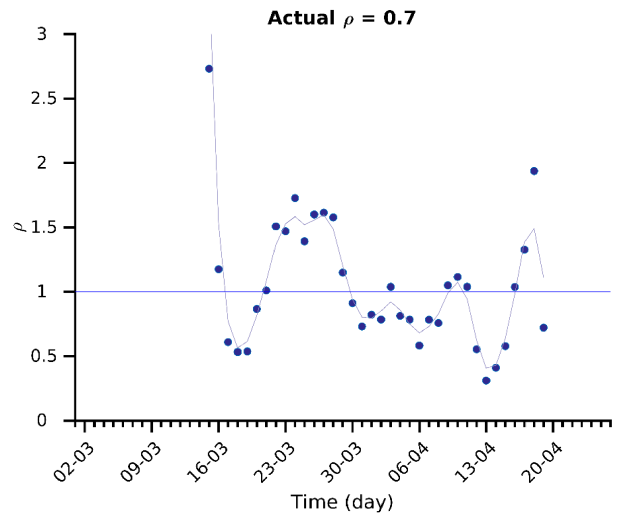
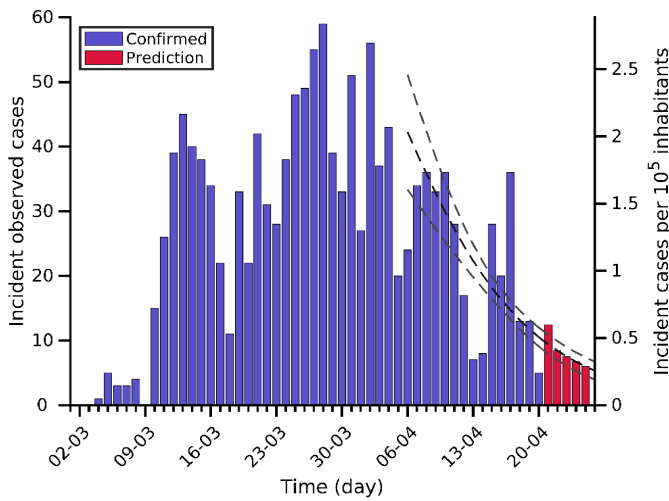
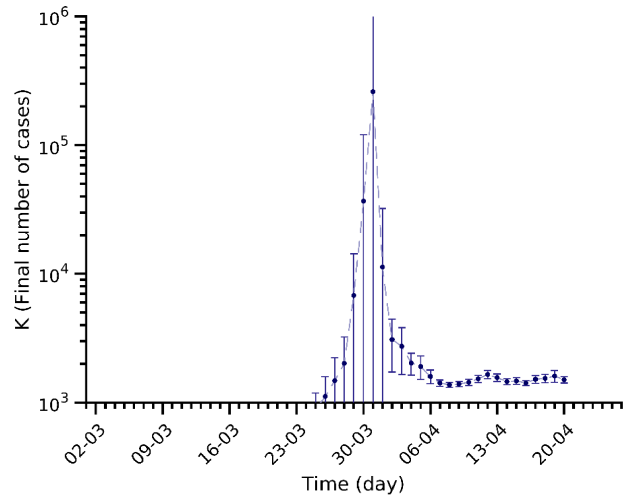
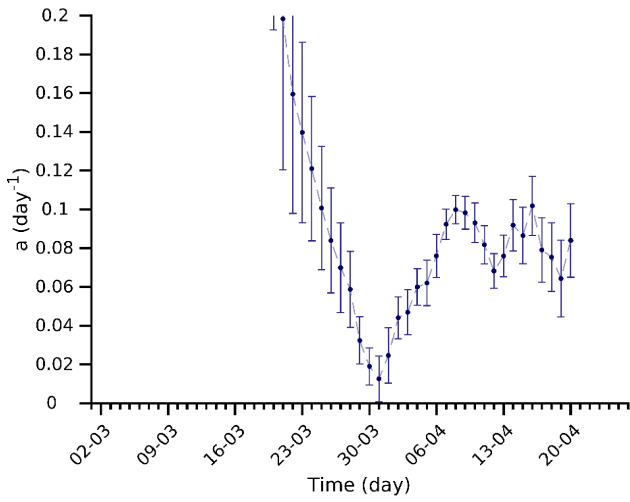
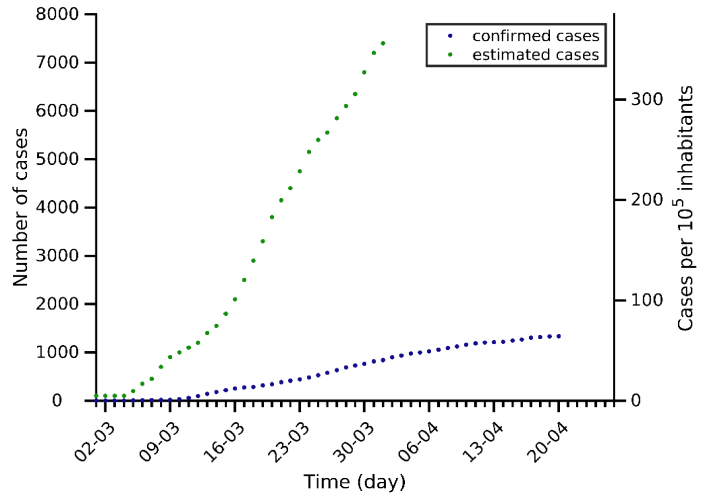
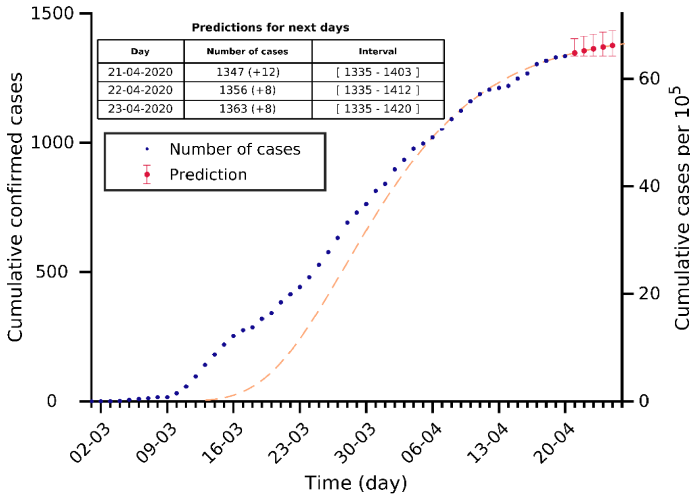
Estonia 20-04-2020. Population: 1.3M. Current cumulated incidence: 116/10⁵



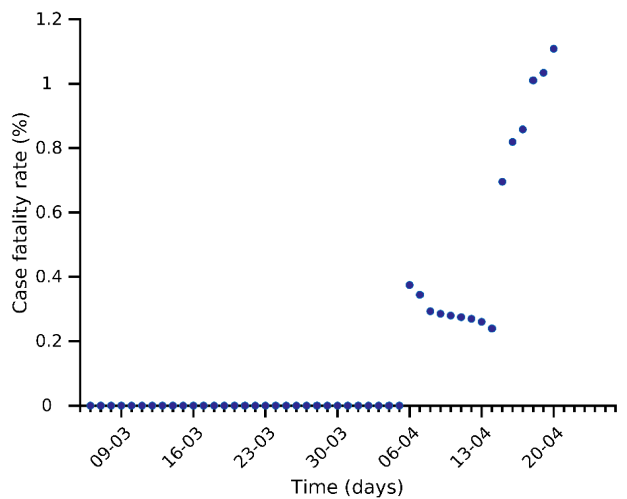
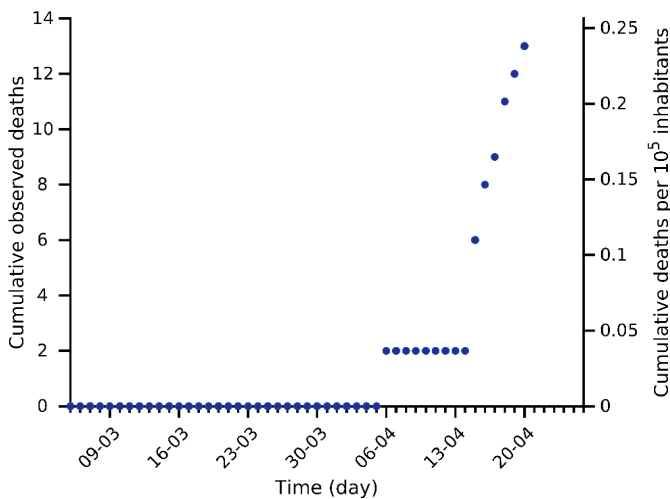
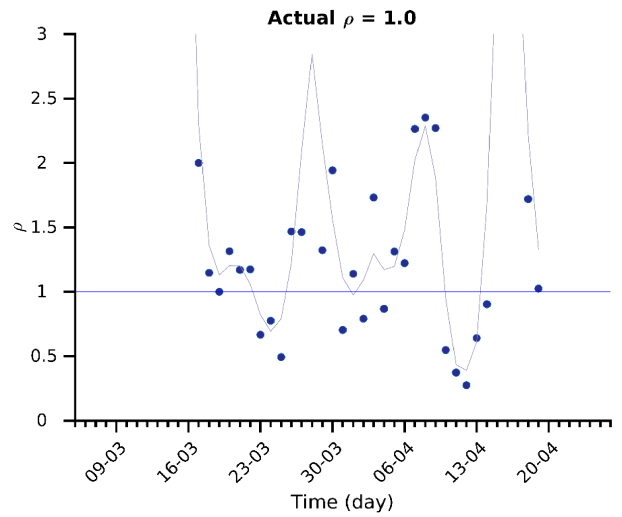
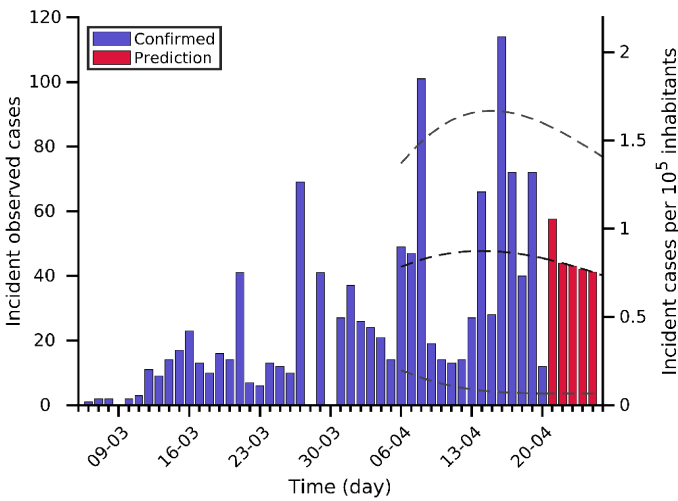
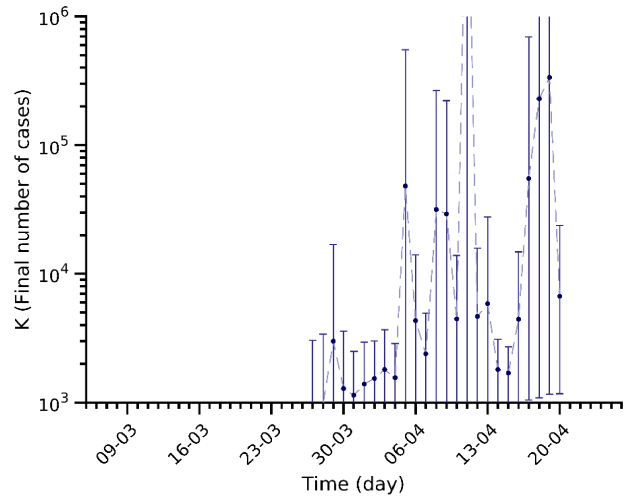
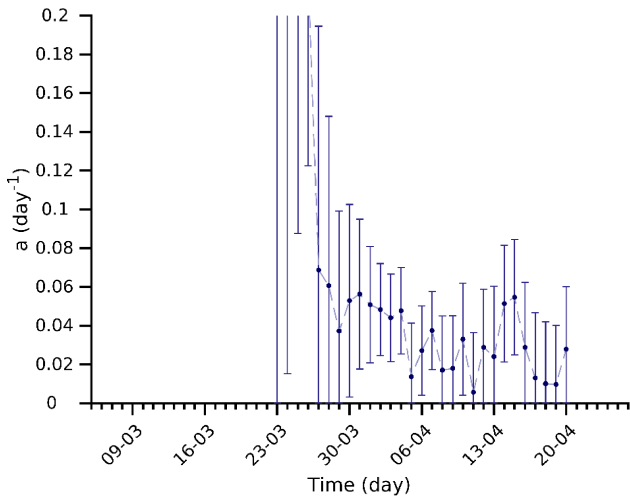
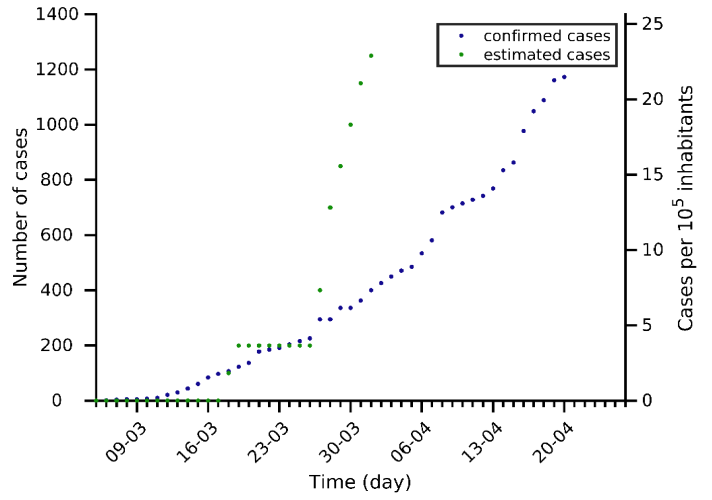
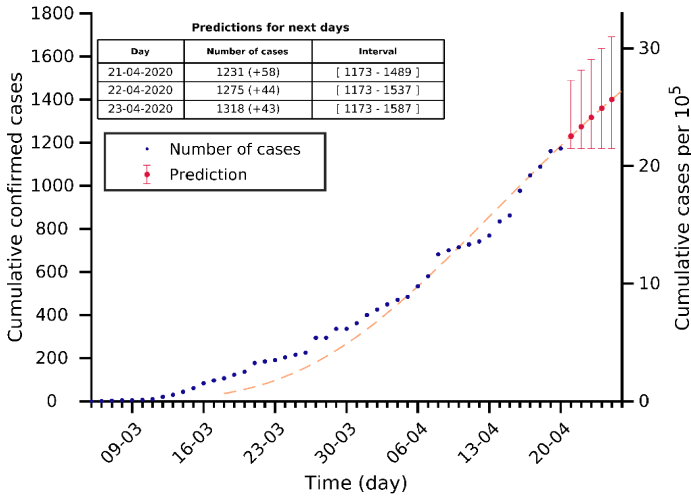
Lithuania 20-04-2020. Population: 2.7M. Current cumulated incidence: 50/10⁵



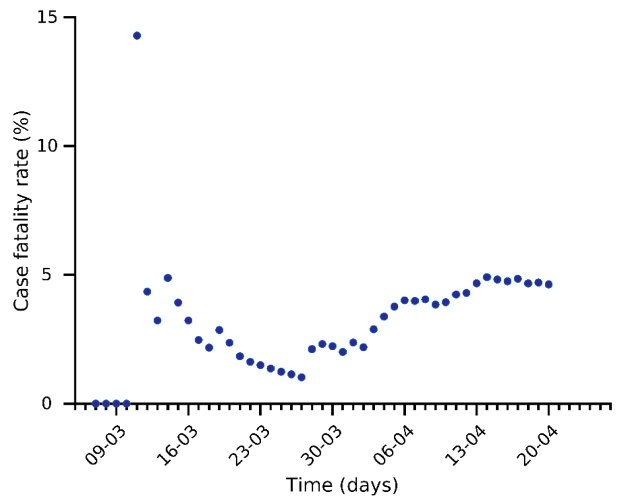
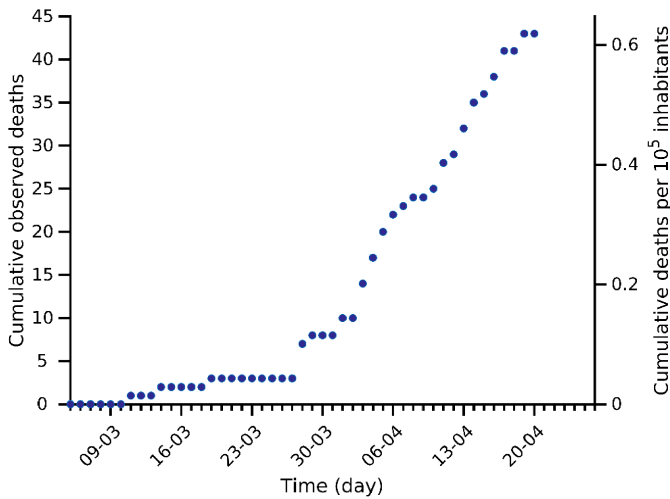
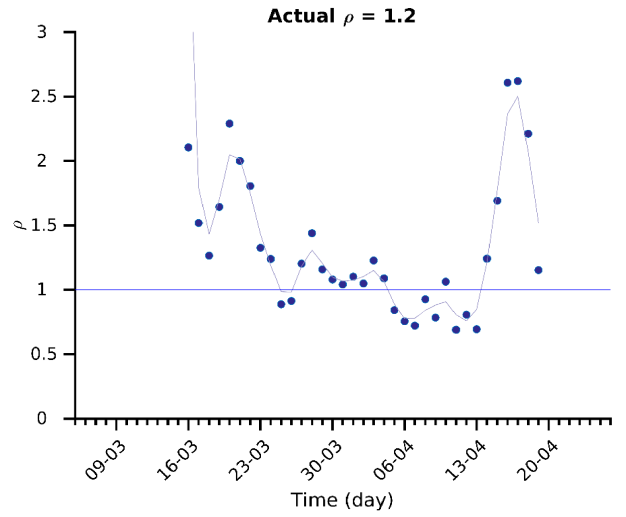
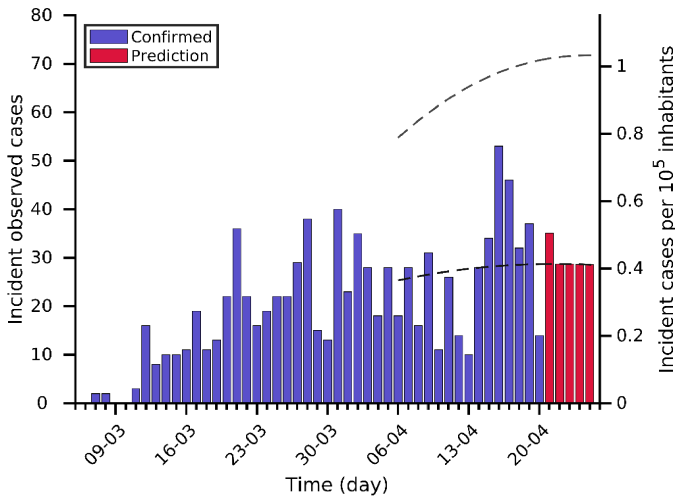
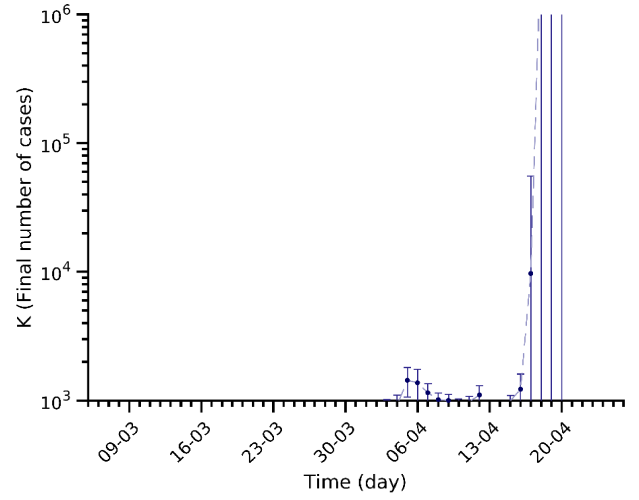
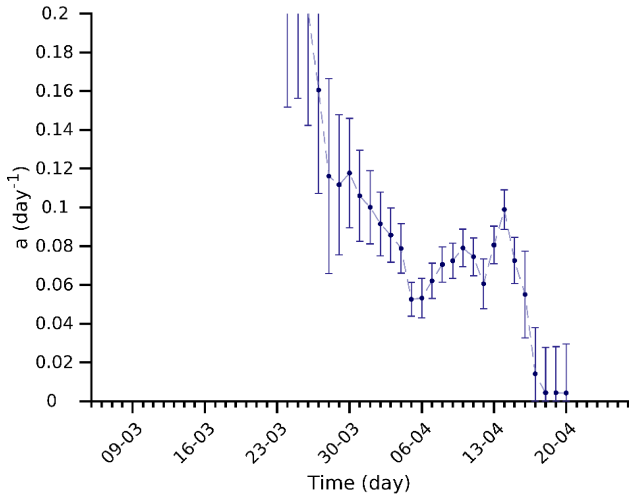
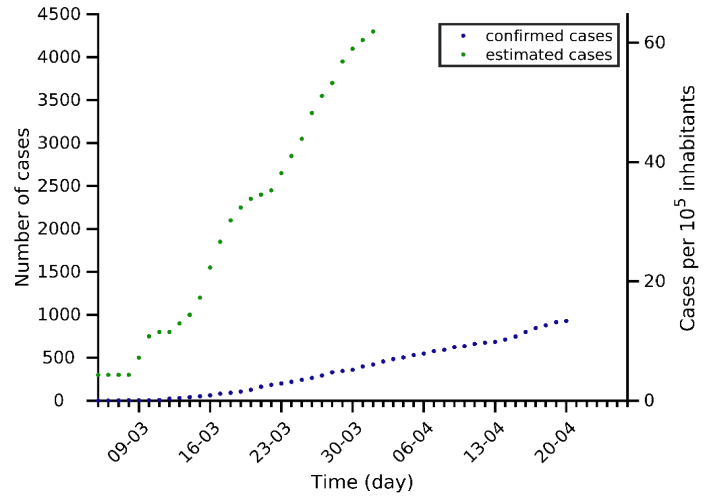
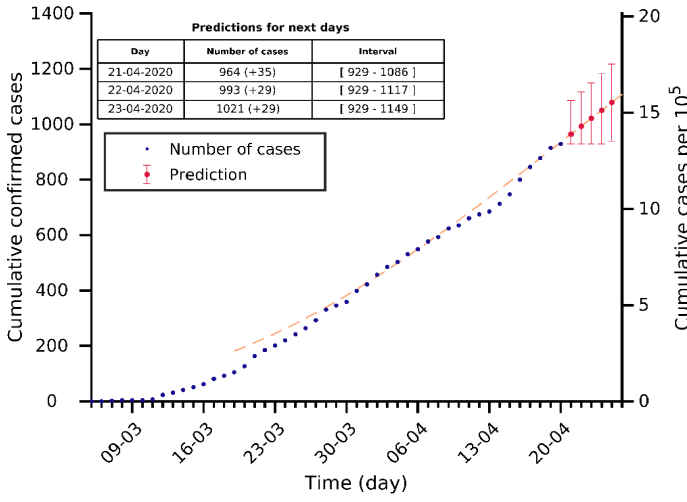
Slovenia 20-04-2020. Population: 2.1M. Current cumulated incidence: 64/10⁵



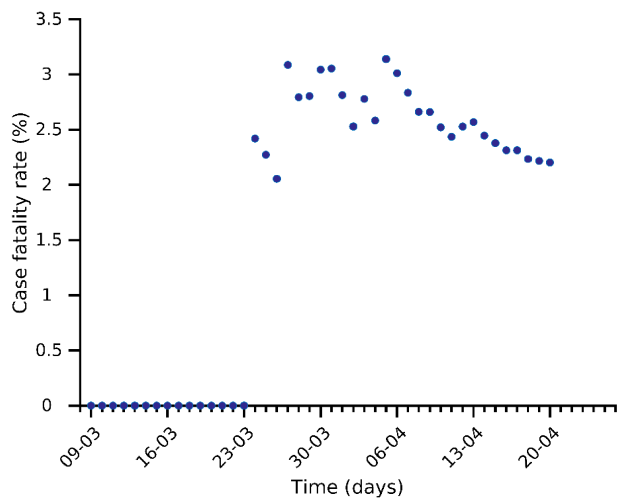
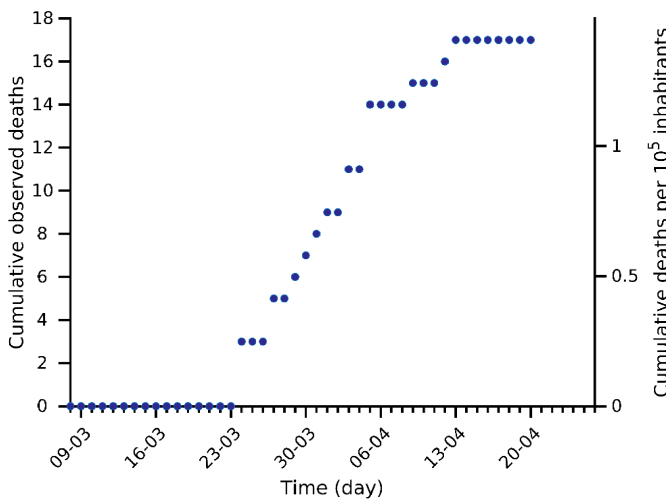
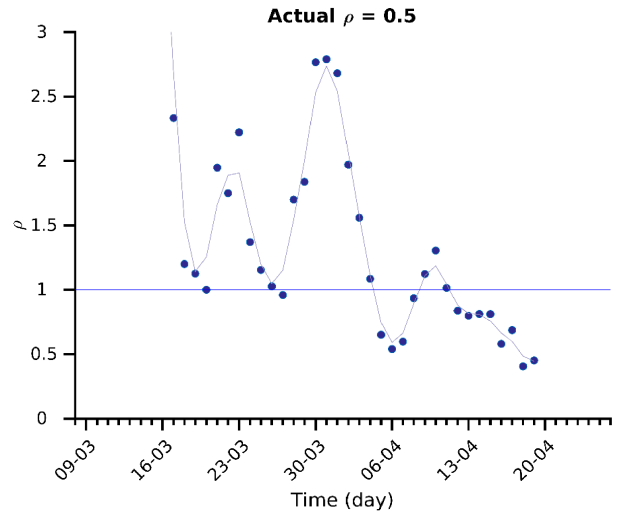
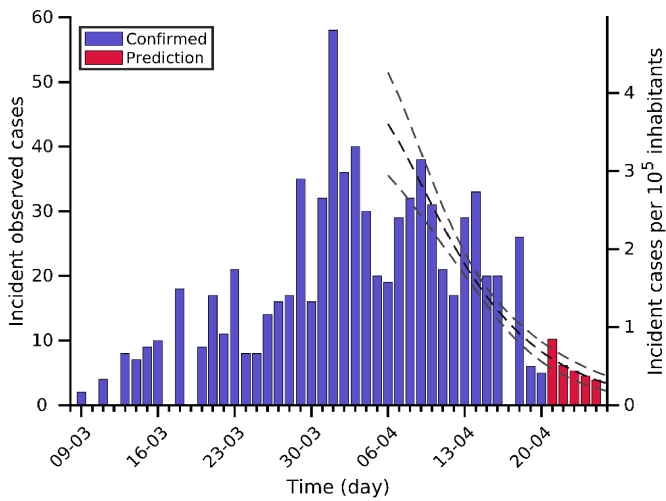
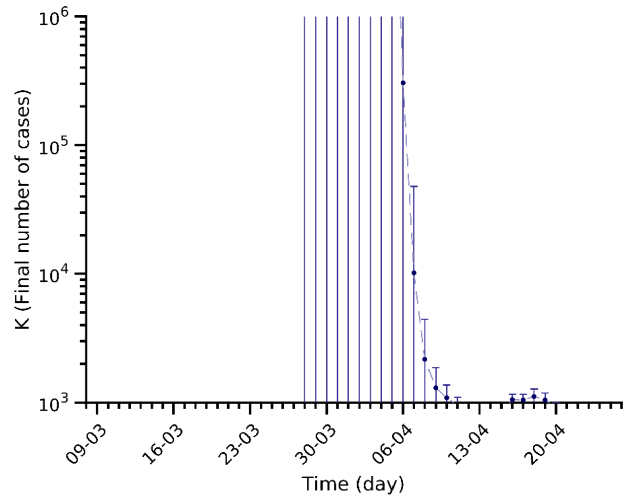
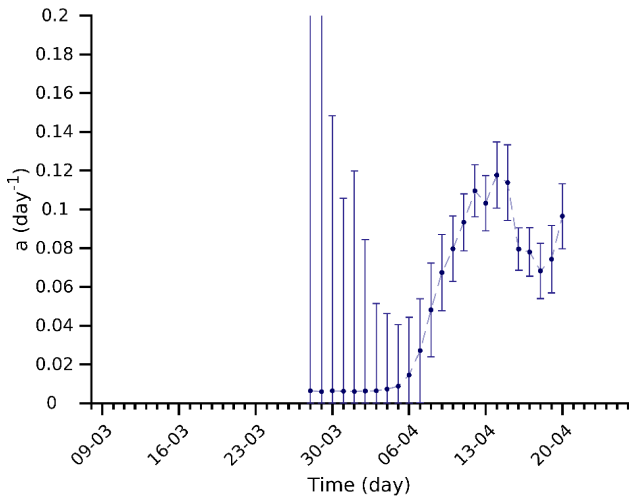
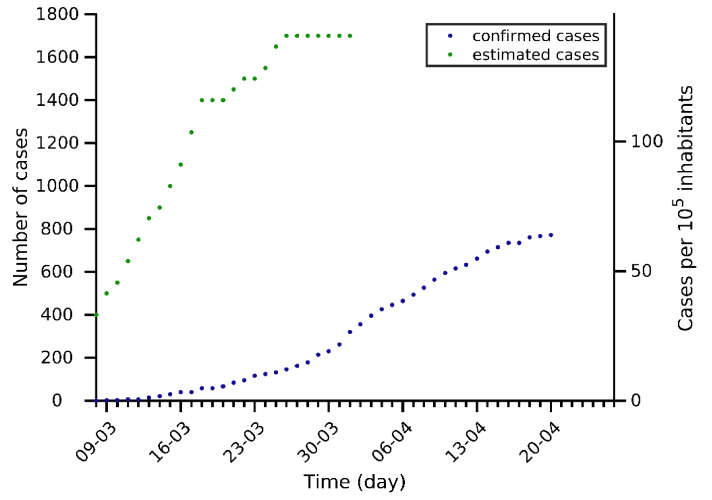
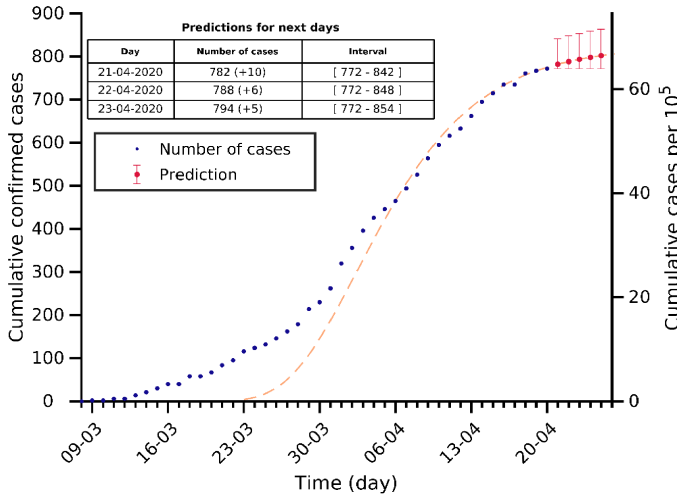
Slovakia 20-04-2020. Population: 5.5M. Current cumulated incidence: 21/10⁵



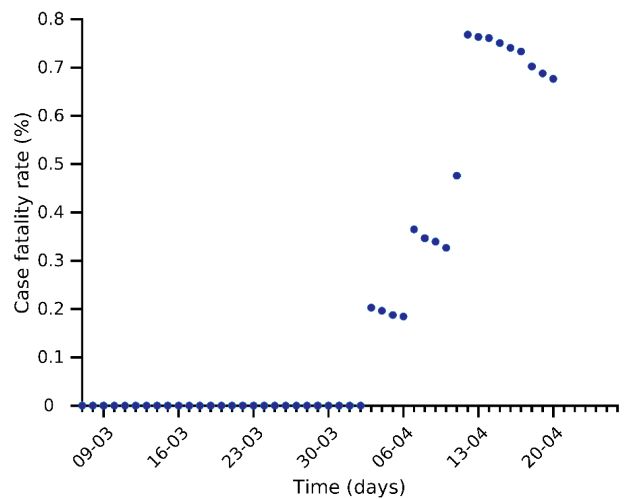
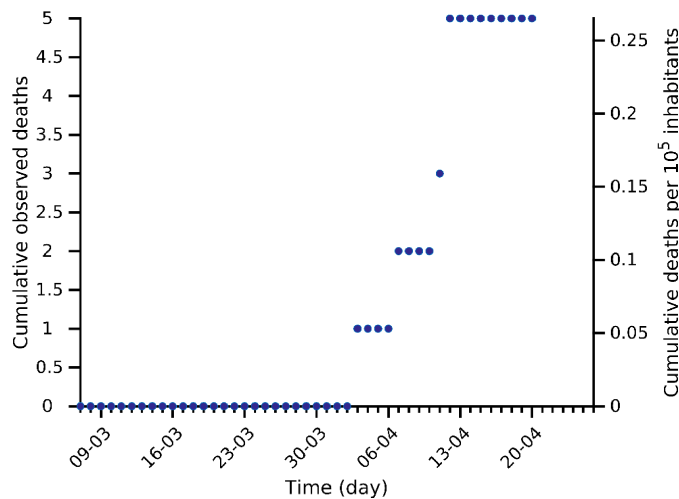
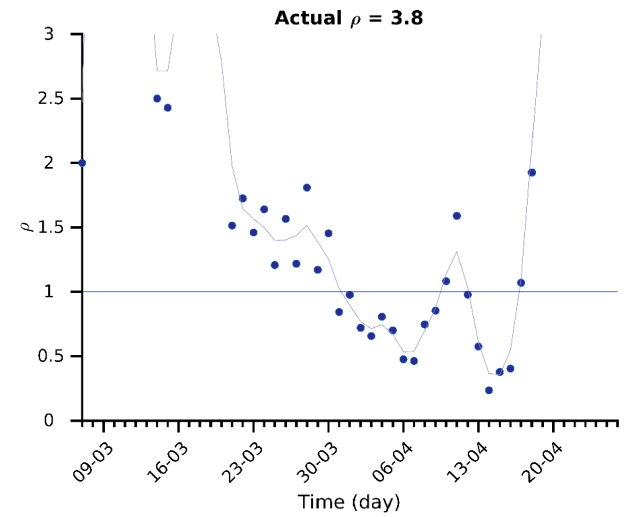
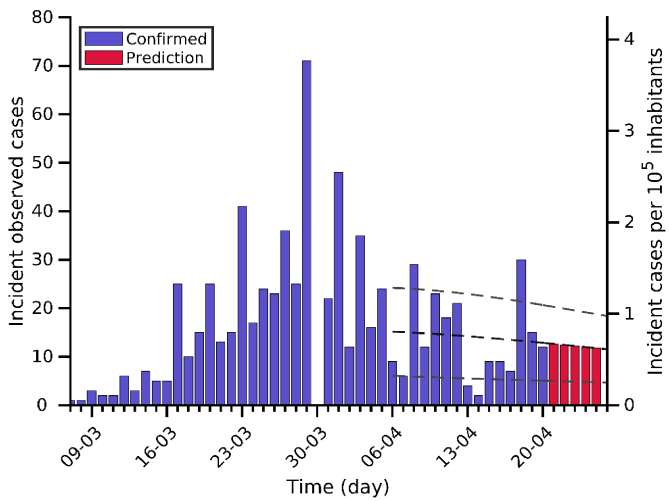
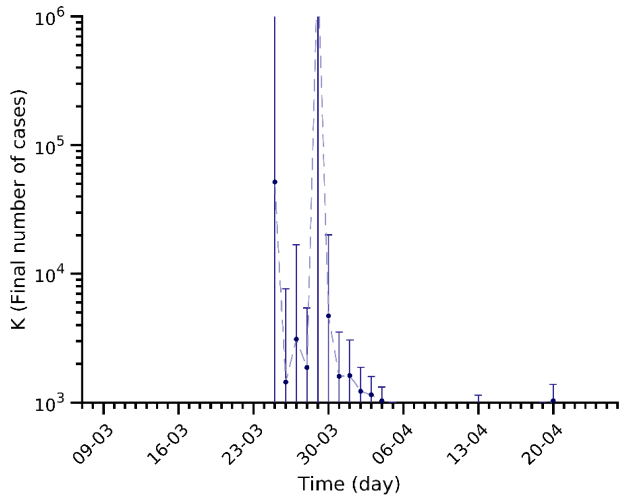
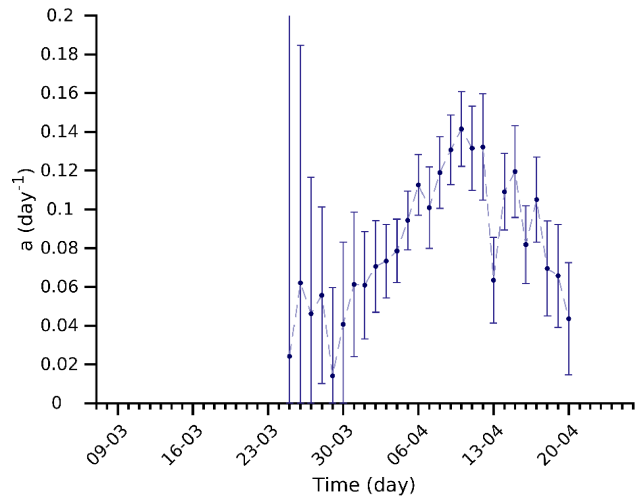
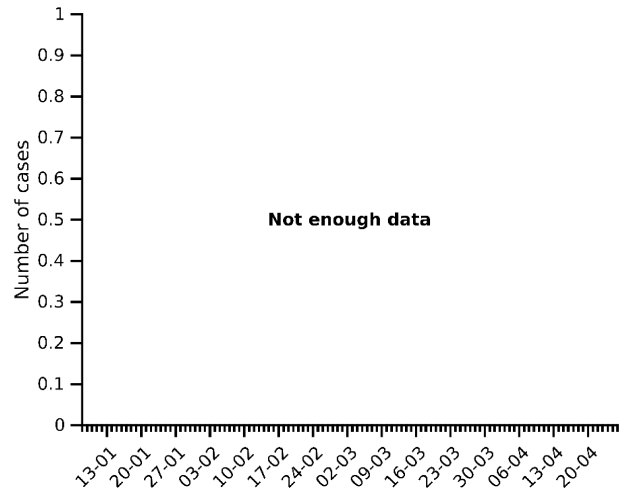
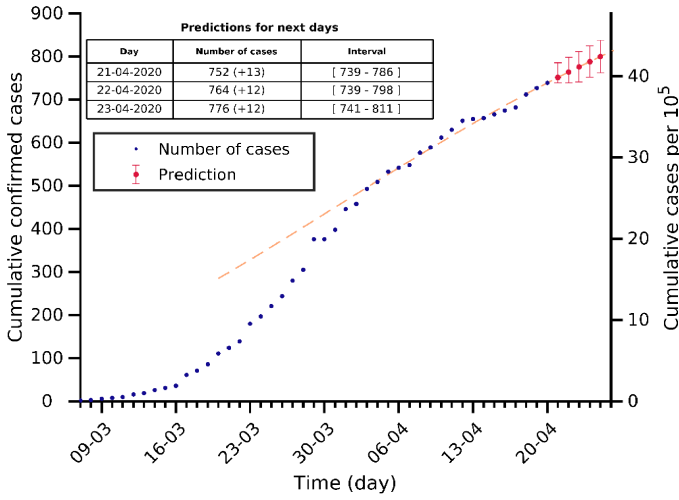
Bulgaria 20-04-2020. Population: 6.9M. Current cumulated incidence: 13/10⁵



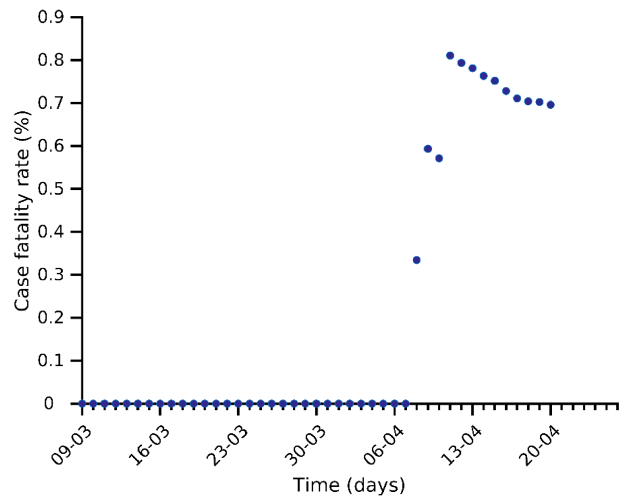
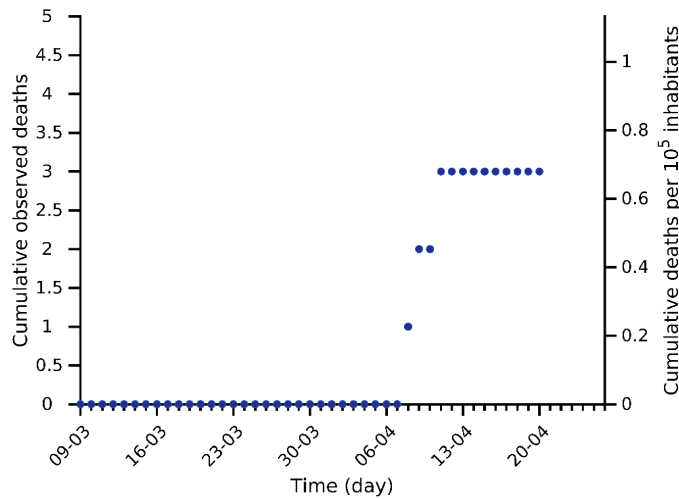
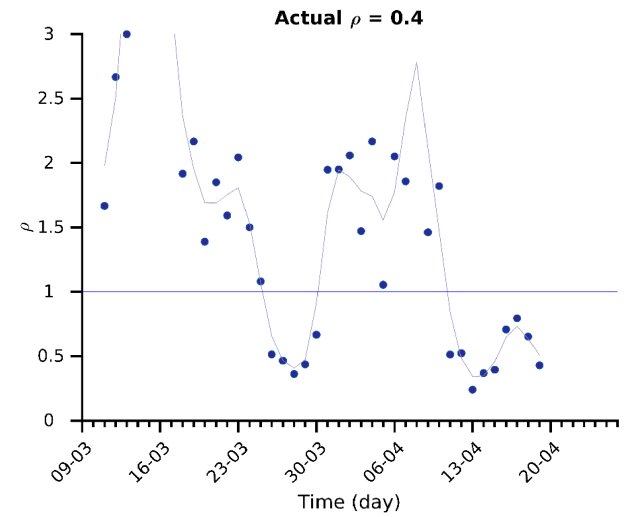
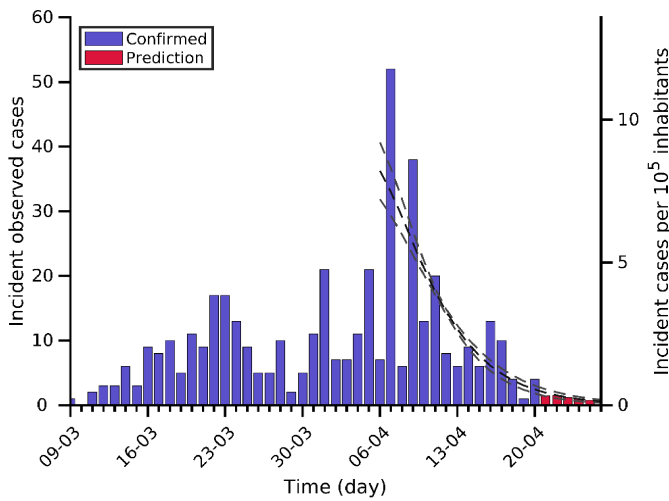
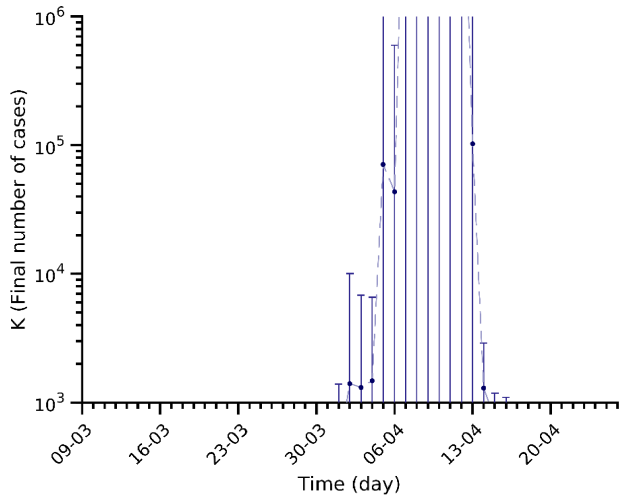
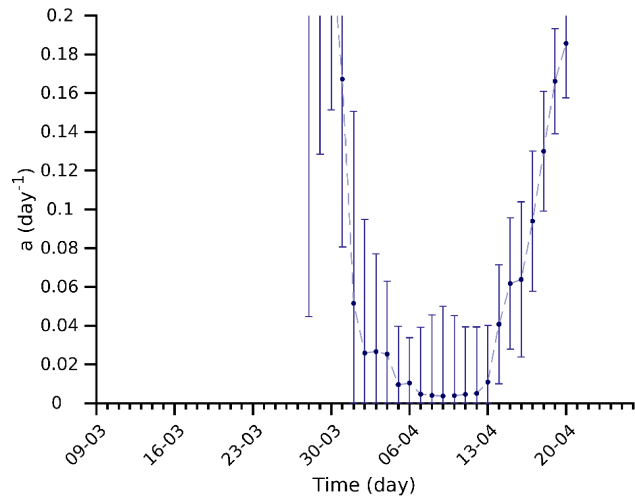
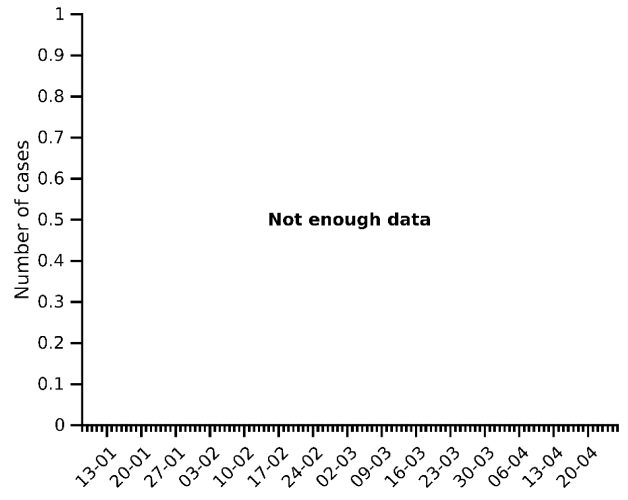
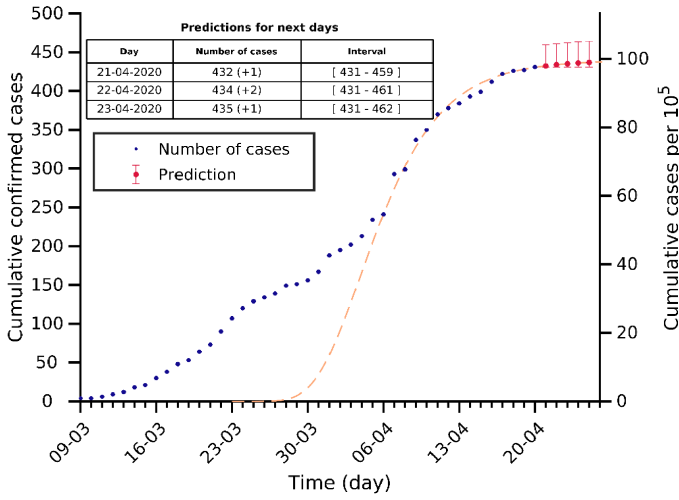
Cyprus 20-04-2020. Population: 1.2M. Current cumulated incidence: 64/10⁵



Latvia 20-04-2020. Population: 1.9M. Current cumulated incidence: 39/10⁵



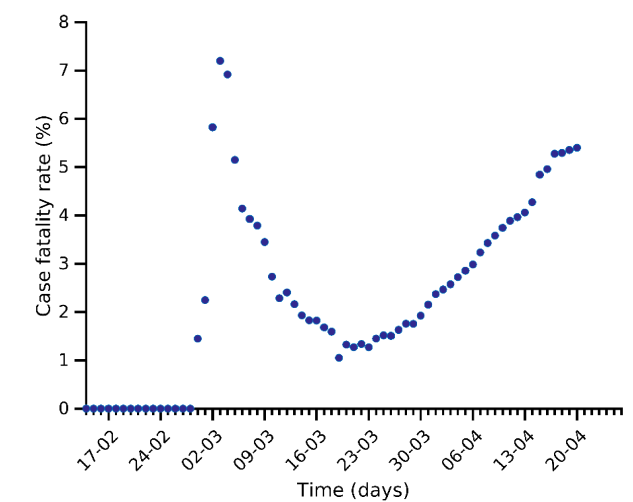
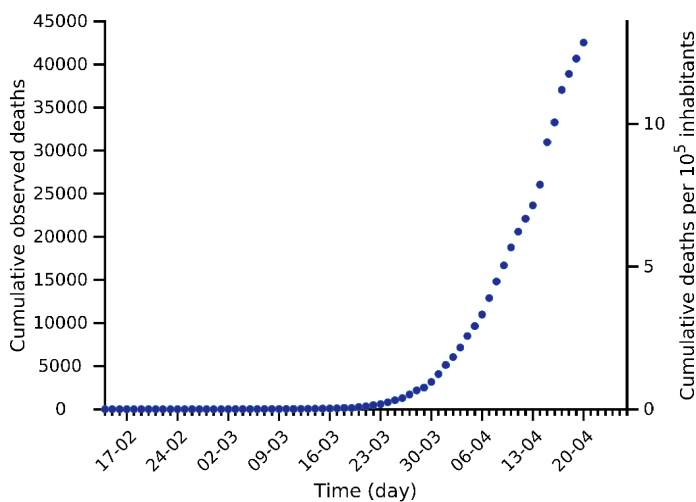
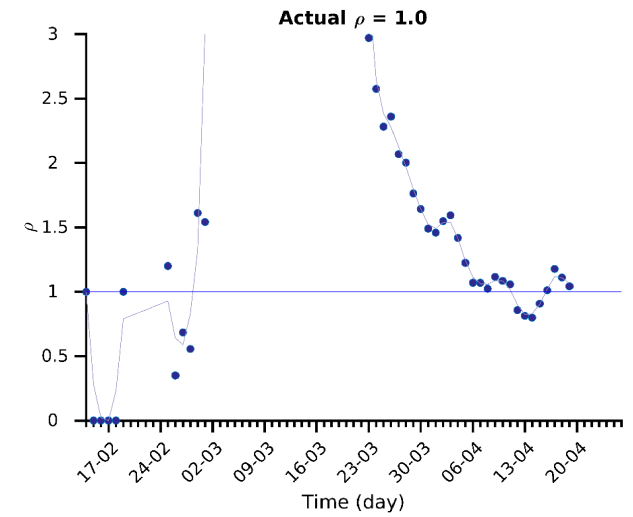
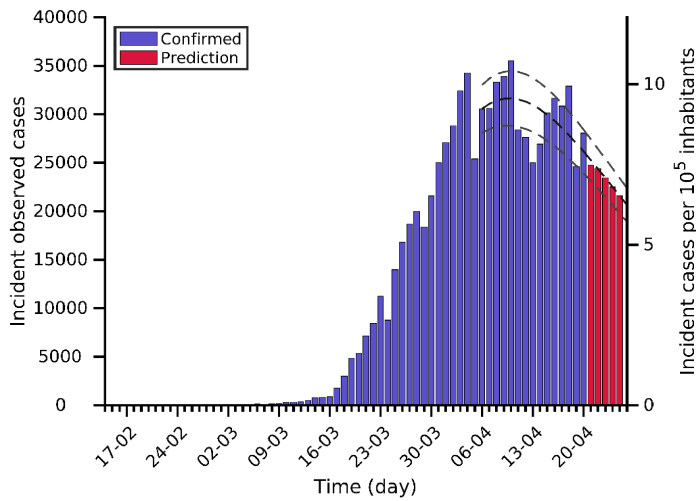
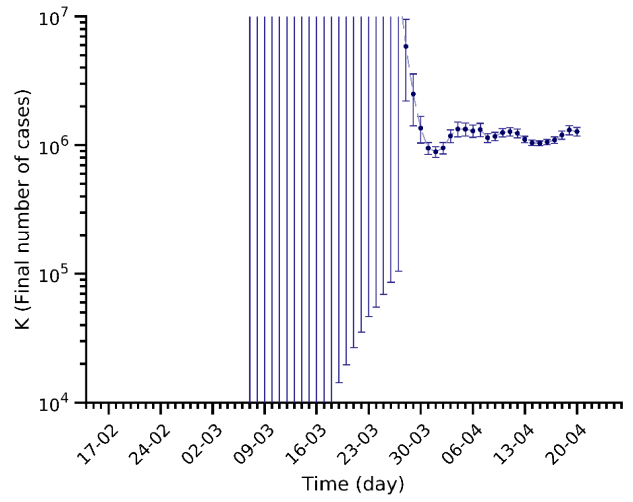
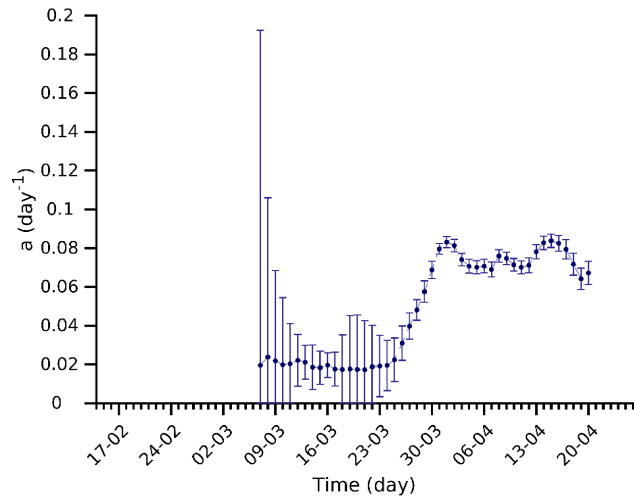
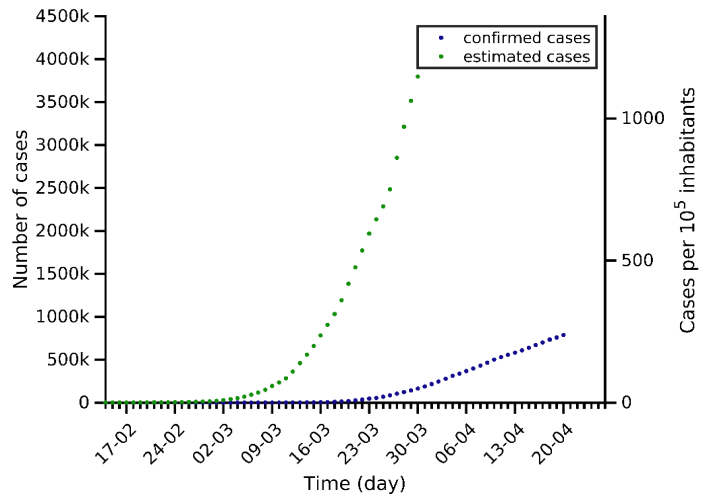
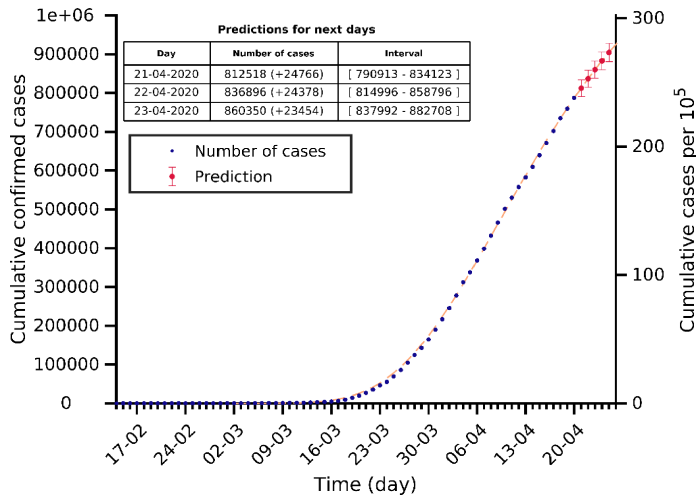
Malta 20-04-2020. Population: 0.4M. Current cumulated incidence: 98/10⁵



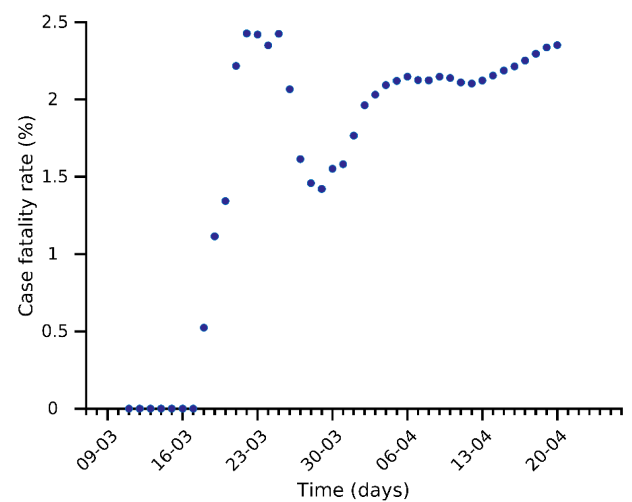
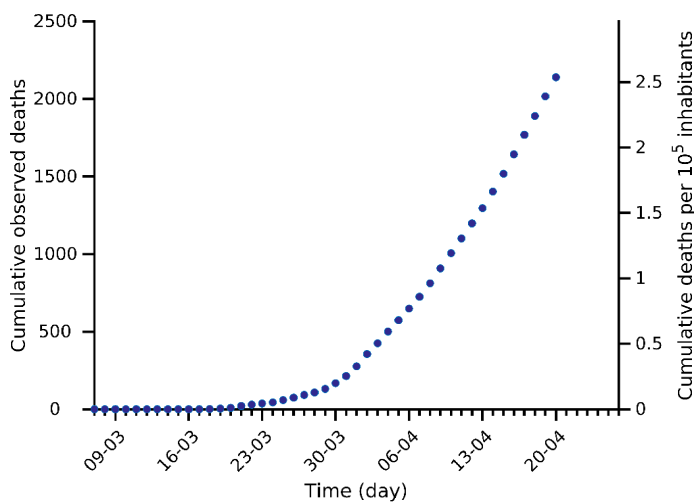
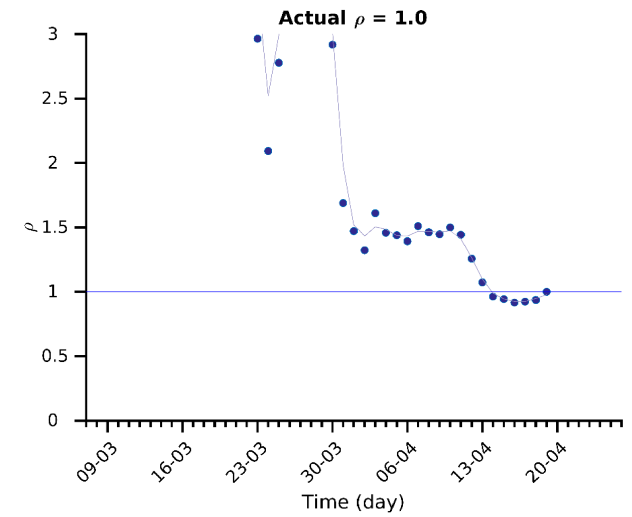
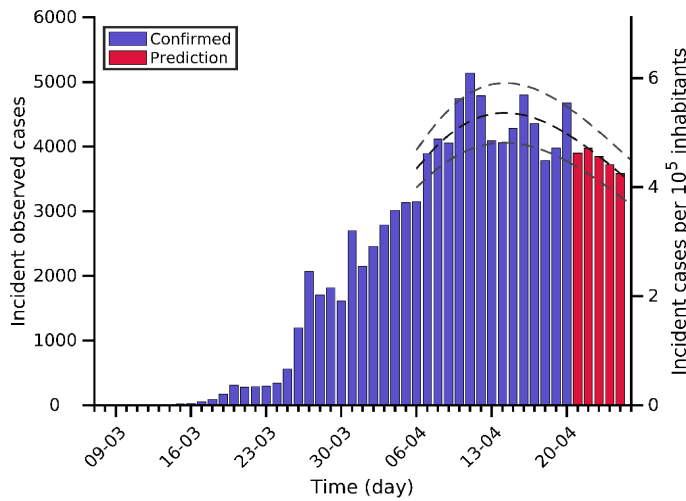
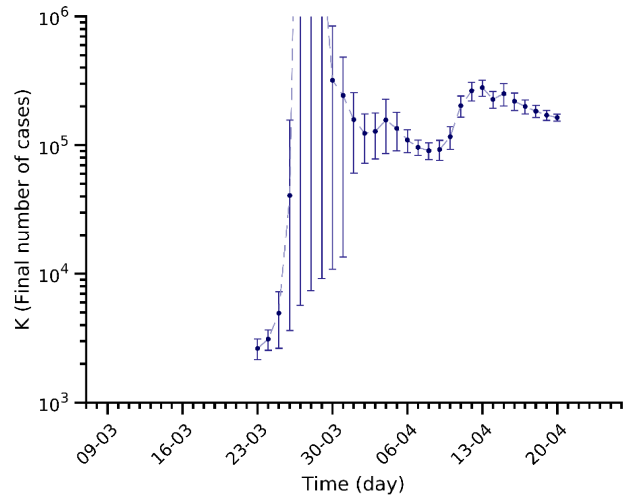
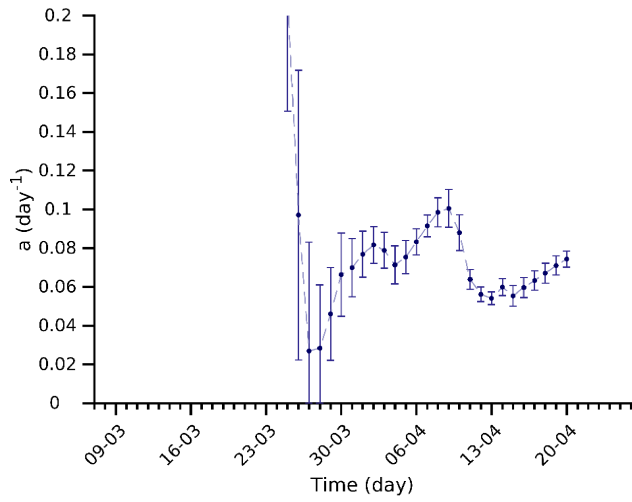
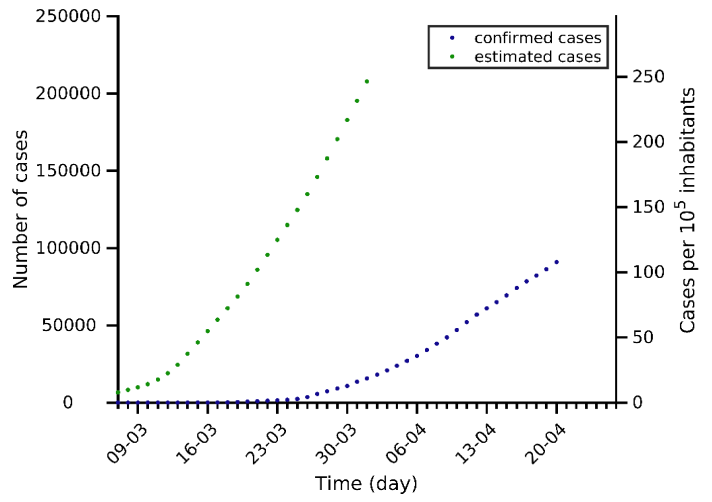
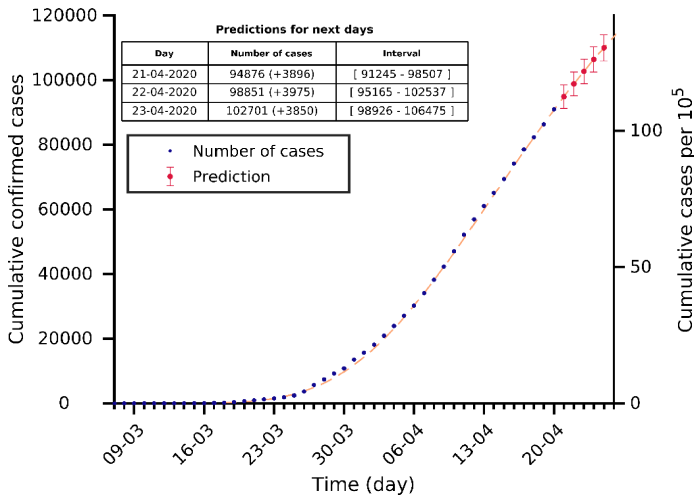
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

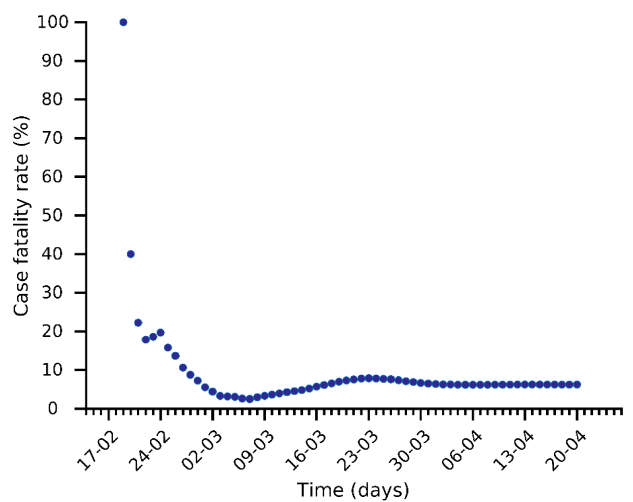
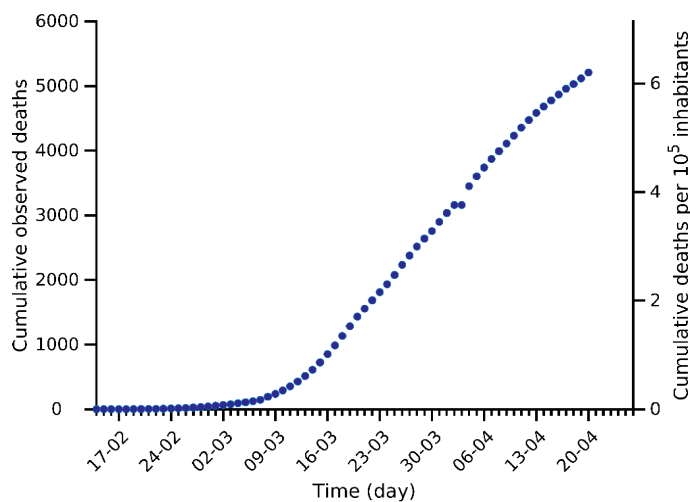
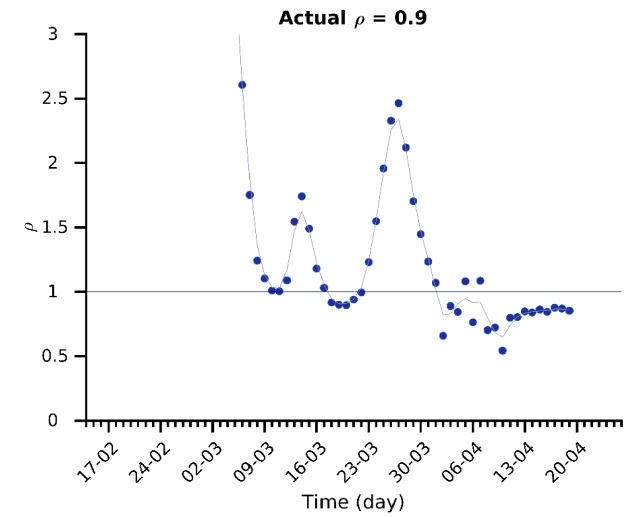
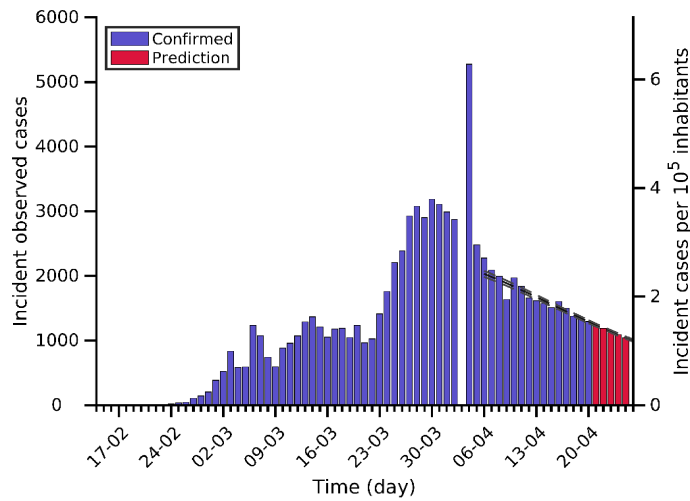
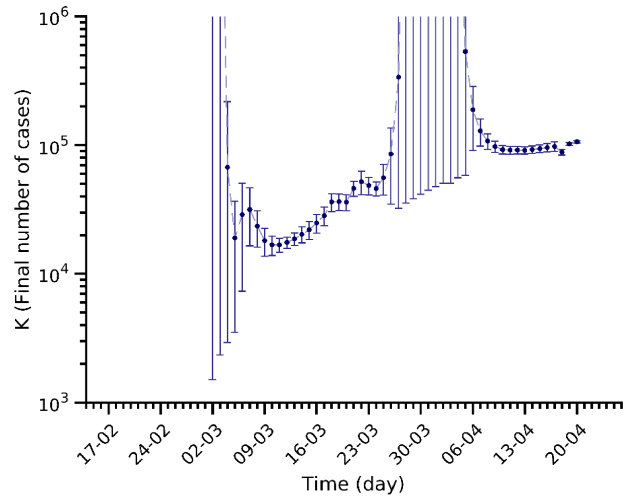
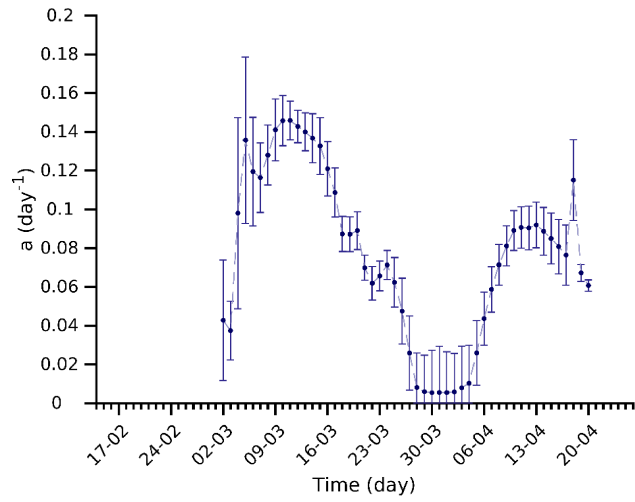
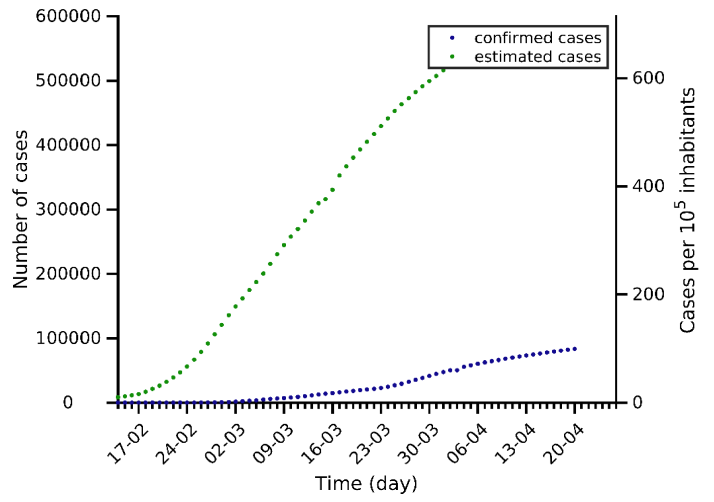
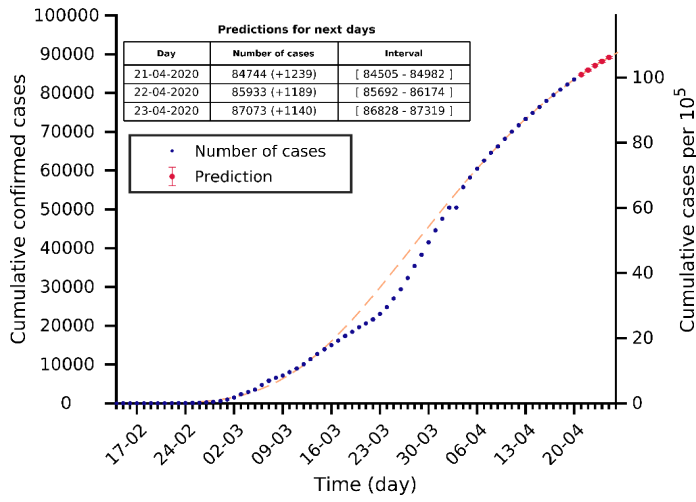
USA 20-04-2020. Population: 331.0M. Current cumulated incidence: 238/10⁵



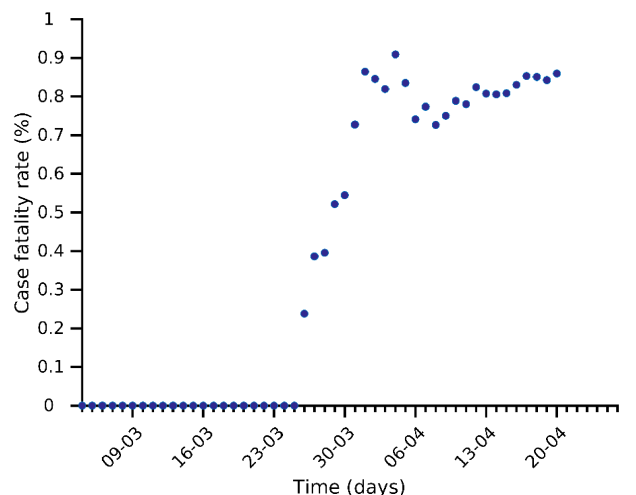
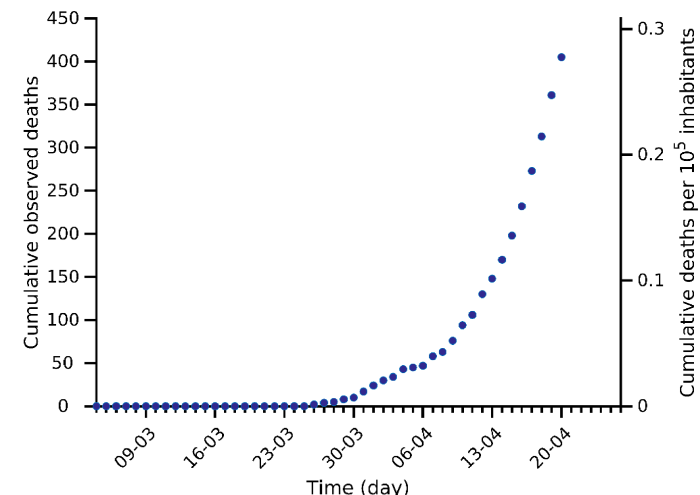
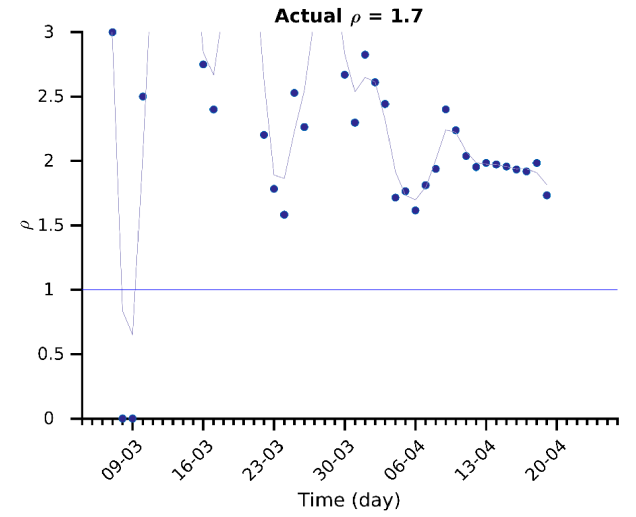
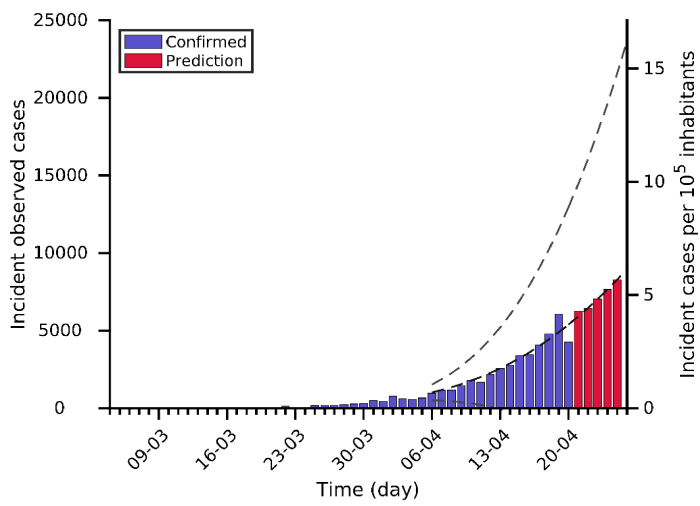
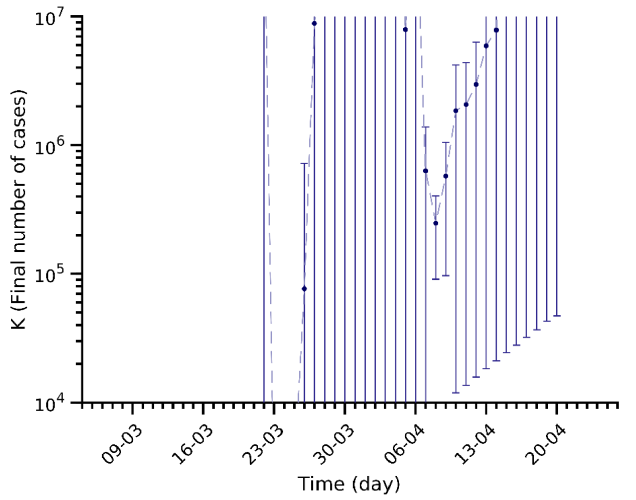
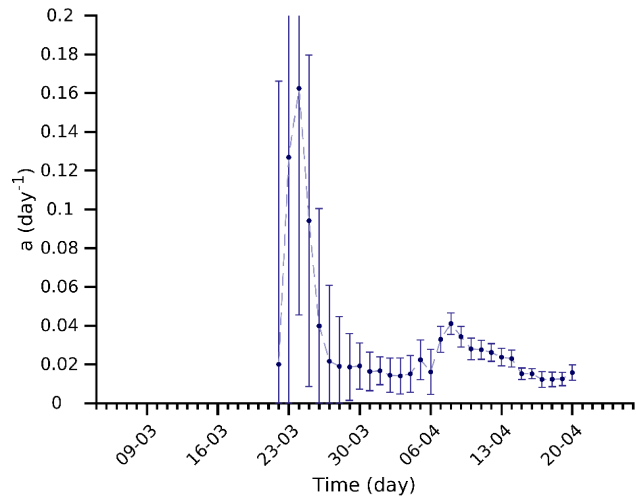
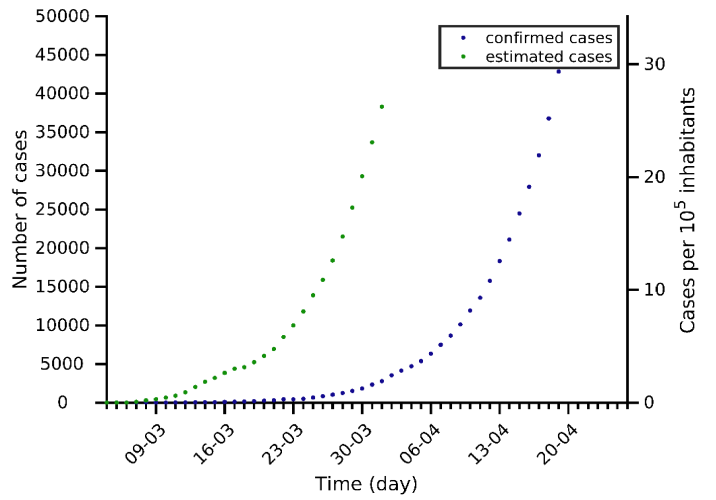
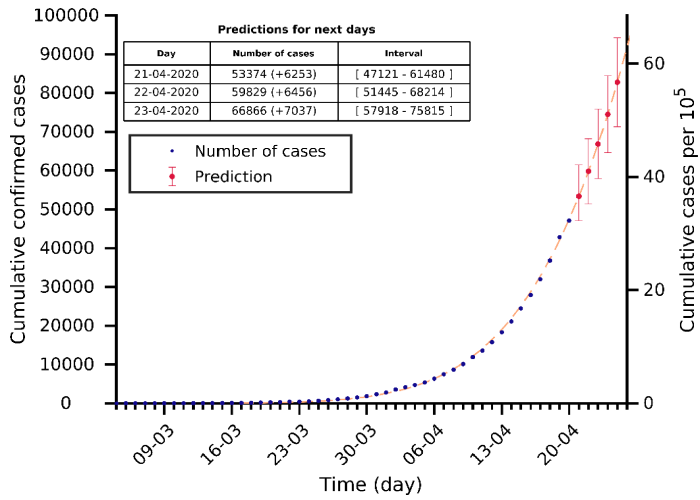
Turkey 20-04-2020. Population: 84.3M. Current cumulated incidence: 108/10⁵



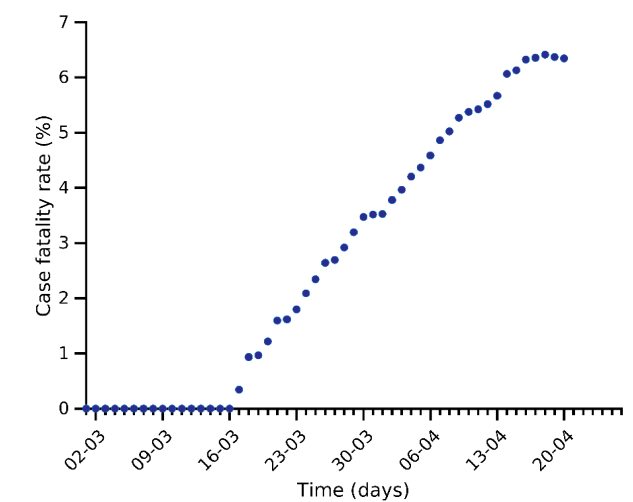
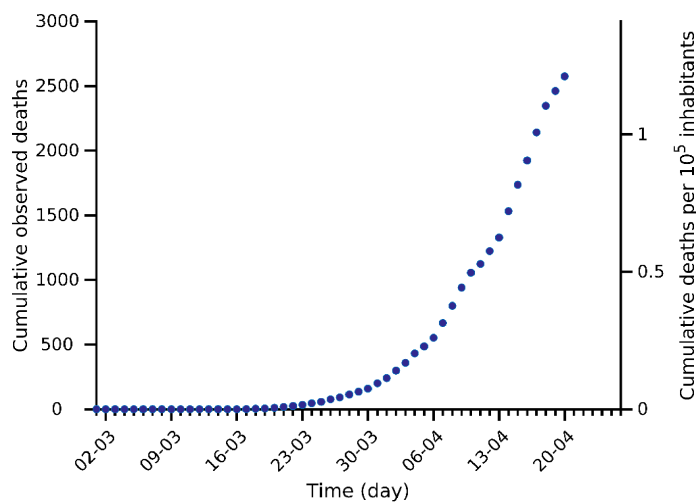
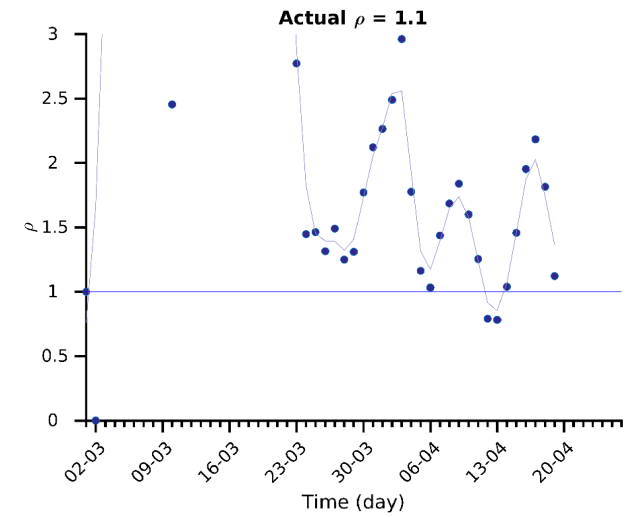
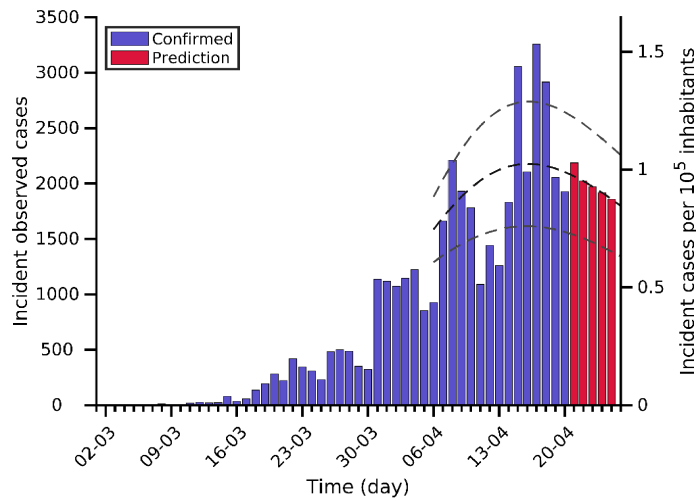
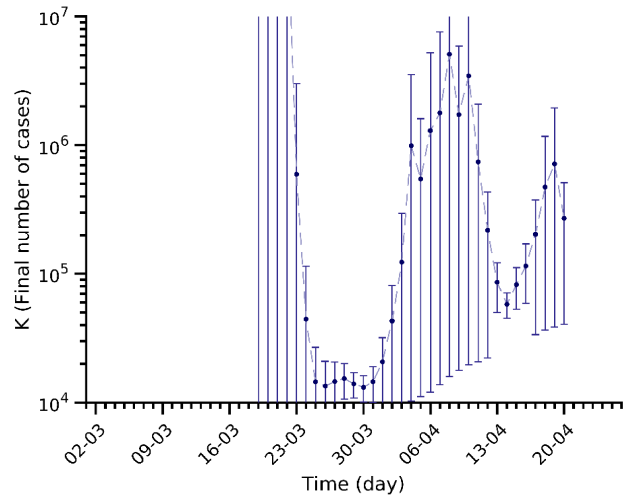
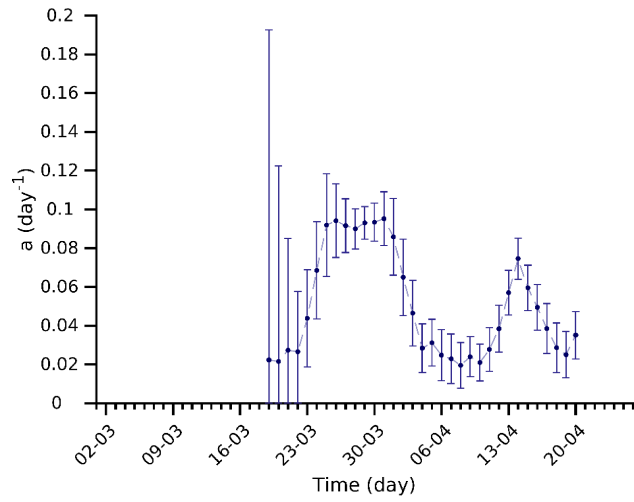
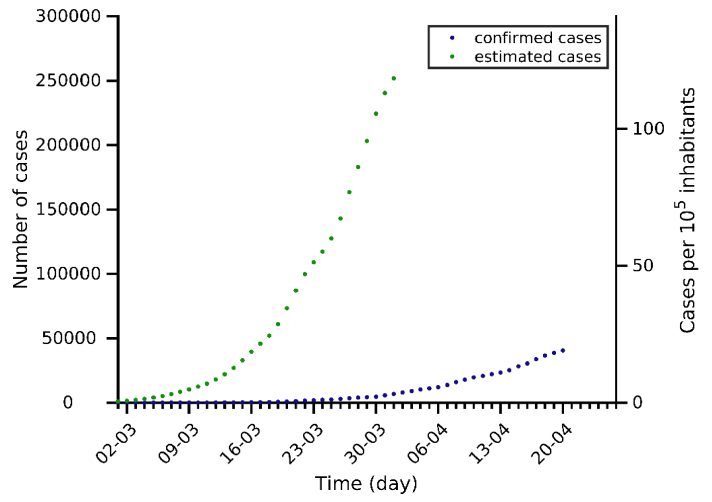
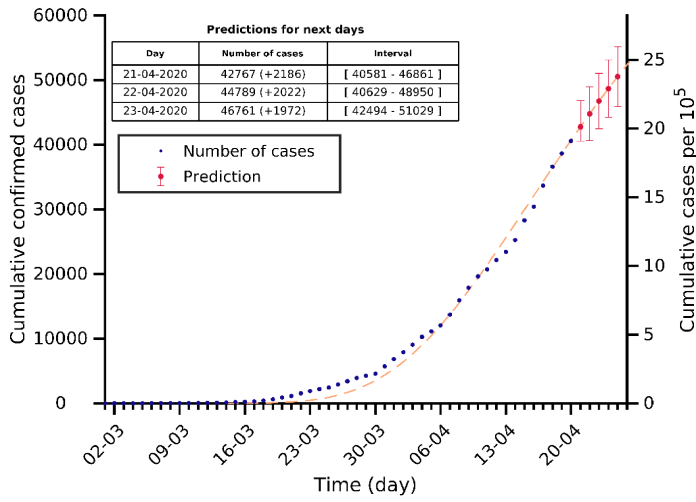
Iran 20-04-2020. Population: 84.0M. Current cumulated incidence: 99/10⁵



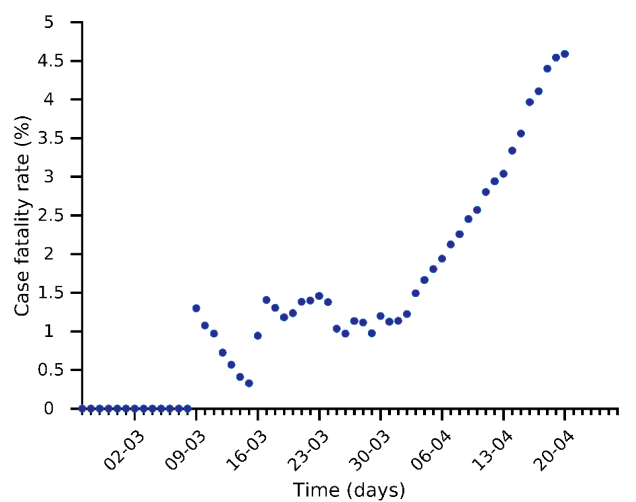
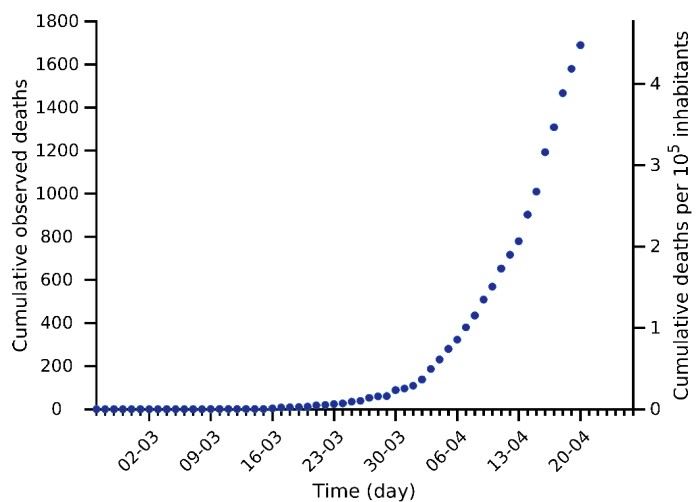
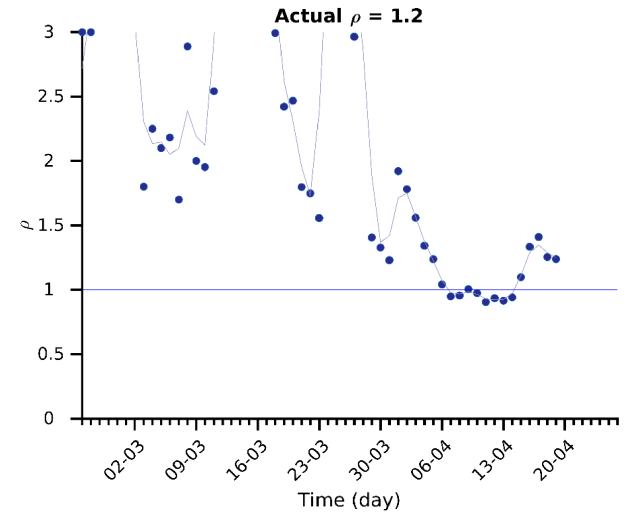
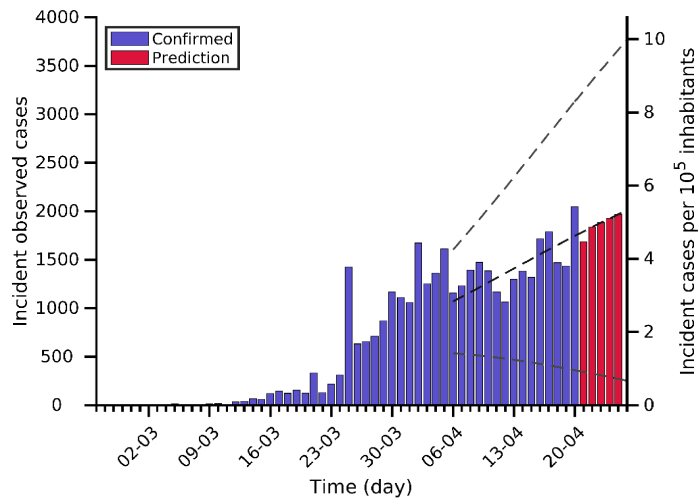
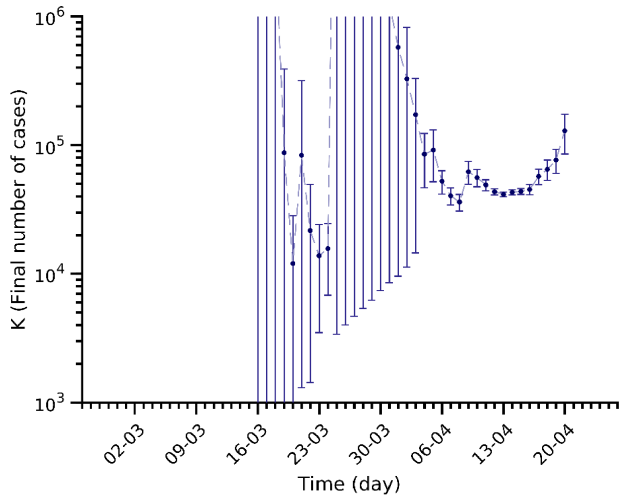
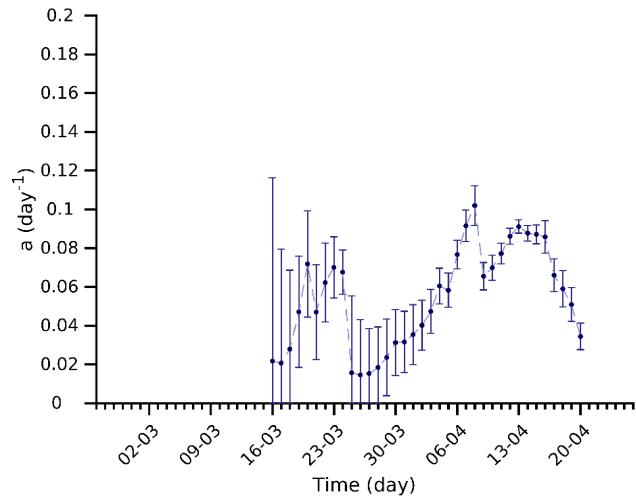
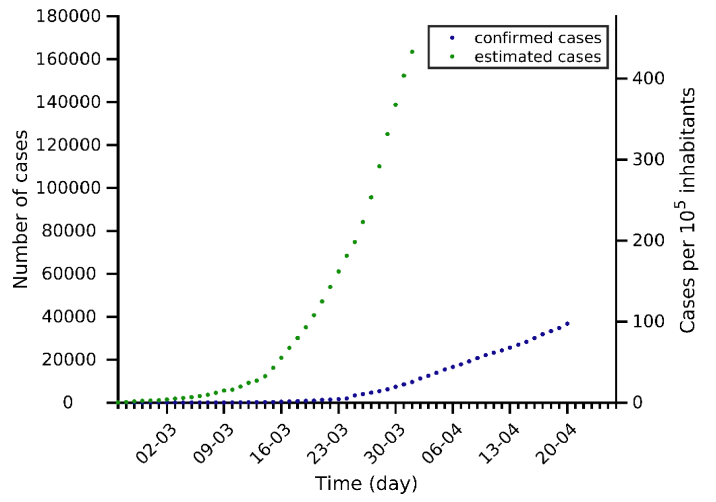
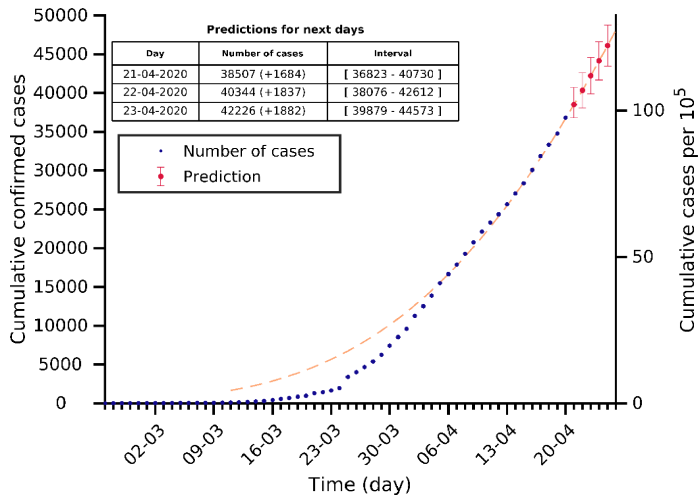
Russia 20-04-2020. Population: 145.9M. Current cumulated incidence: 32/10⁵



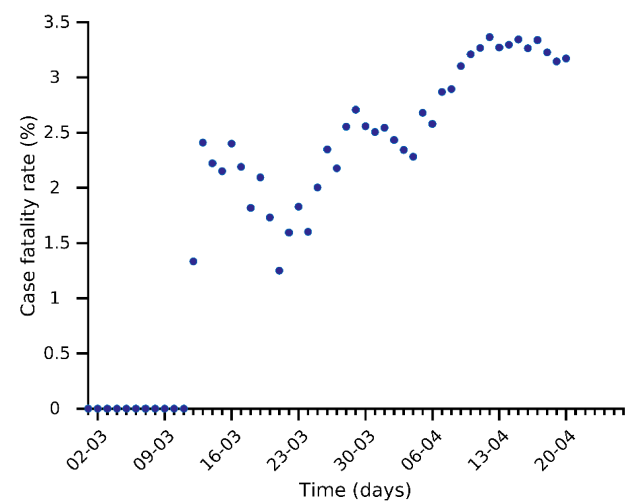
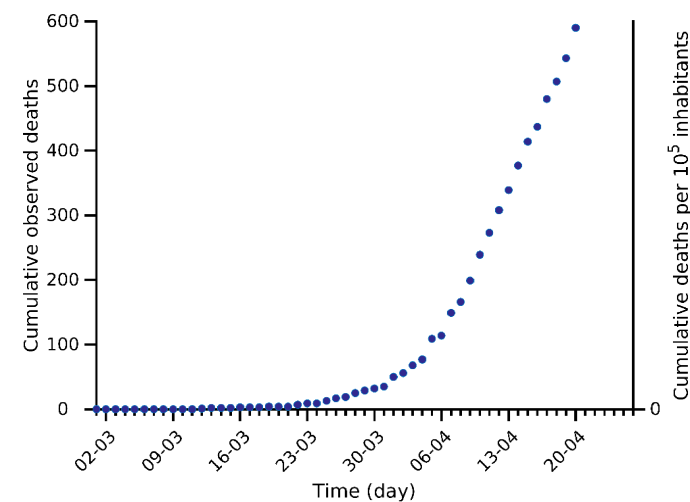
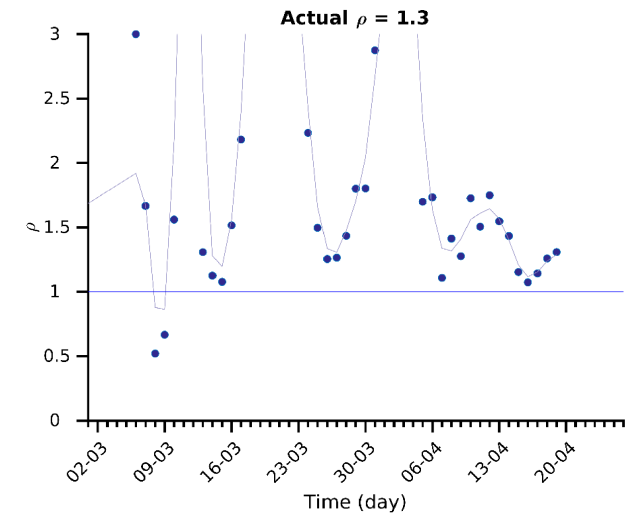
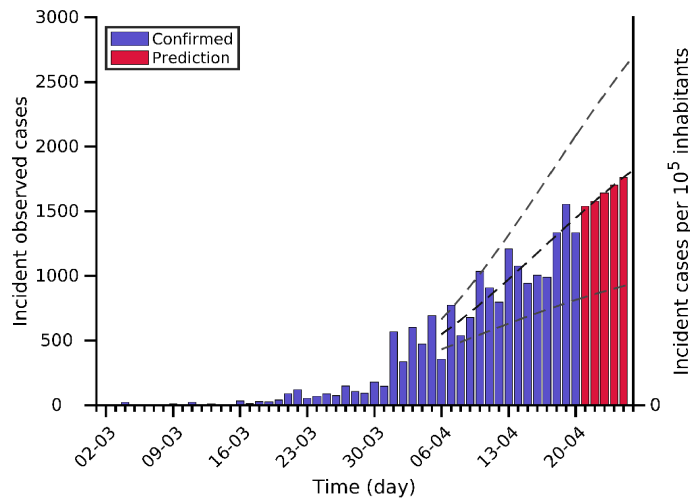
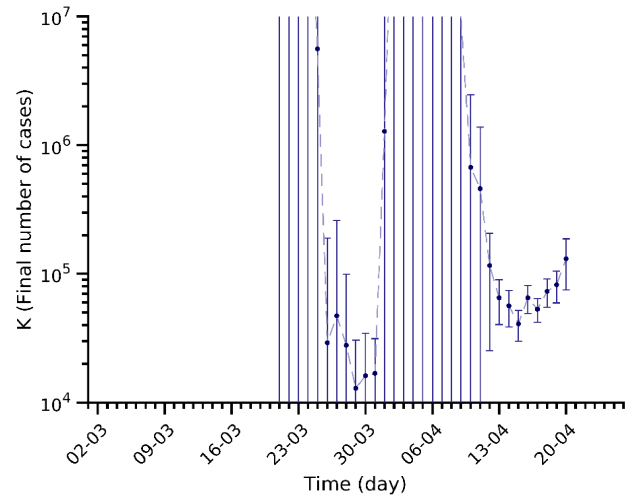
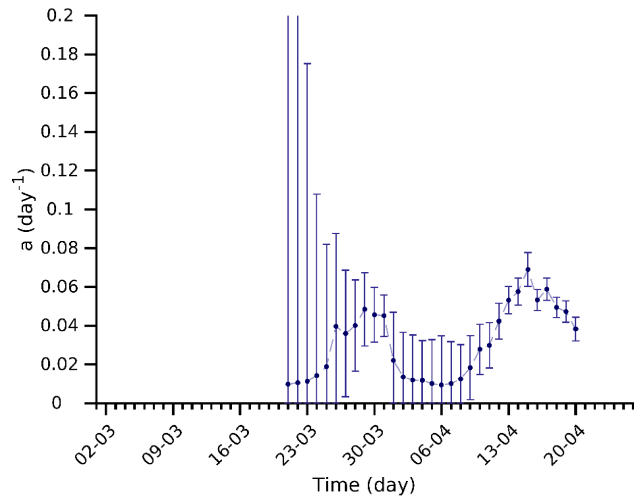
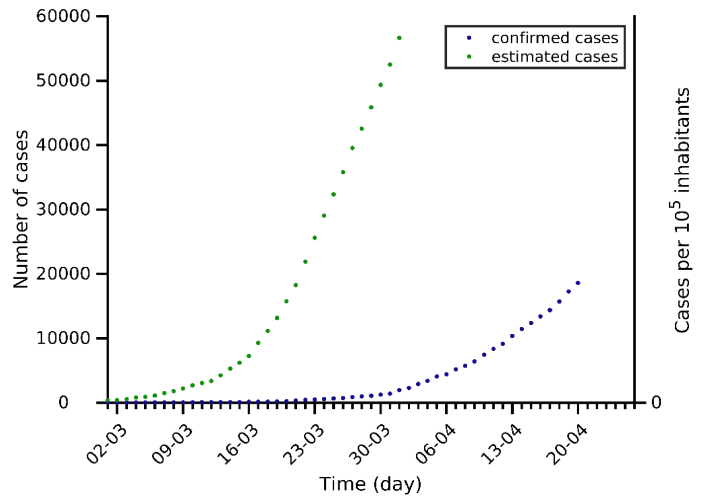
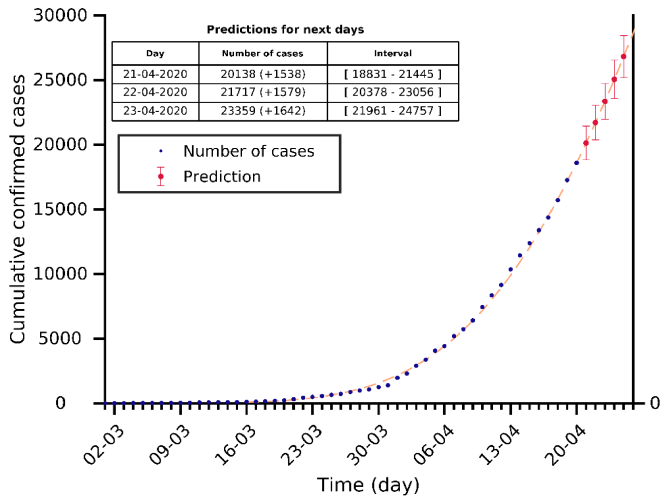
Brazil 20-04-2020. Population: 212.6M. Current cumulated incidence: 19/10⁵



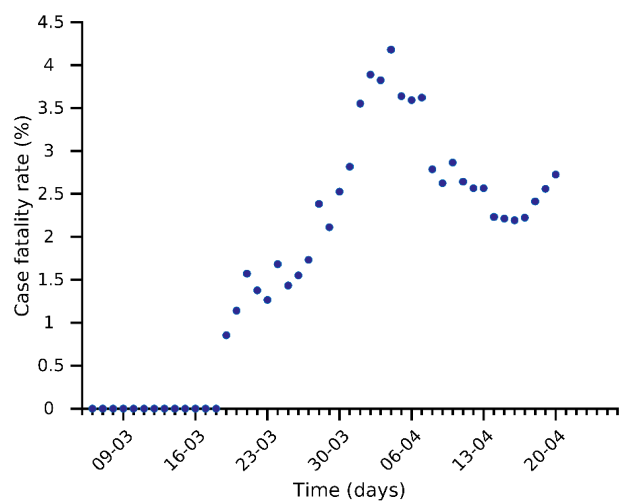
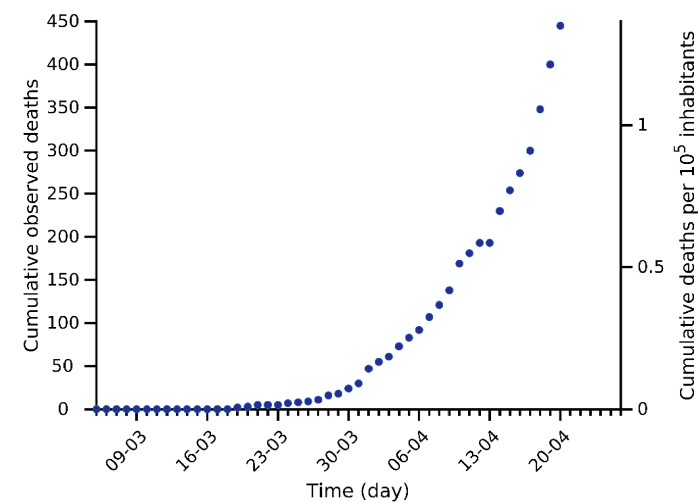
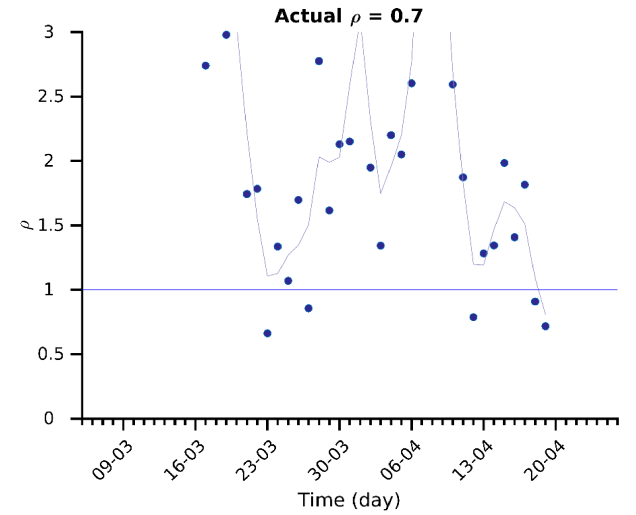
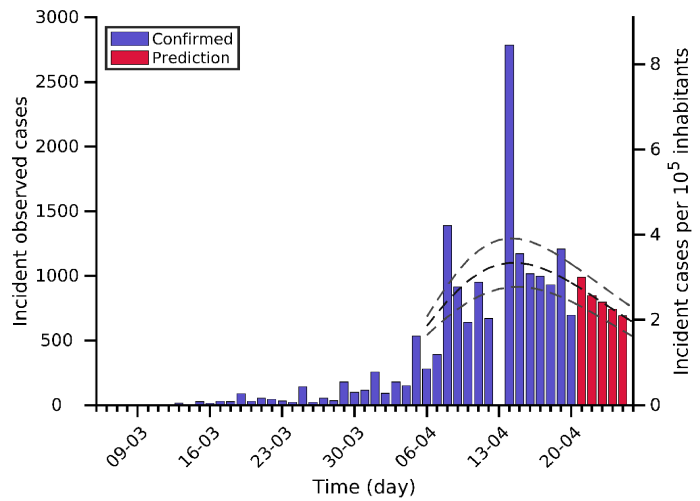
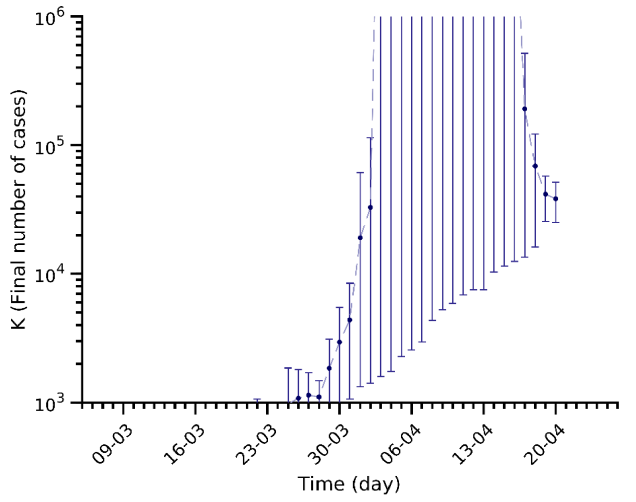
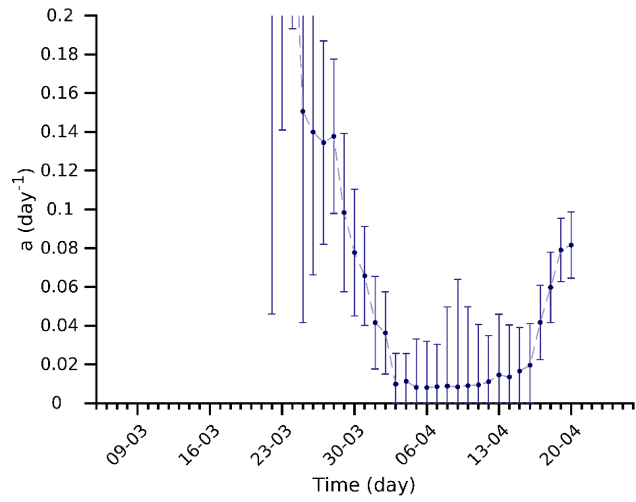
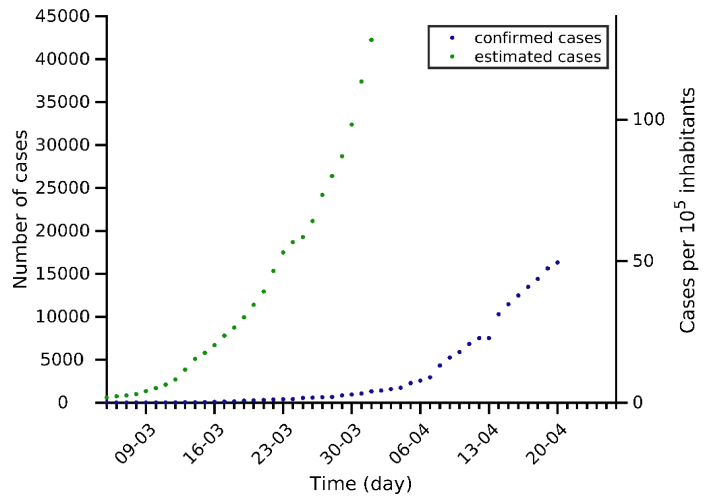
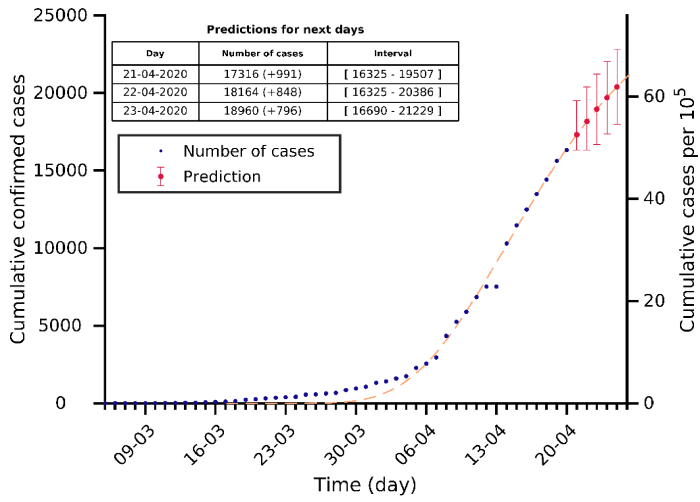
Canada 20-04-2020. Population: 37.7M. Current cumulated incidence: 98/10⁵



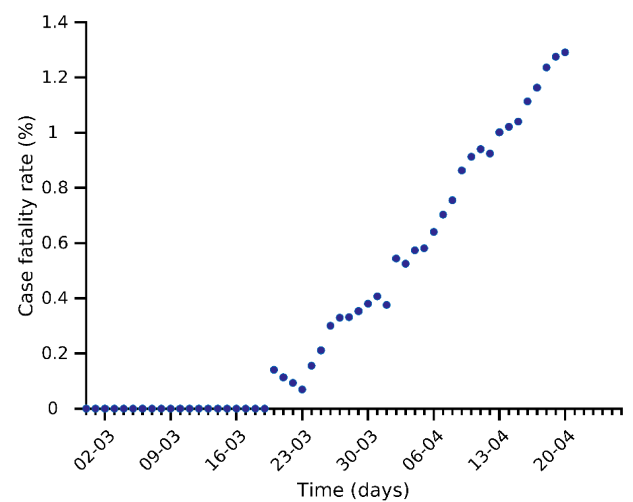
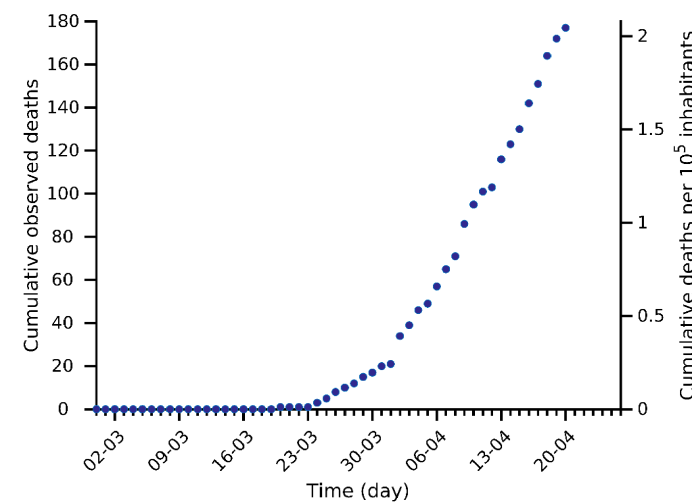
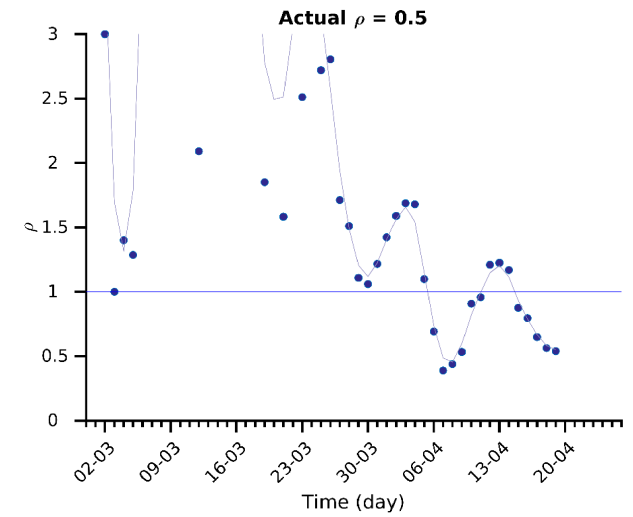
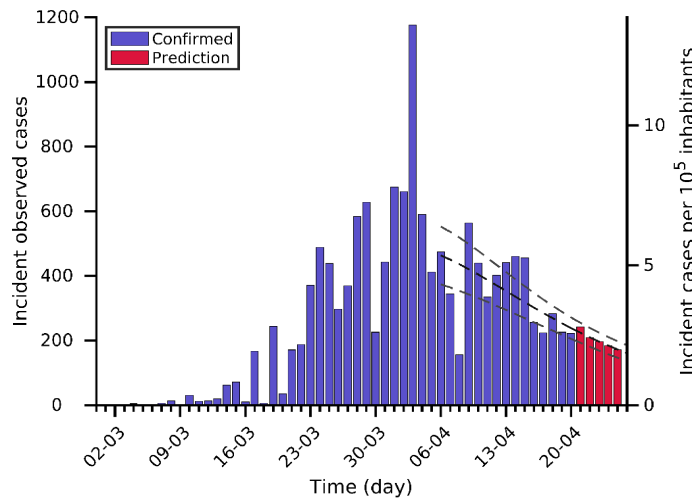
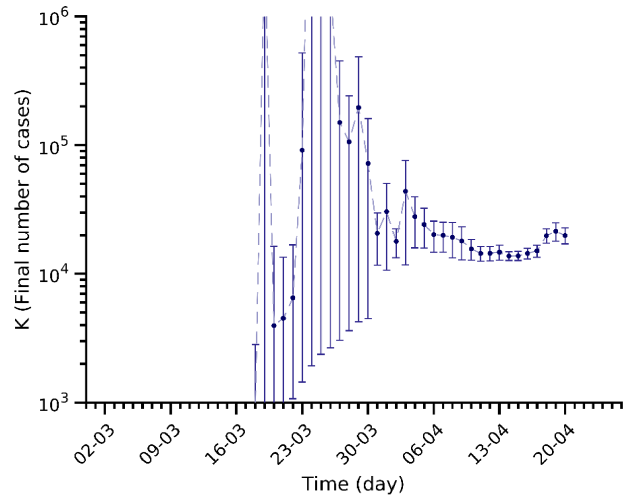
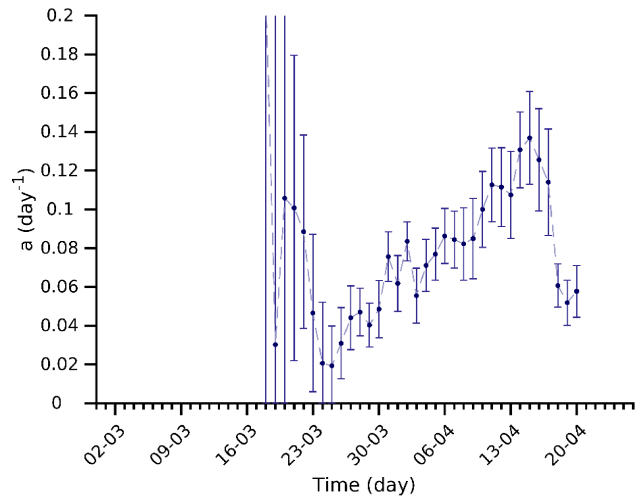
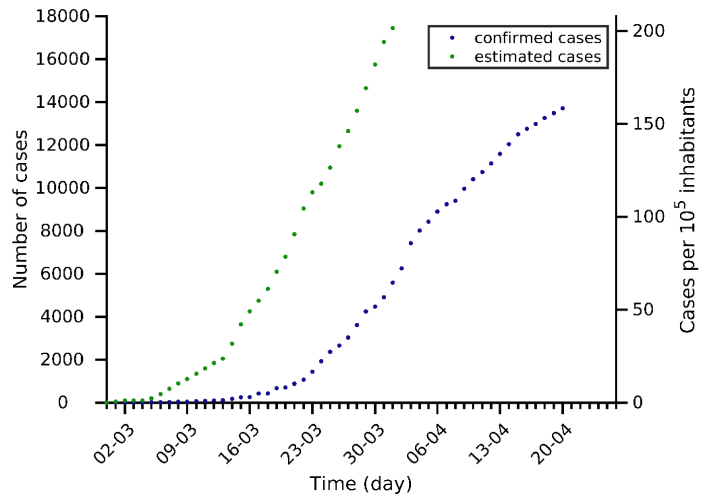
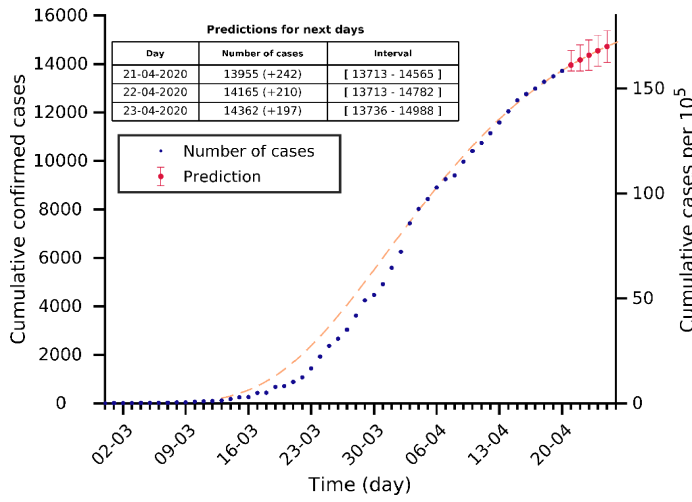
India 20-04-2020. Population: 1353000.0M. Current cumulated incidence: 0/10⁵



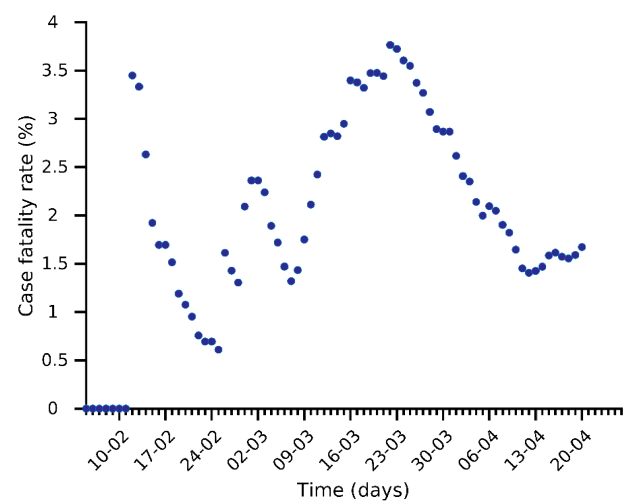
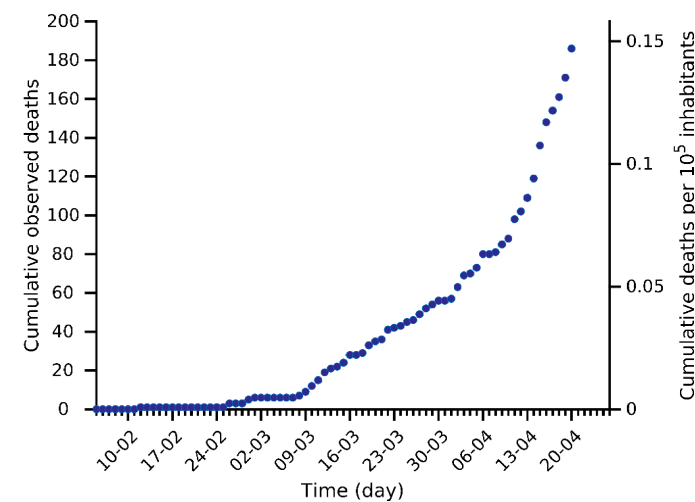
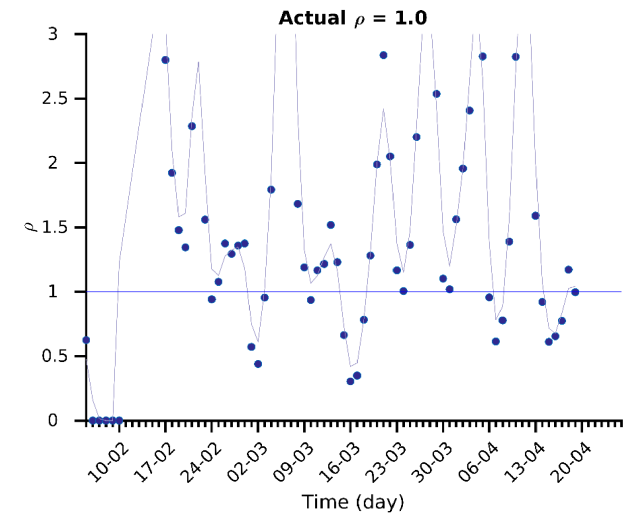
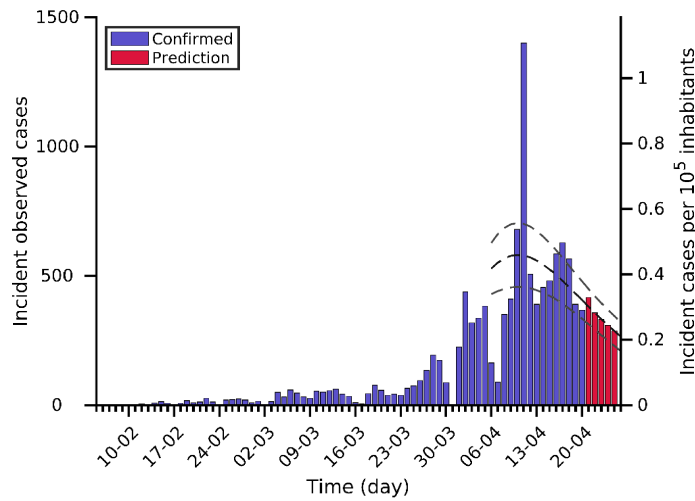
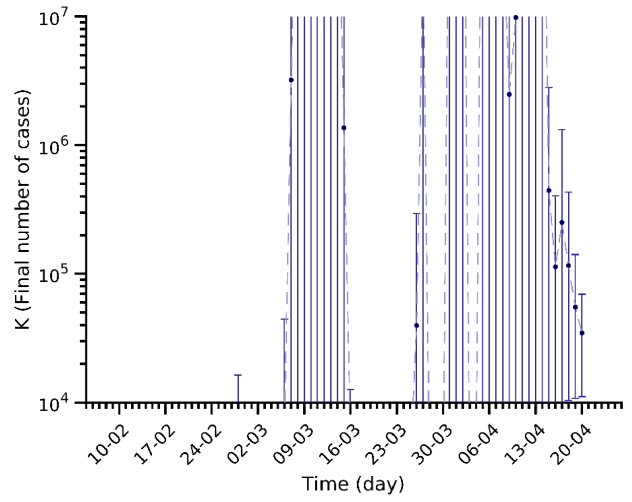
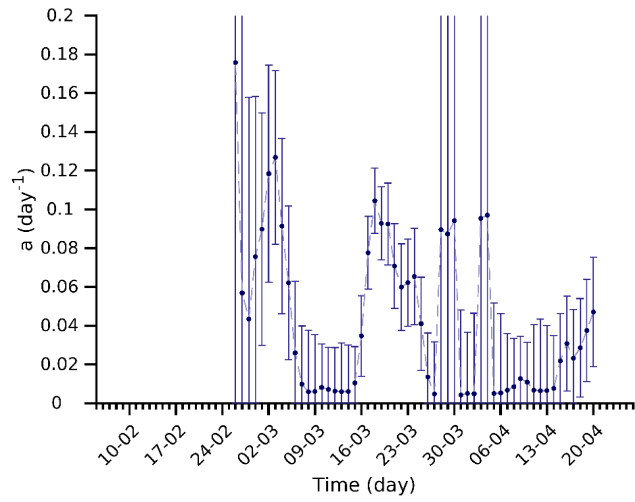
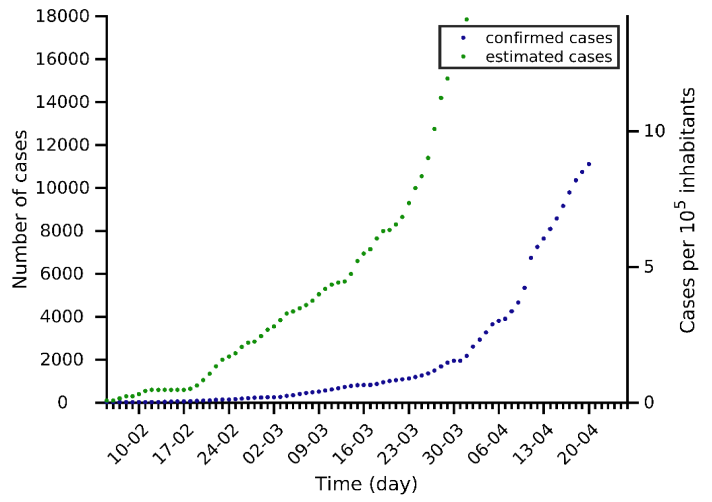
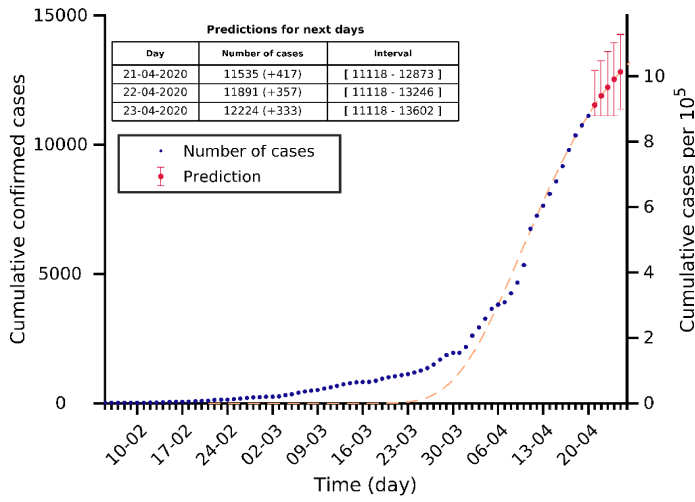
Peru 20-04-2020. Population: 33.0M. Current cumulated incidence: 50/10⁵



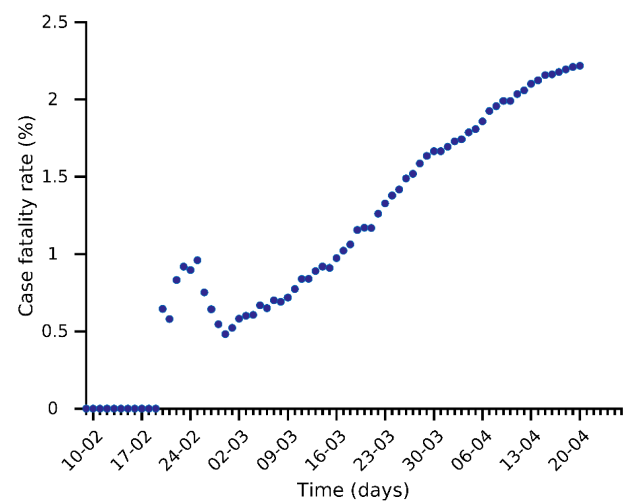
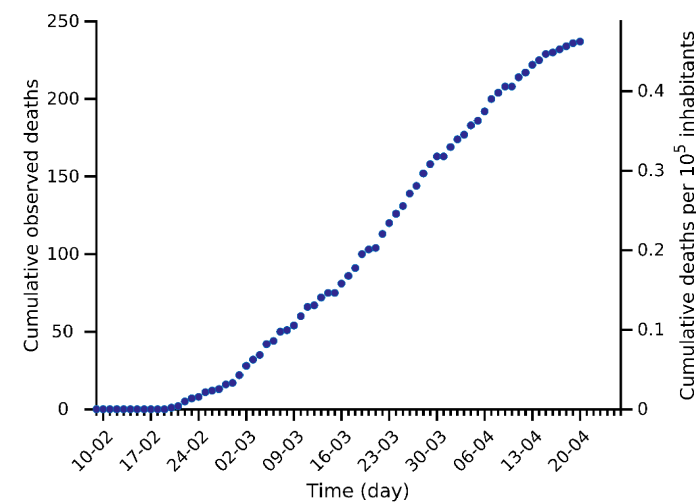
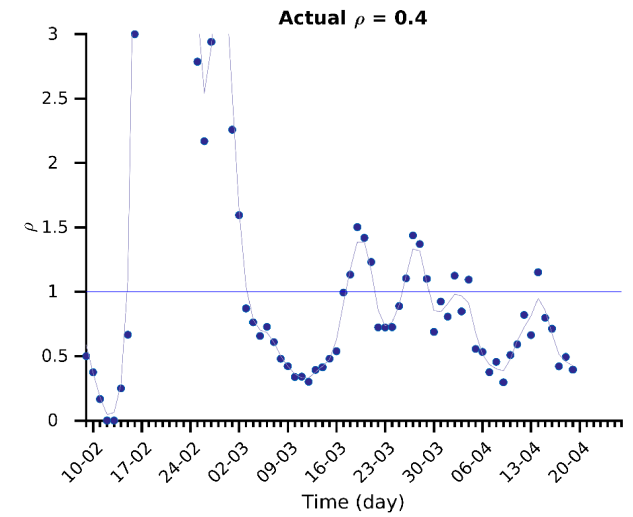
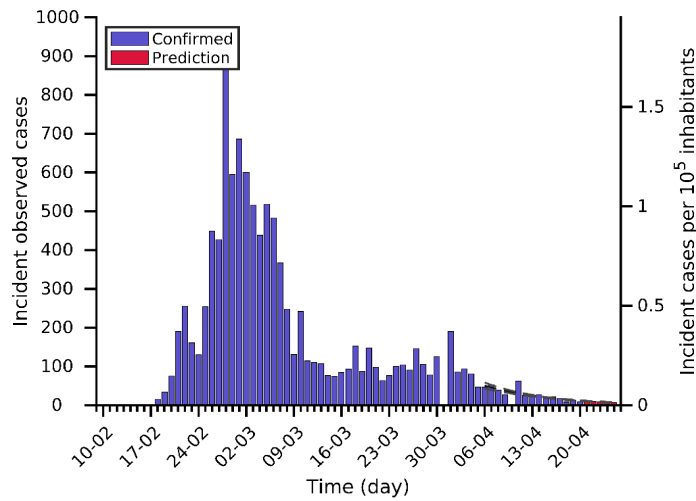
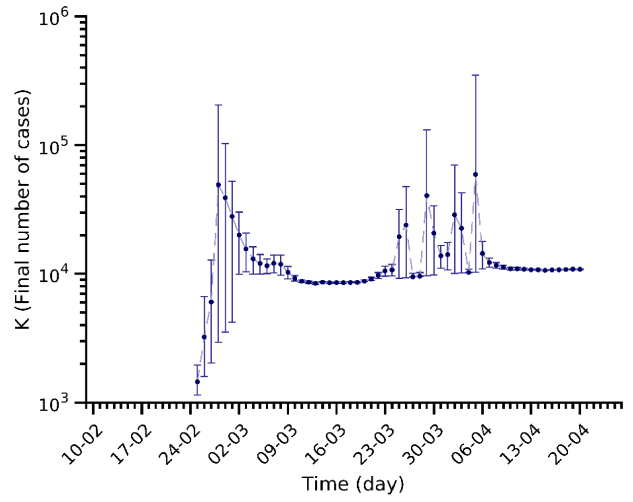
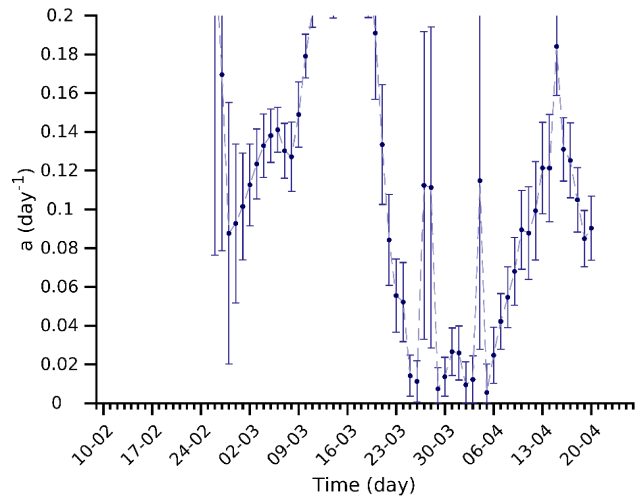
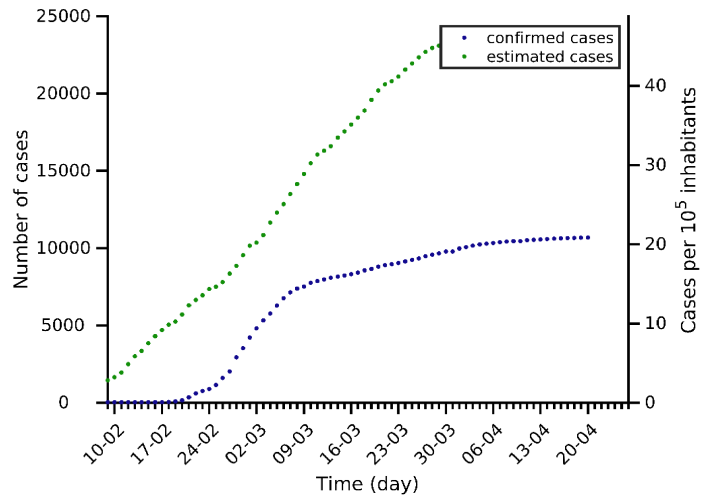
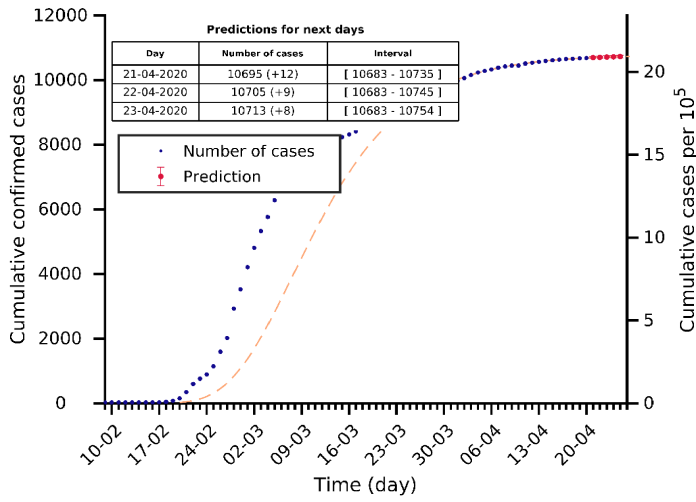
Israel 20-04-2020. Population: 8.7M. Current cumulated incidence: 158/10⁵



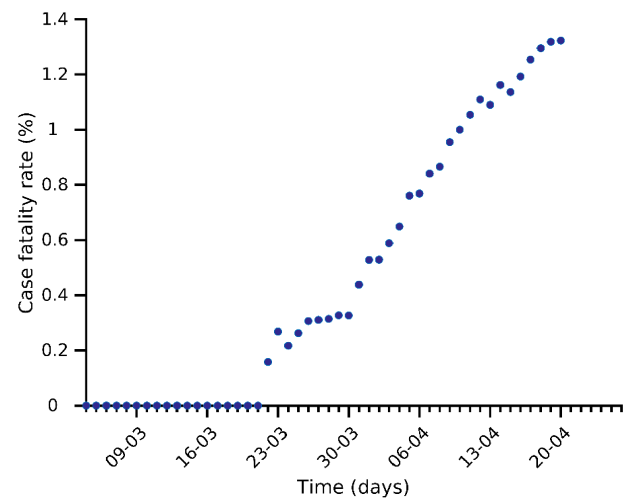
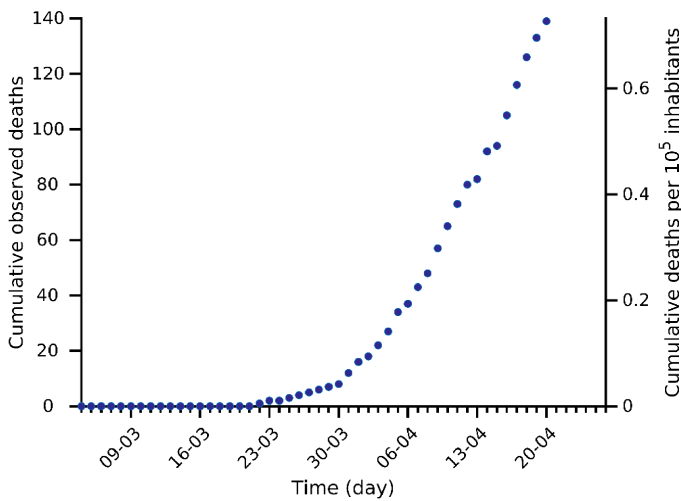
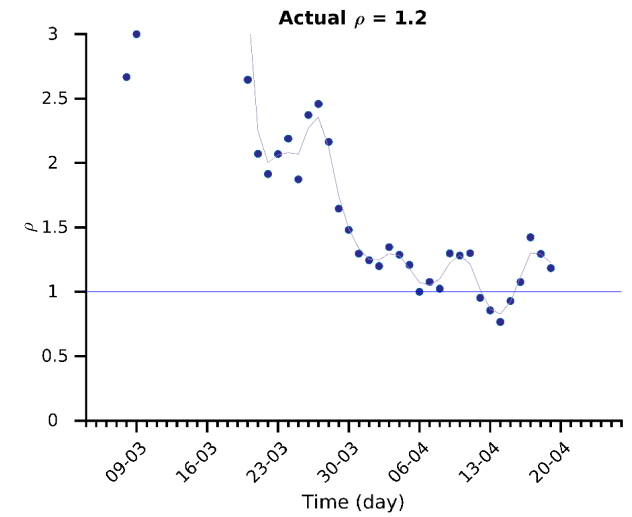
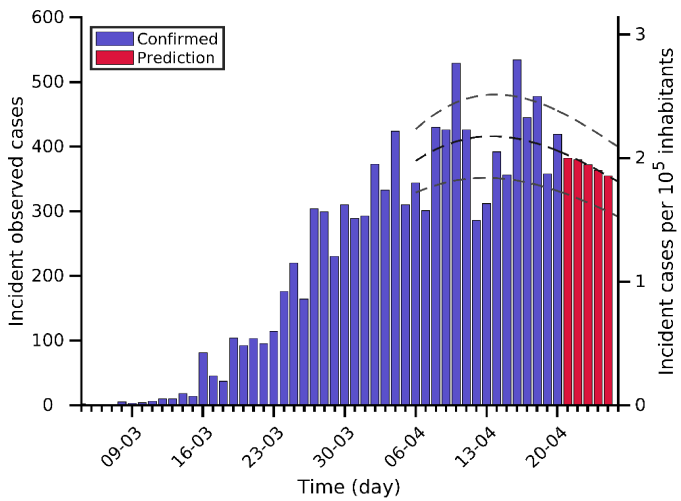
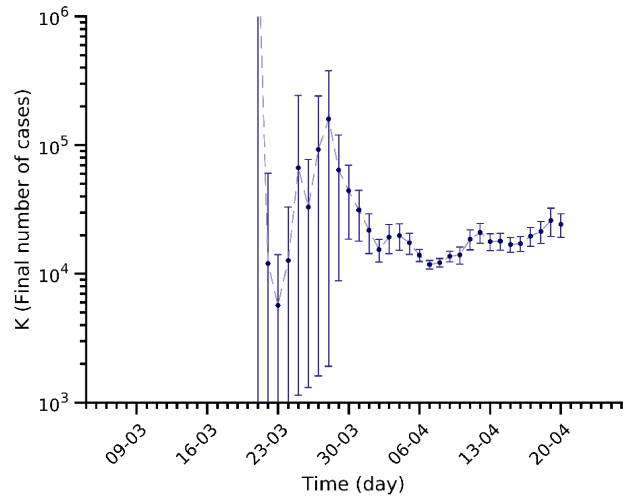
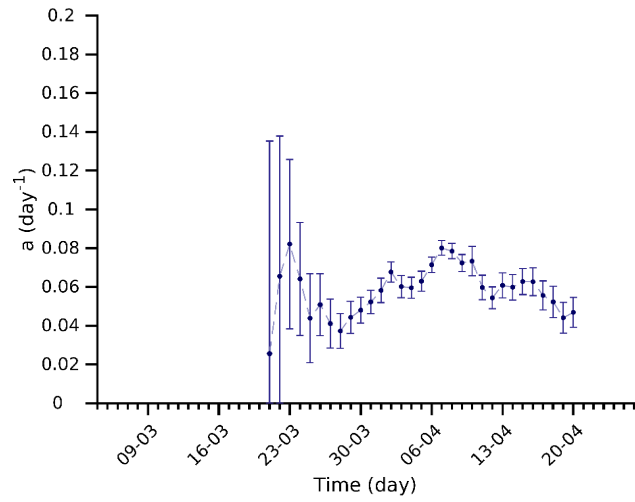
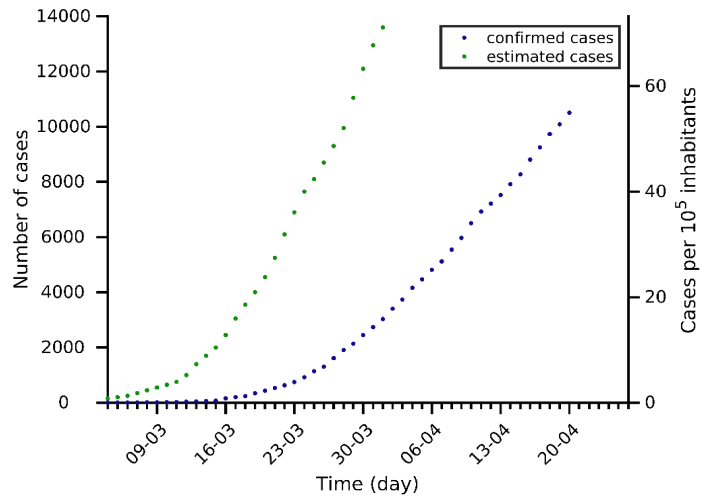
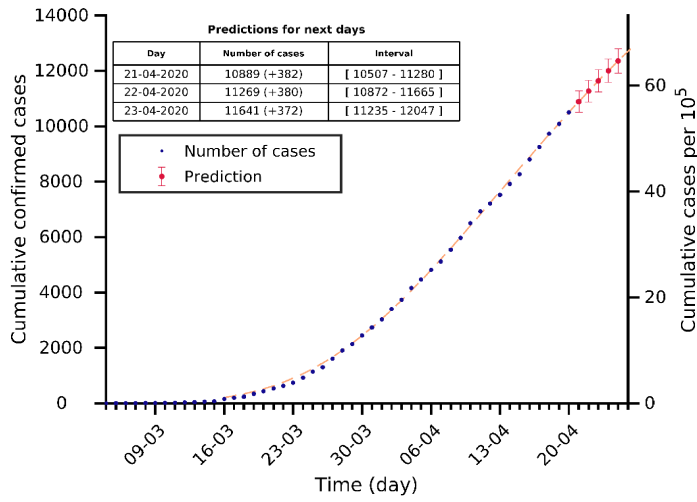
Japan 20-04-2020. Population: 126.5M. Current cumulated incidence: $9/10^5$



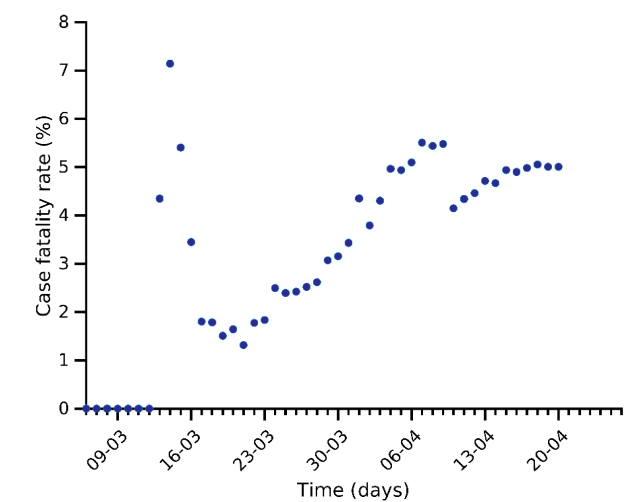
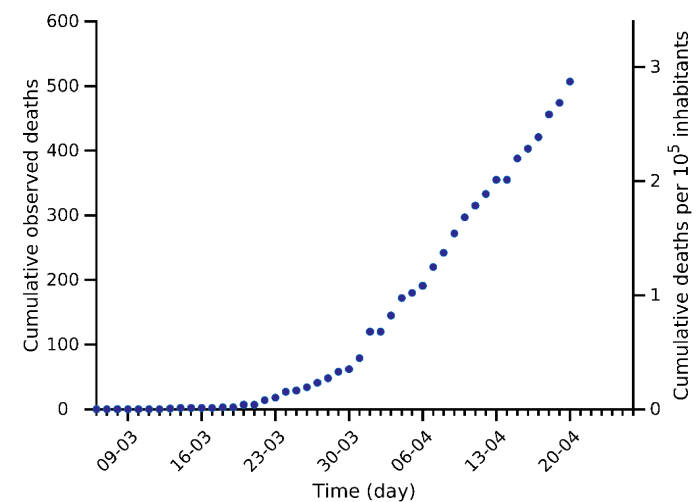
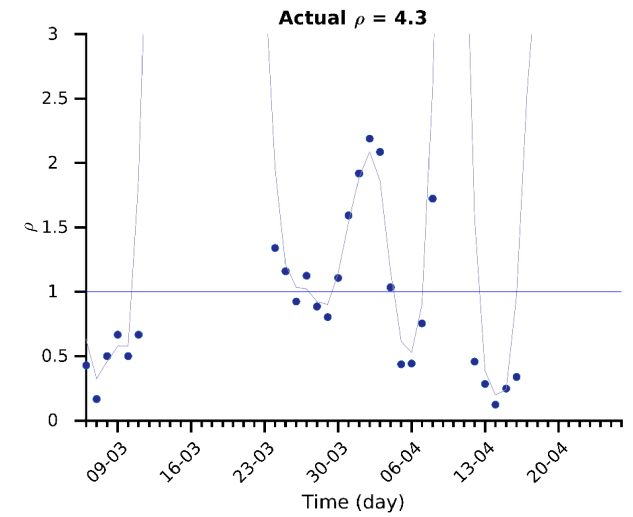
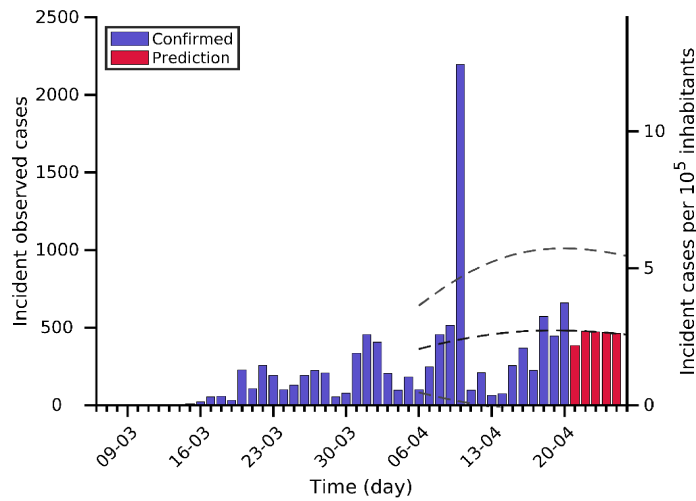
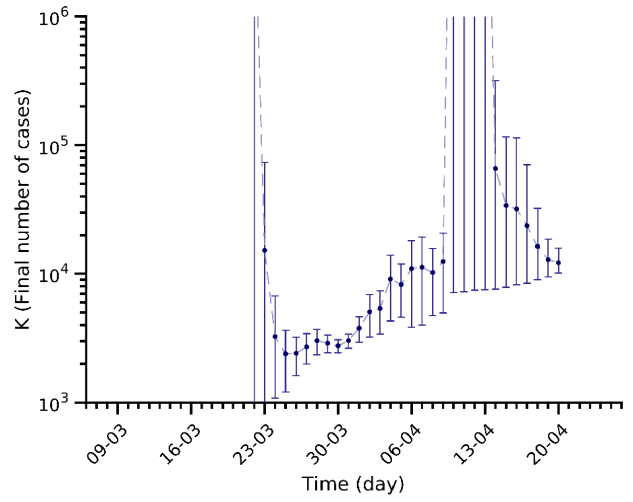
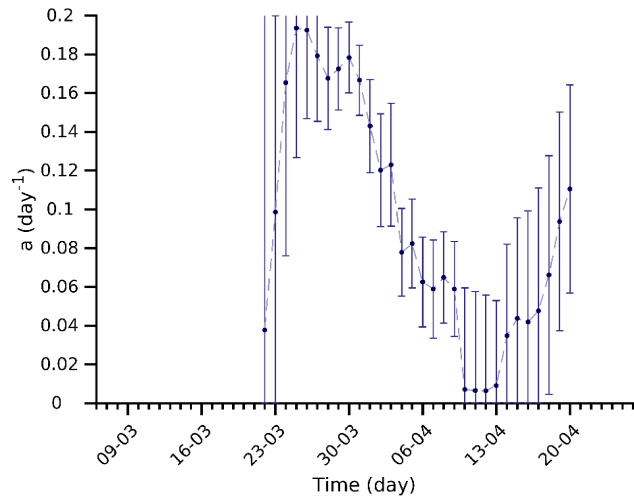
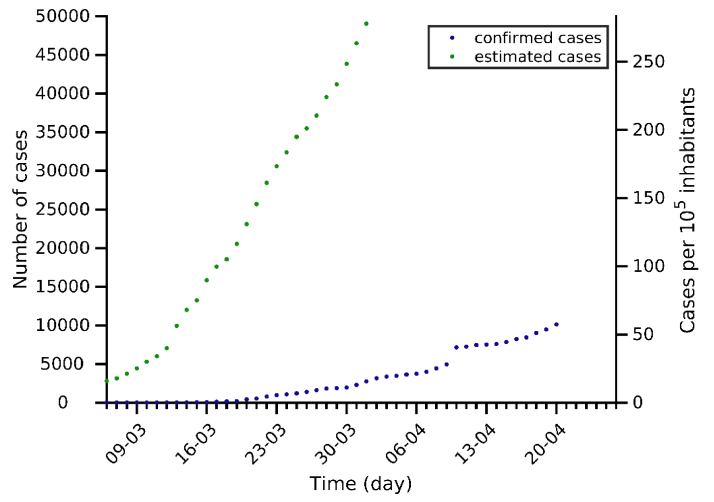
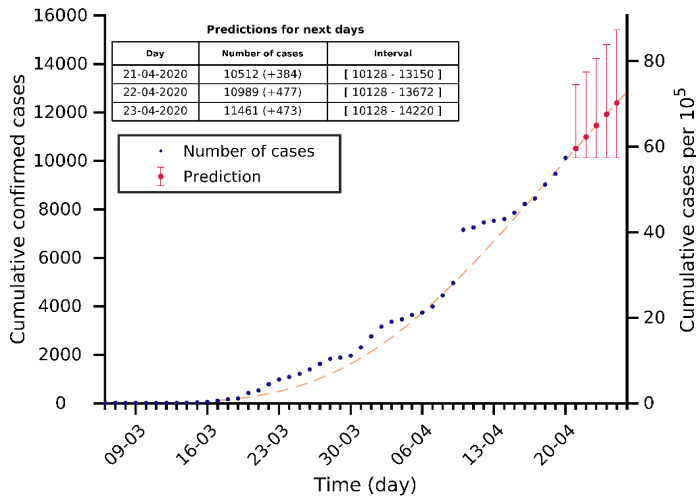
South Korea 20-04-2020. Population: 51.3M. Current cumulated incidence: 21/10⁵



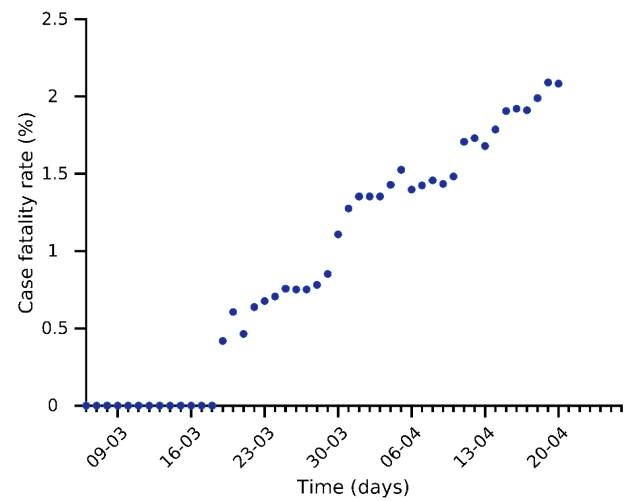
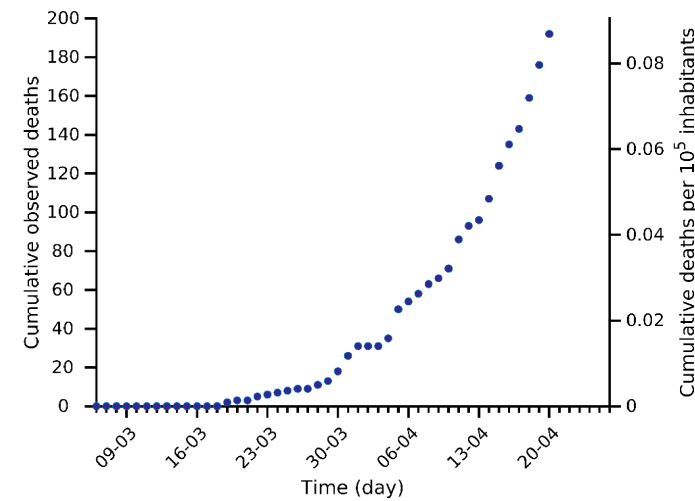
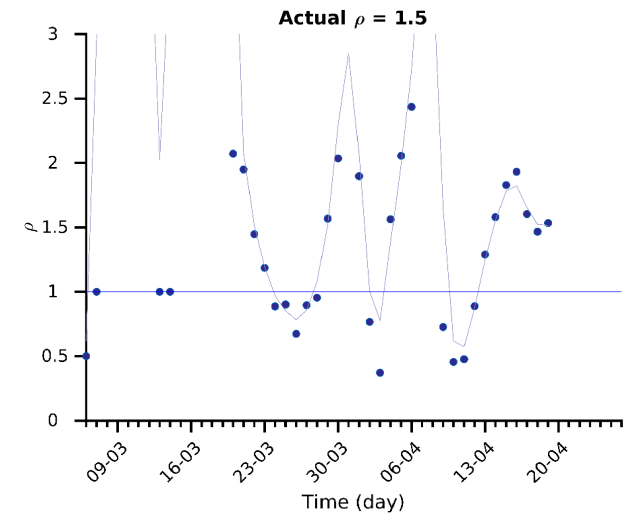
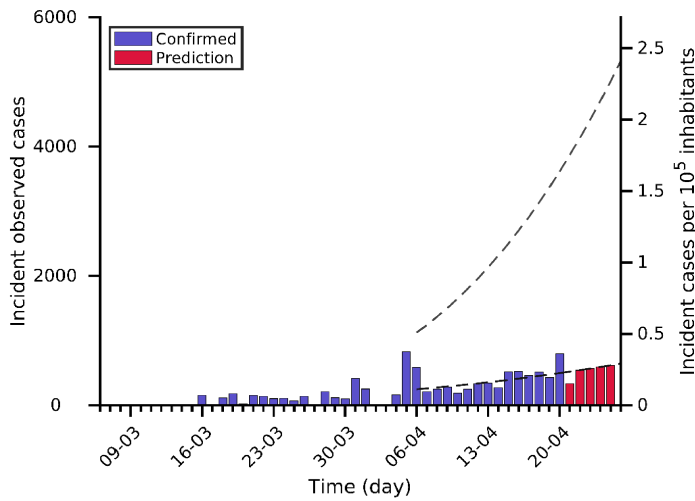
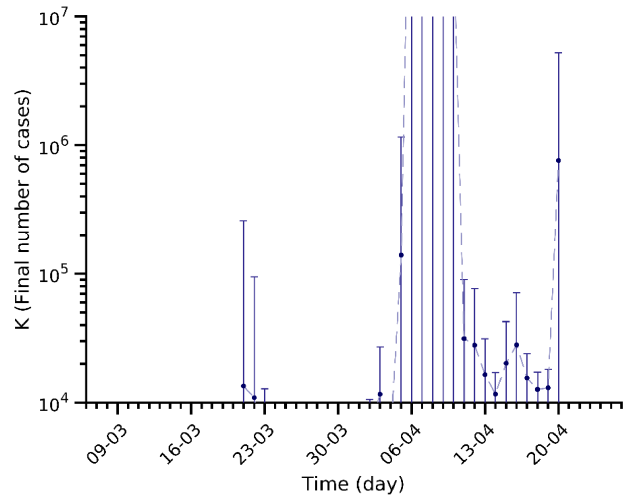
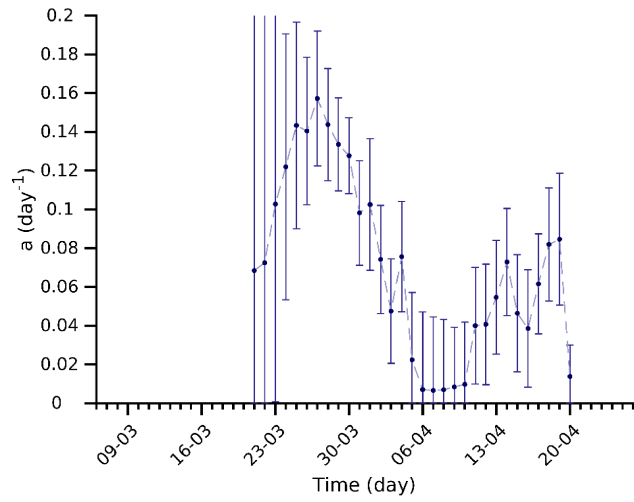
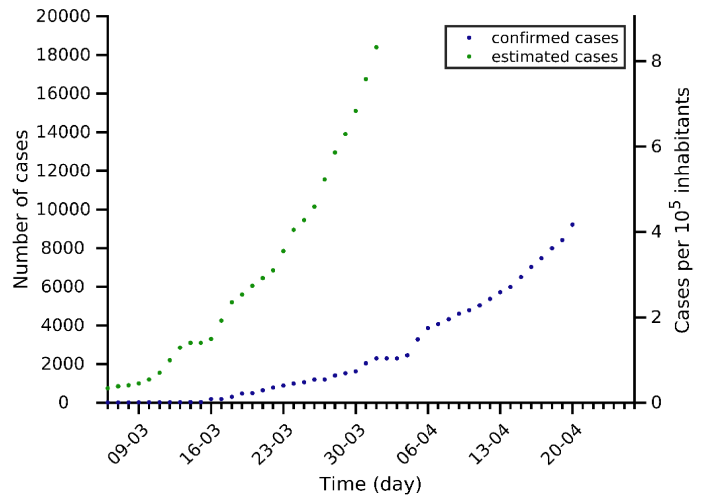
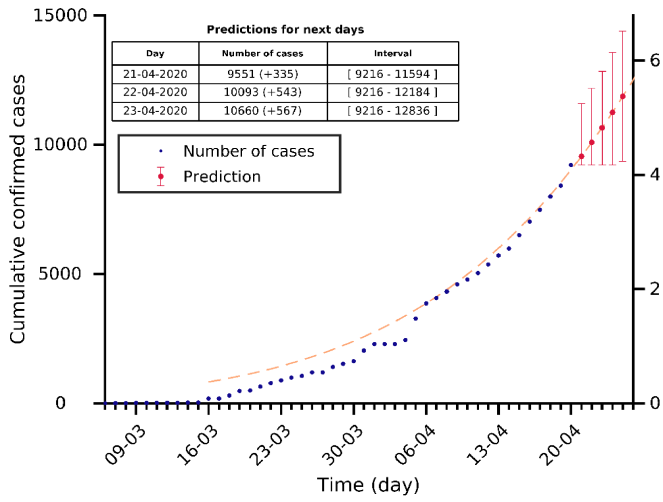
Chile 20-04-2020. Population: 19.1M. Current cumulated incidence: 55/10⁵



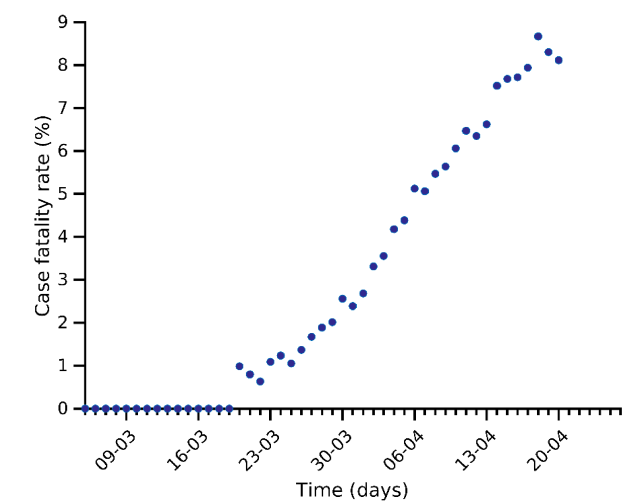
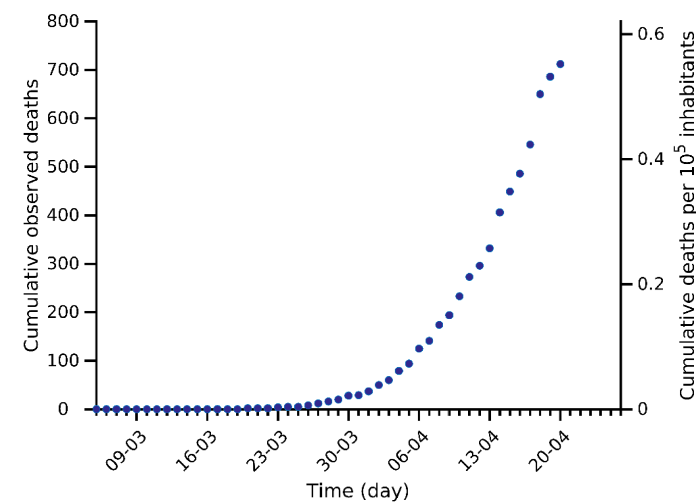
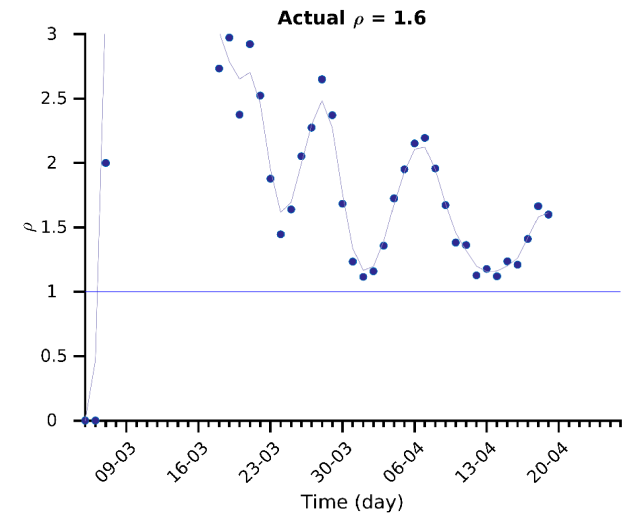
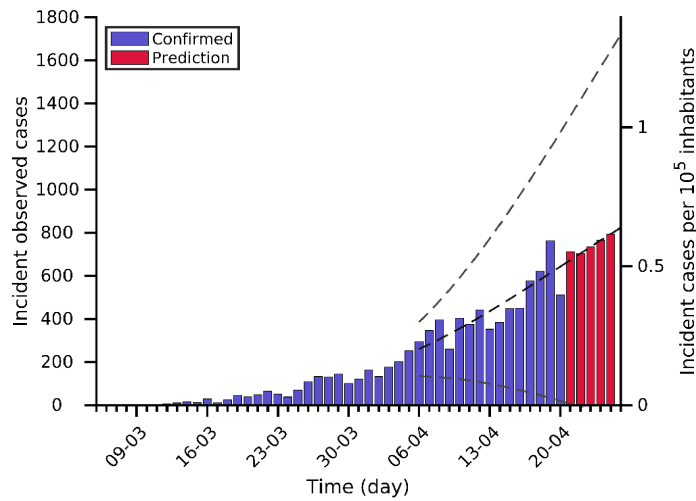
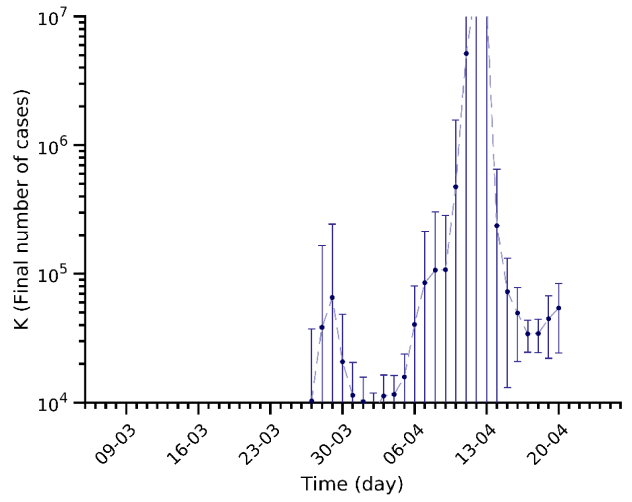
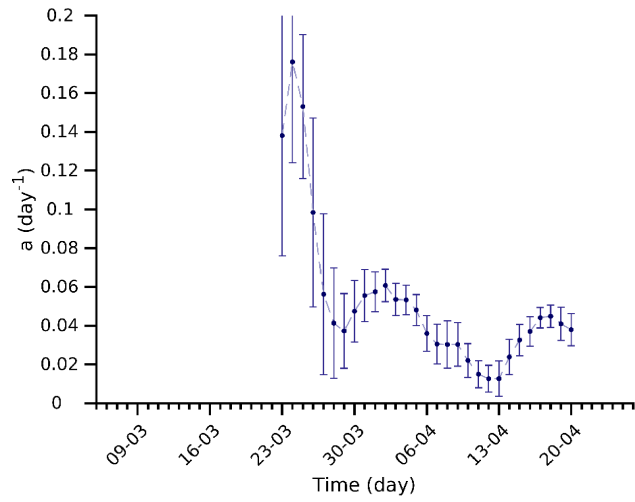
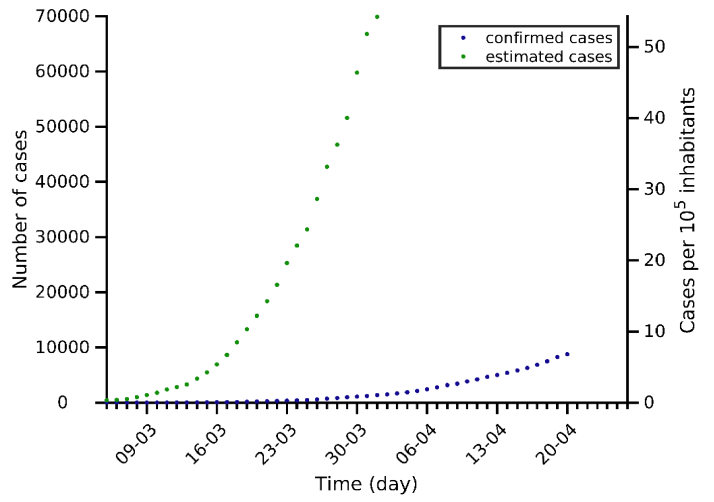
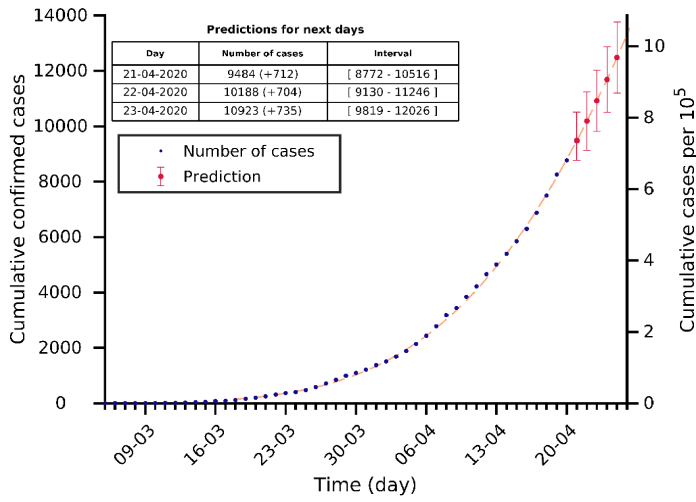
Ecuador 20-04-2020. Population: 17.6M. Current cumulated incidence: 57/10⁵



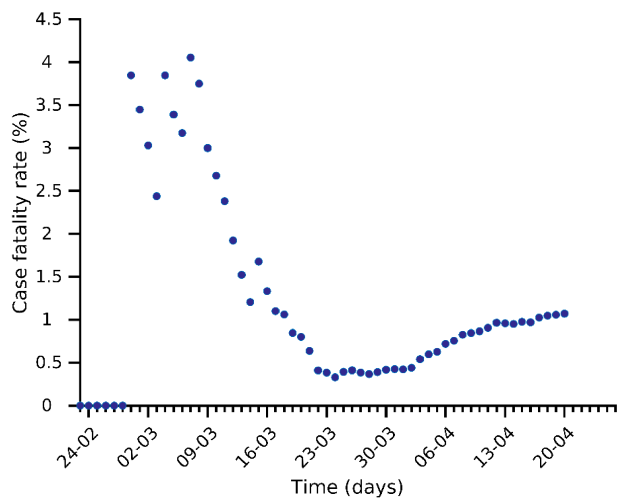
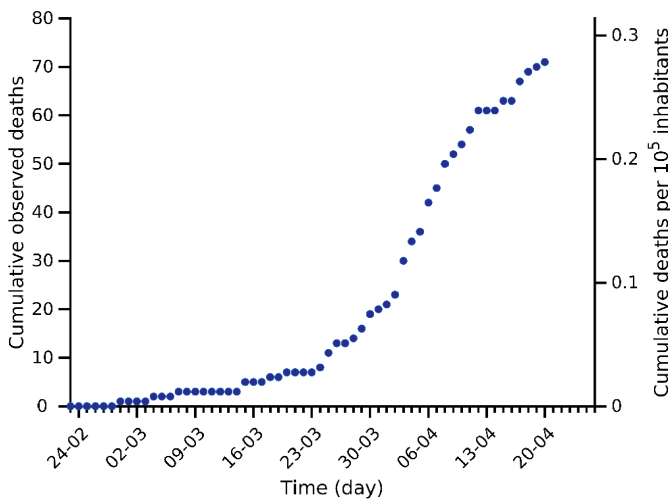
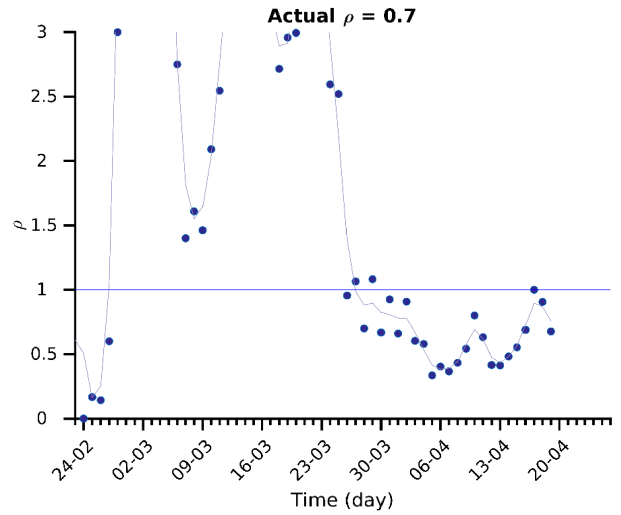
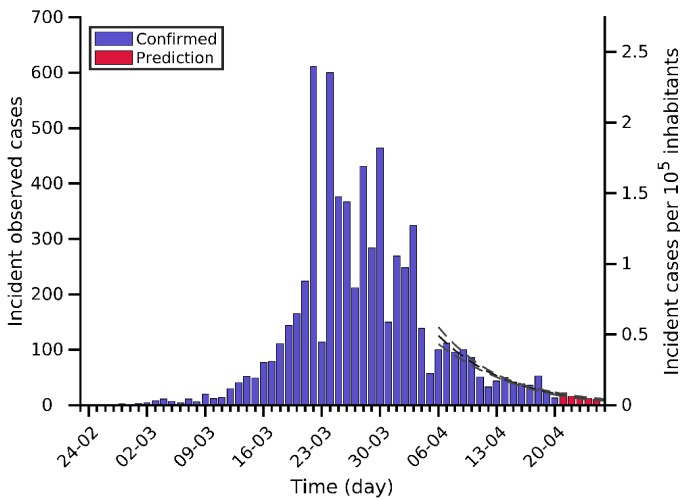
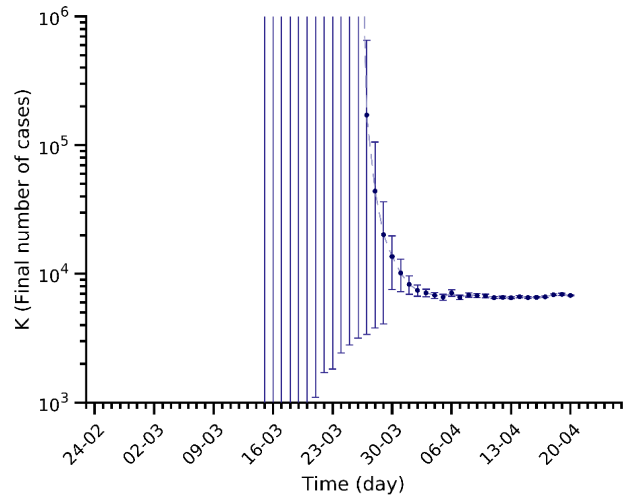
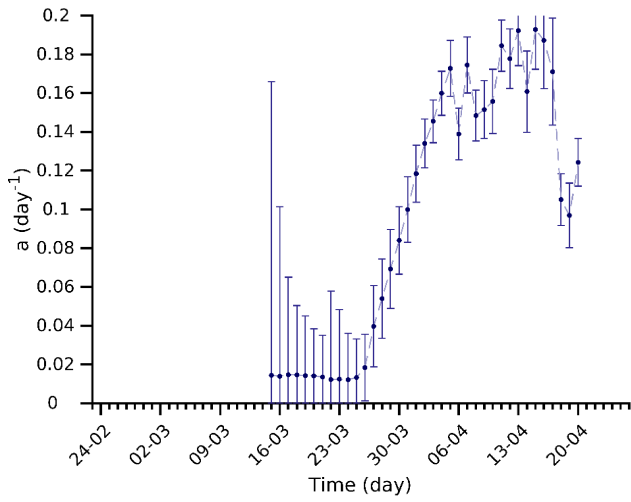
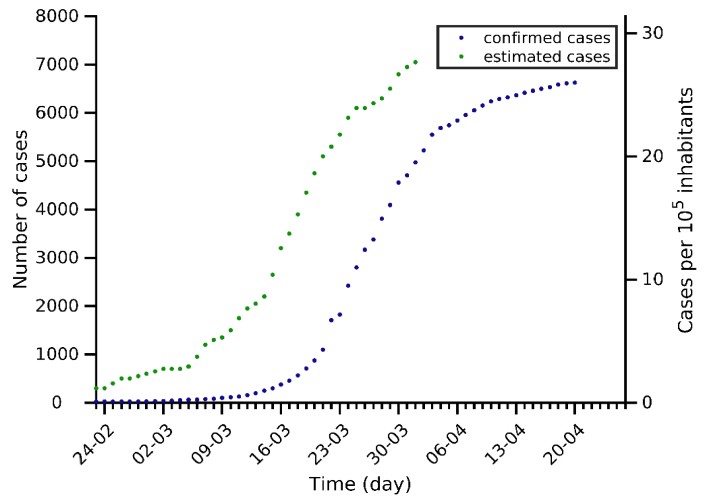
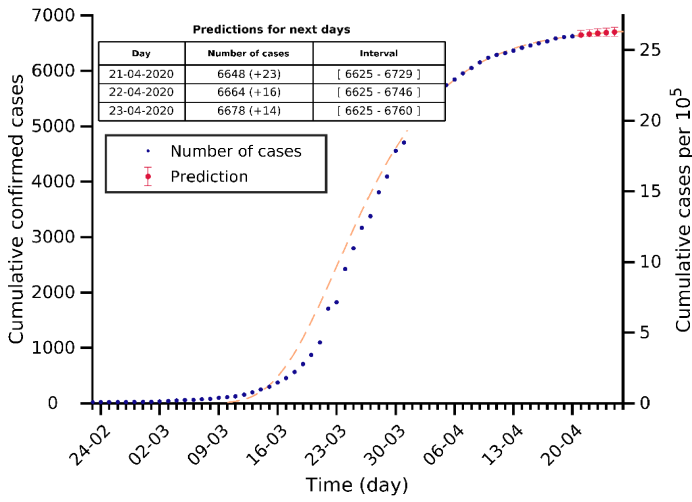
Pakistan 20-04-2020. Population: 220.9M. Current cumulated incidence: 4/10⁵



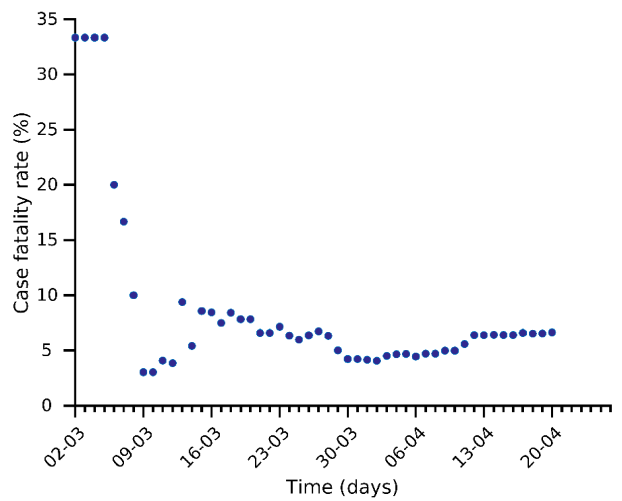
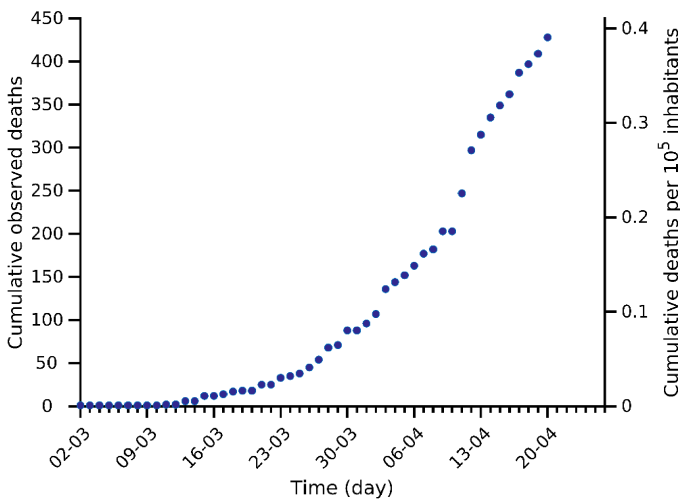
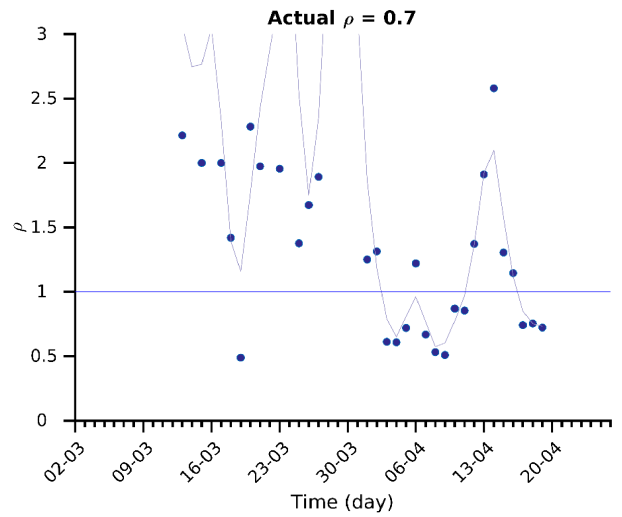
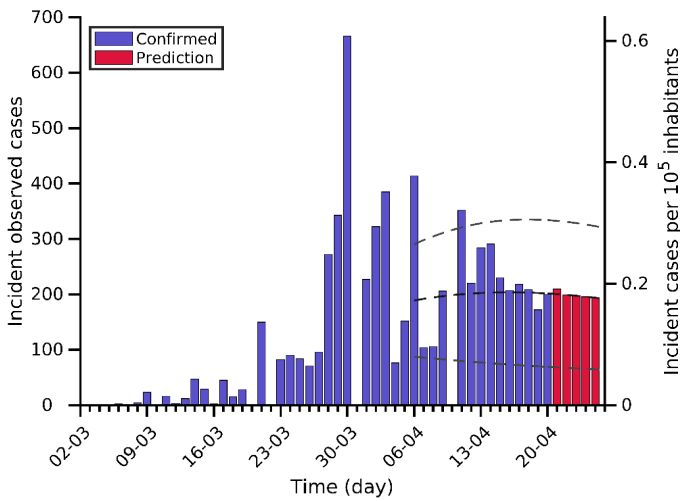
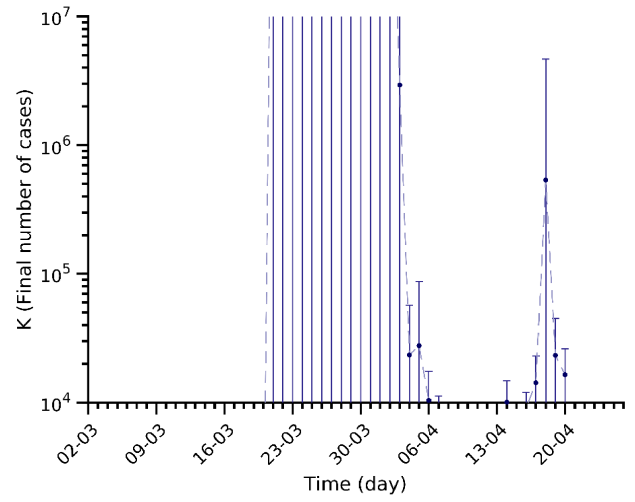
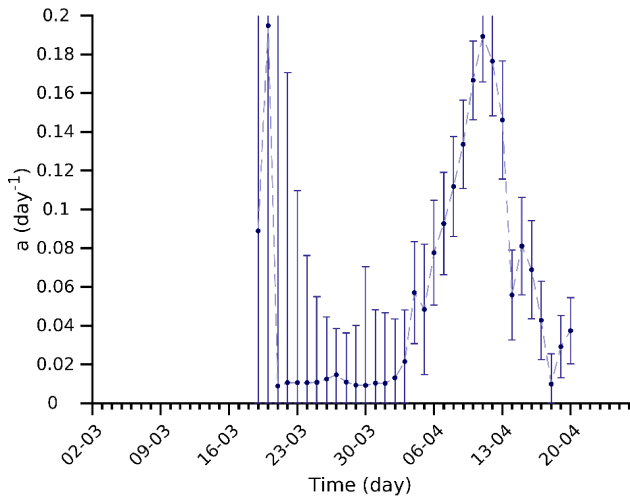
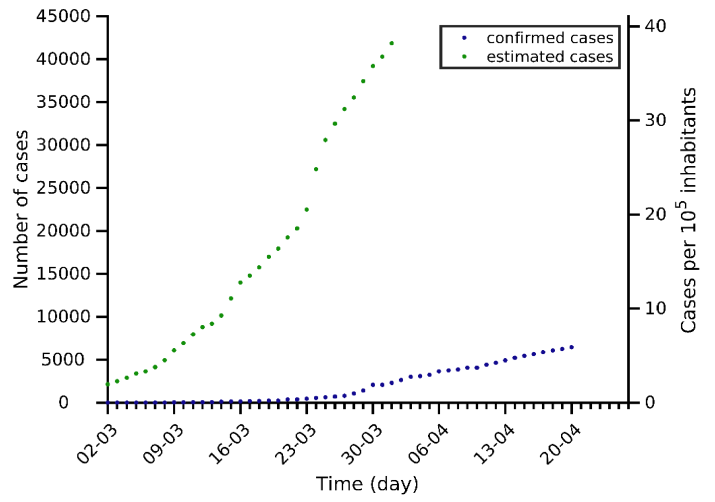
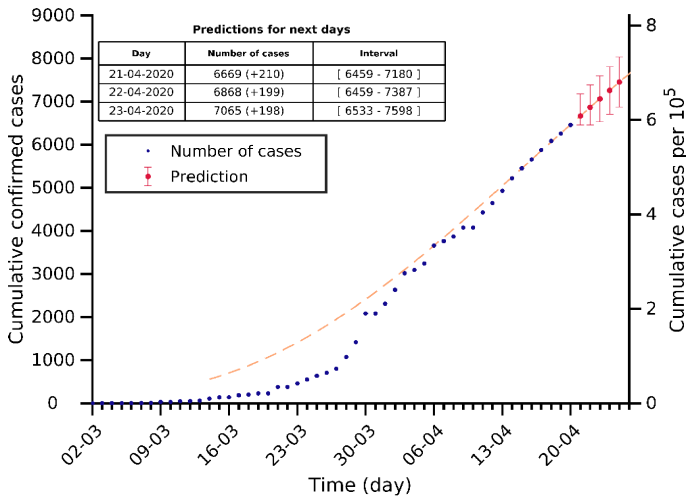
Mexico 20-04-2020. Population: 128.9M. Current cumulated incidence: 7/10⁵



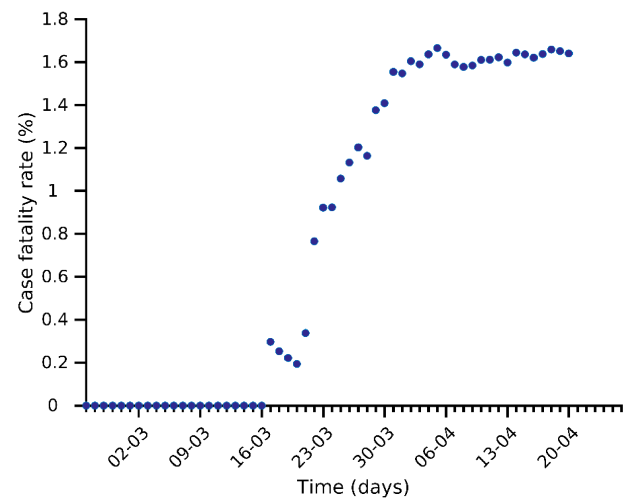
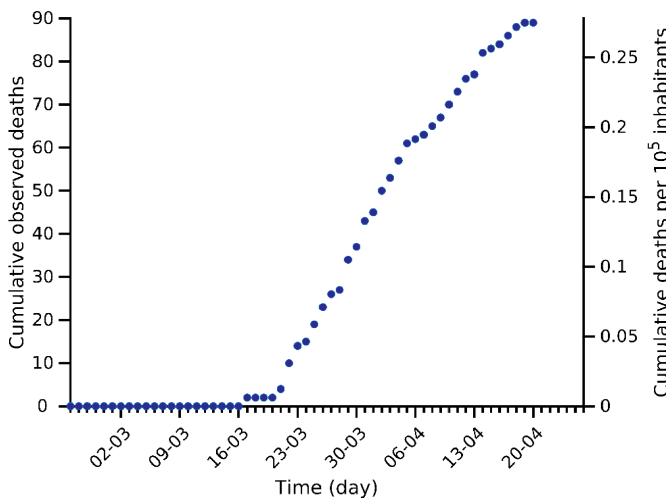
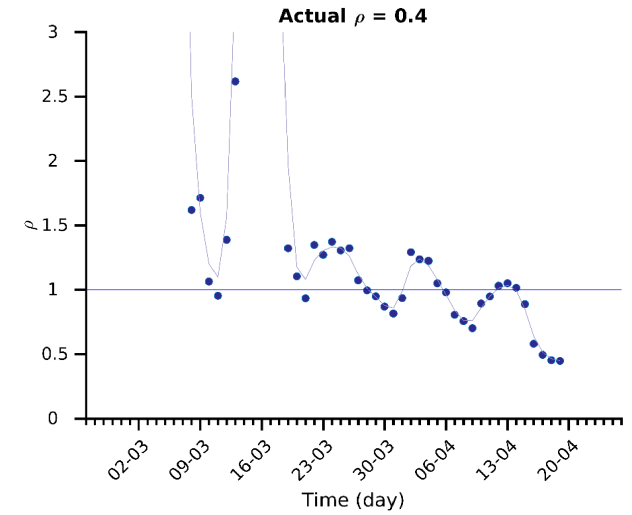
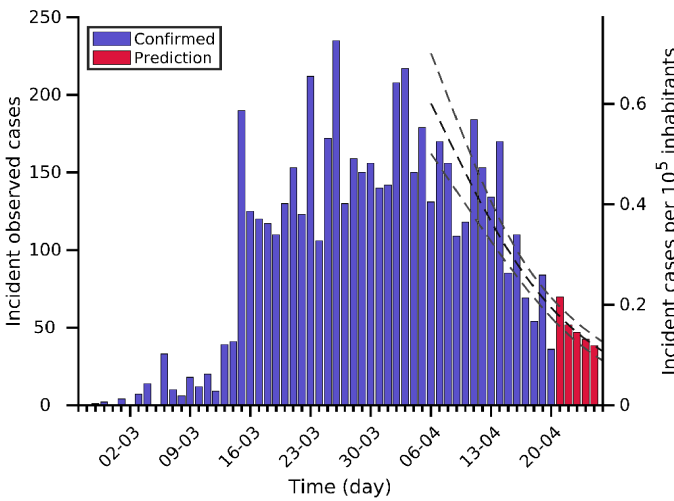
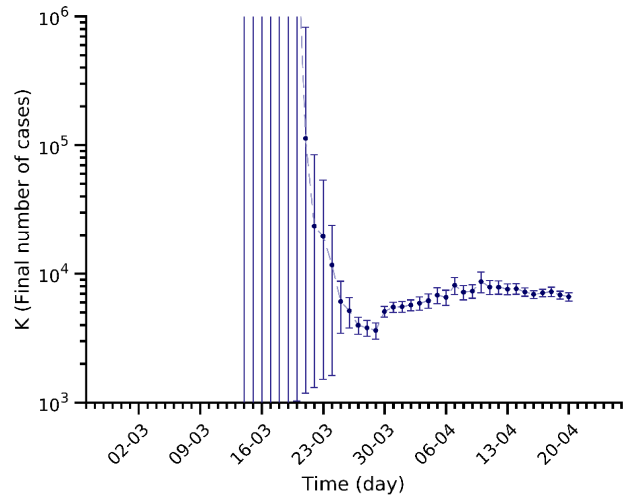
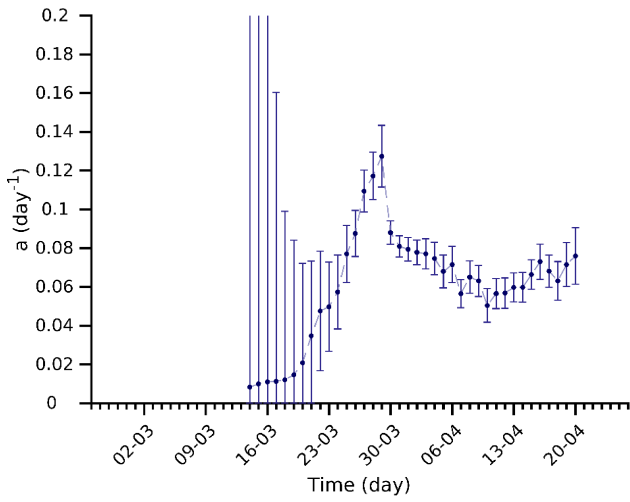
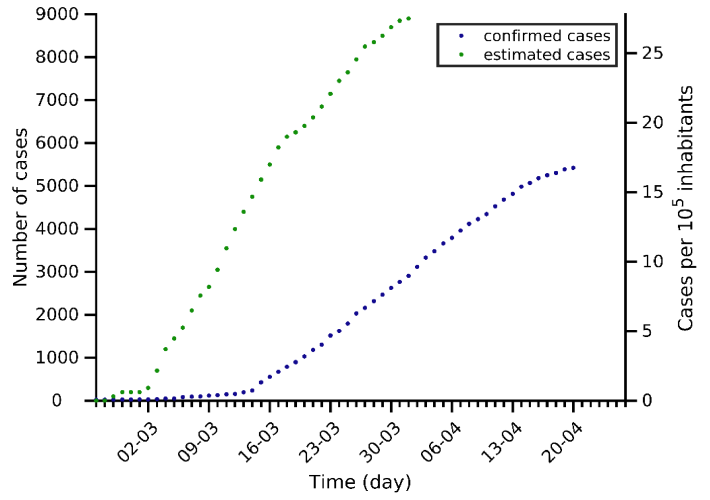
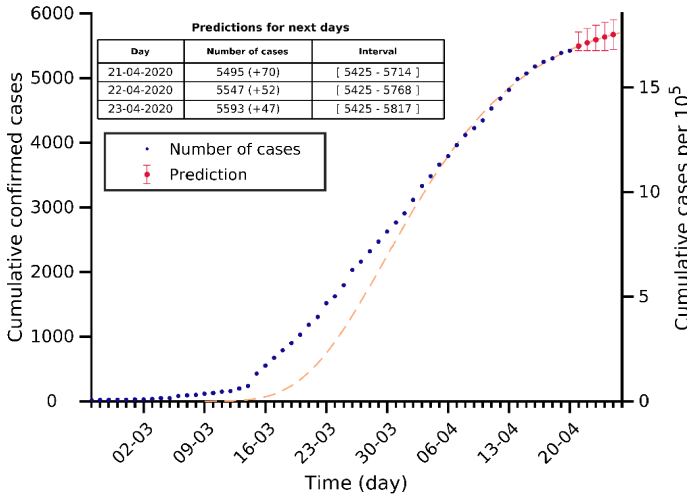
Australia 20-04-2020. Population: 25.5M. Current cumulated incidence: 26/10⁵



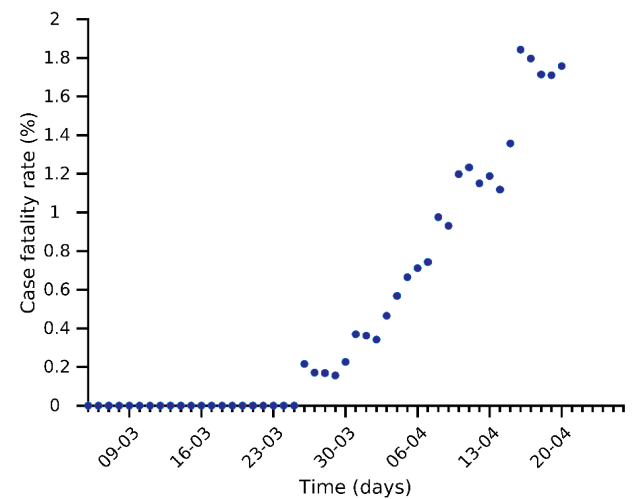
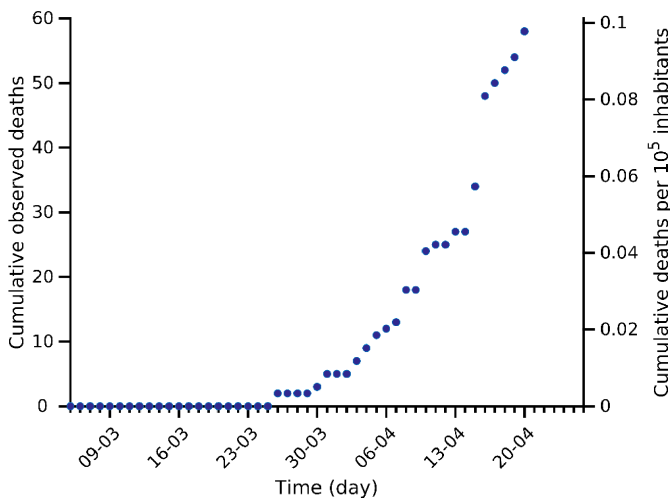
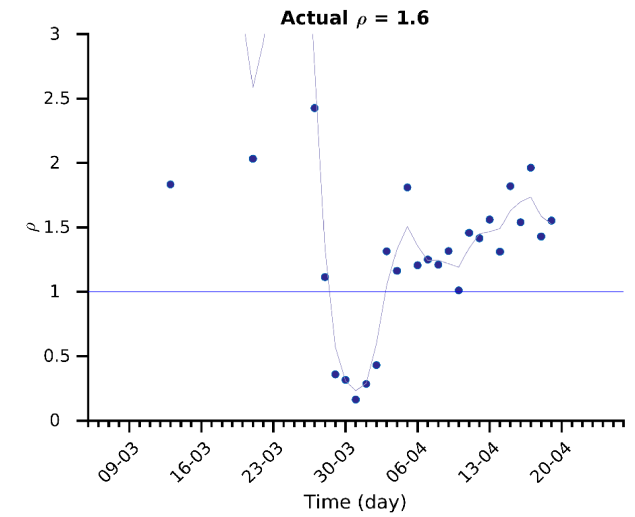
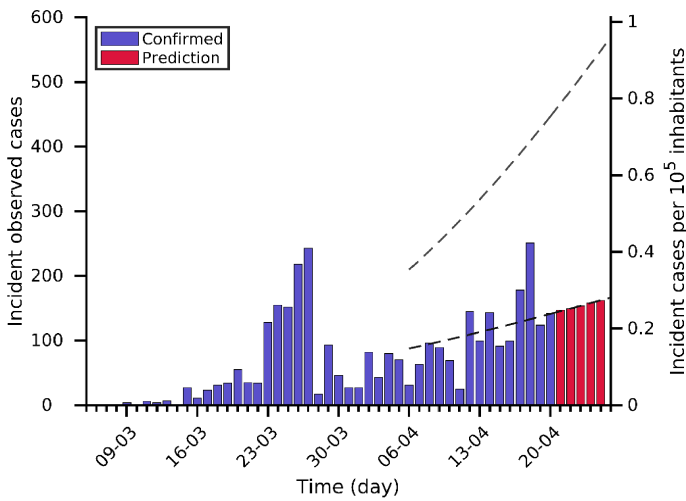
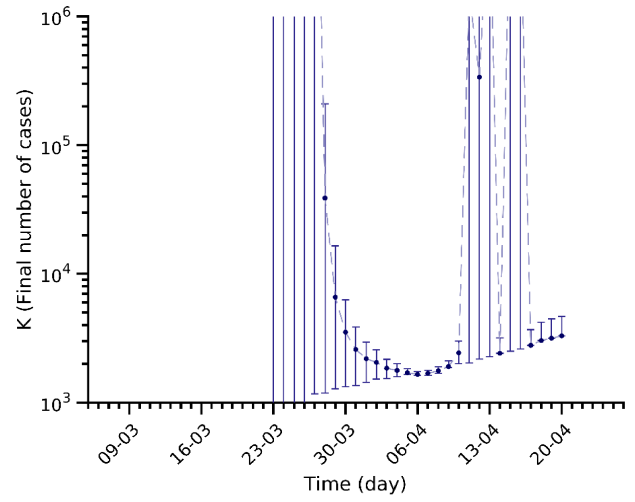
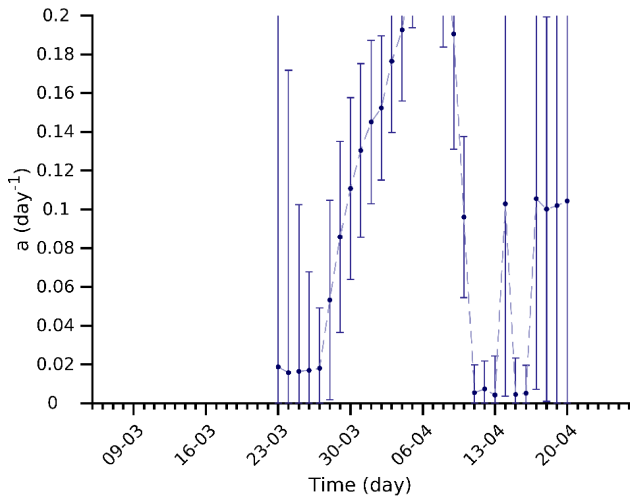
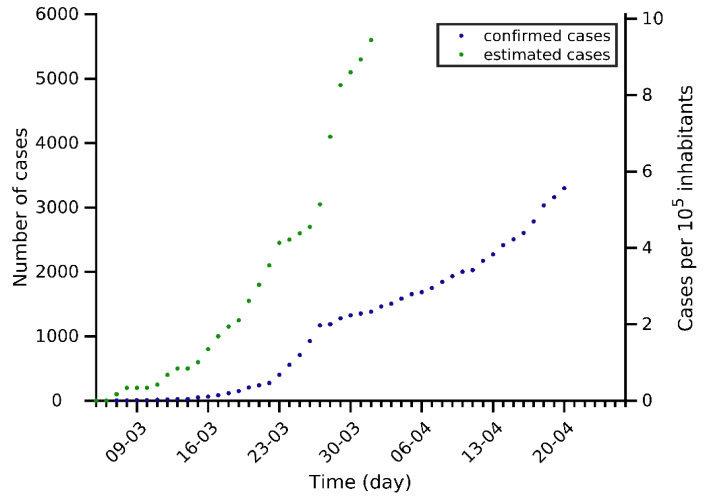
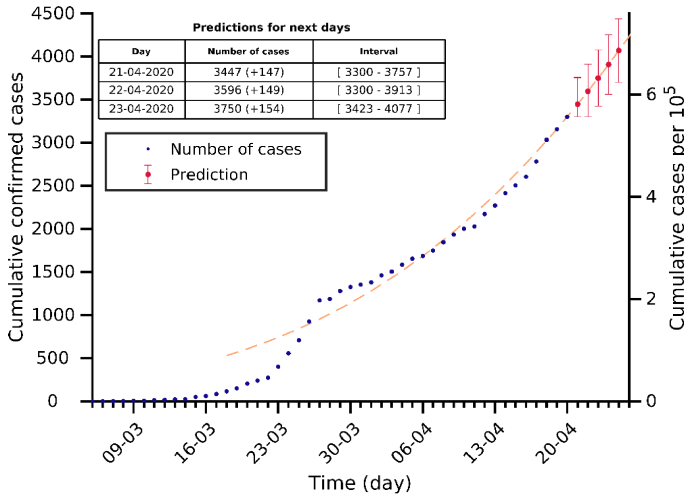
Philippines 20-04-2020. Population: 109.6M. Current cumulated incidence: 6/10⁵



Malaysia 20-04-2020. Population: 32.4M. Current cumulated incidence: 17/10⁵



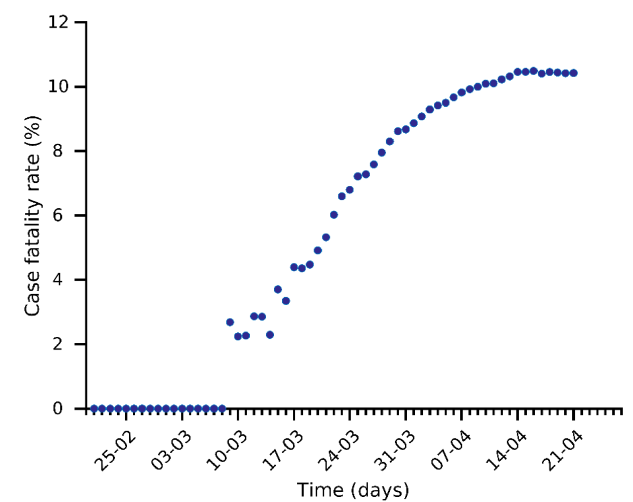
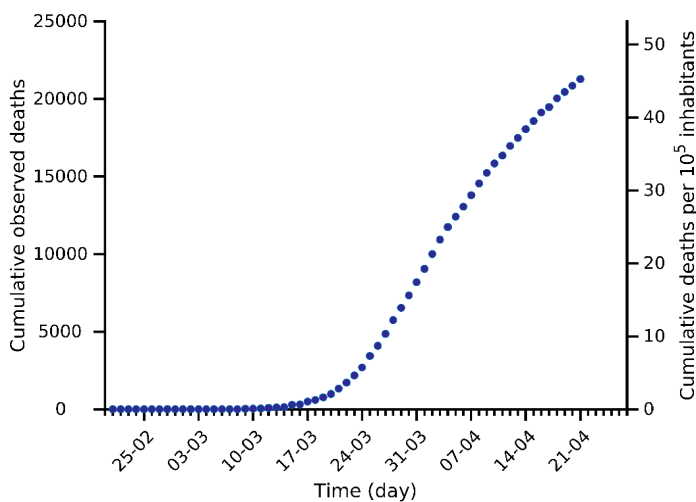
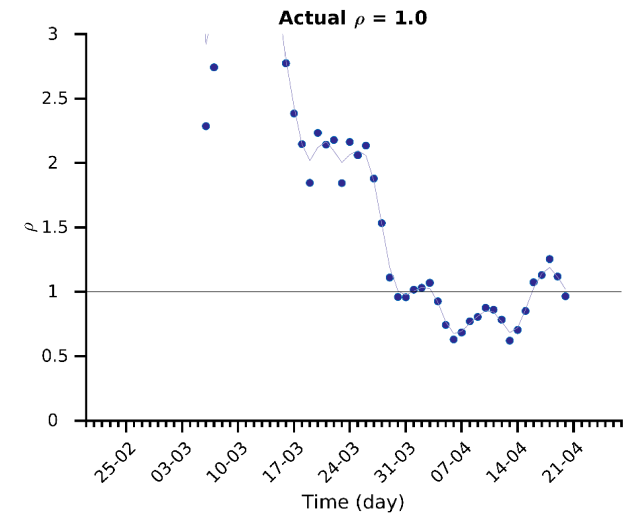
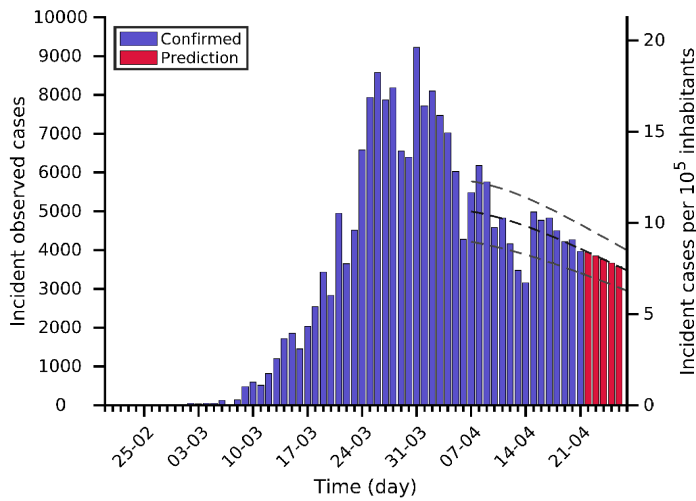
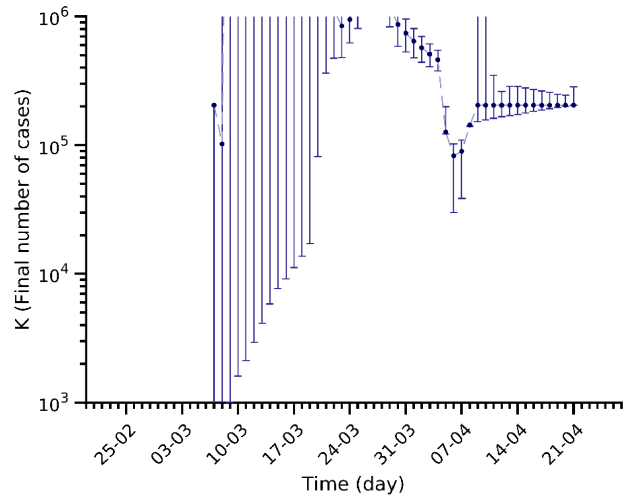
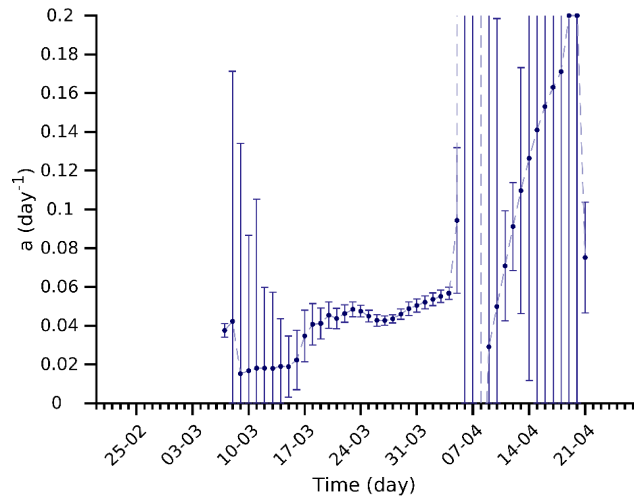
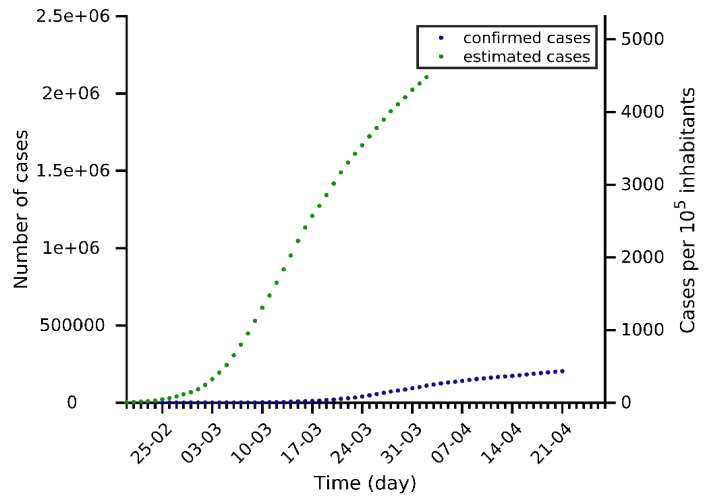
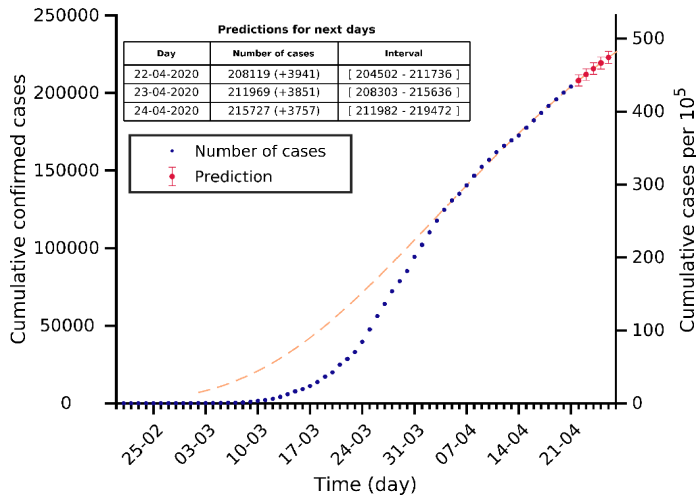
South Africa 20-04-2020. Population: 59.3M. Current cumulated incidence: 6/10⁵



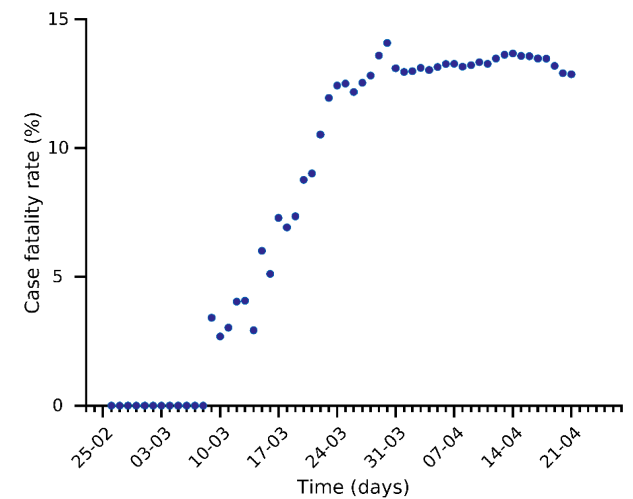
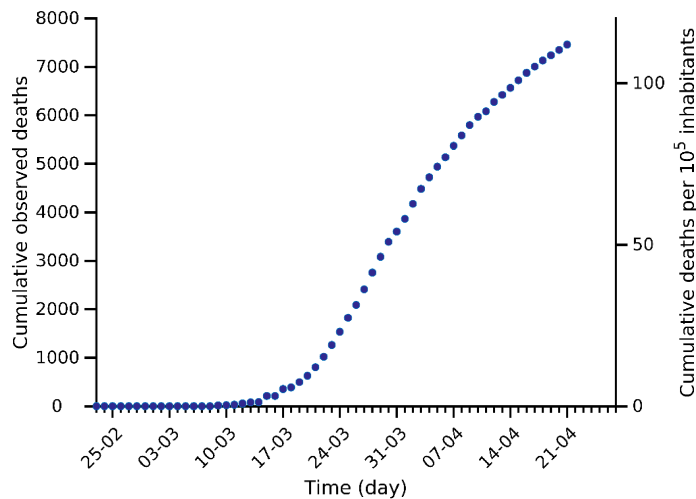
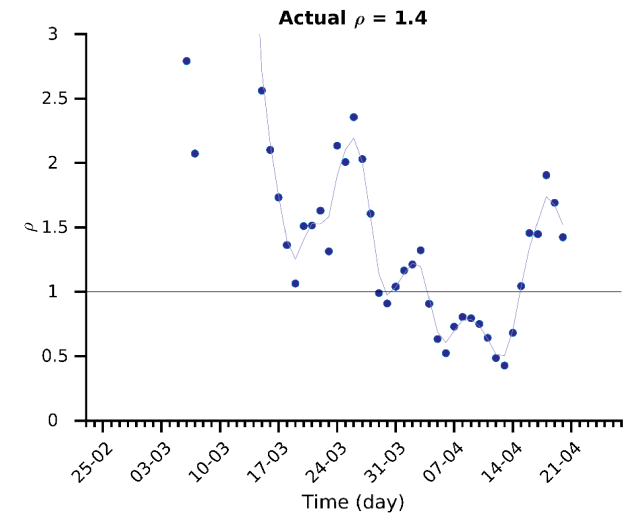
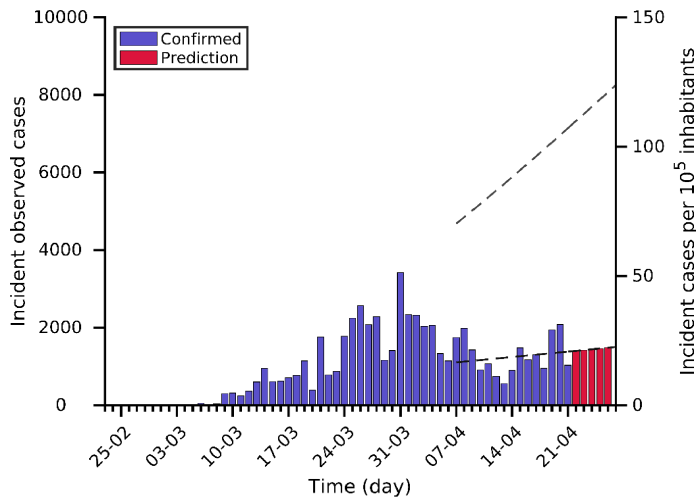
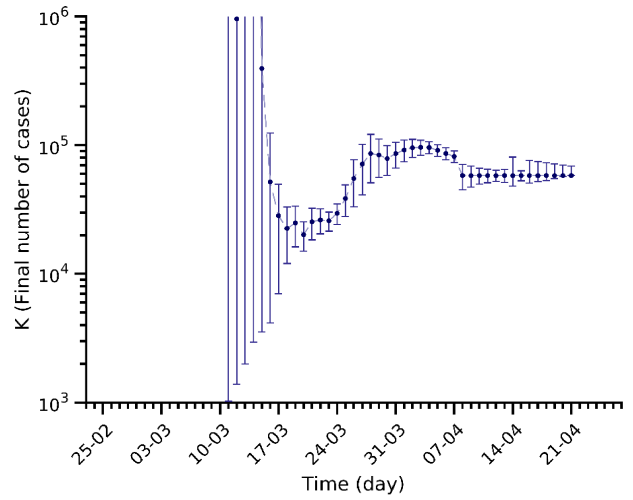
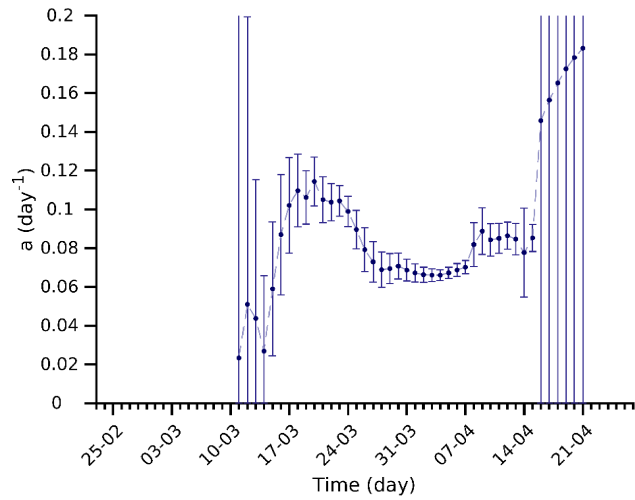
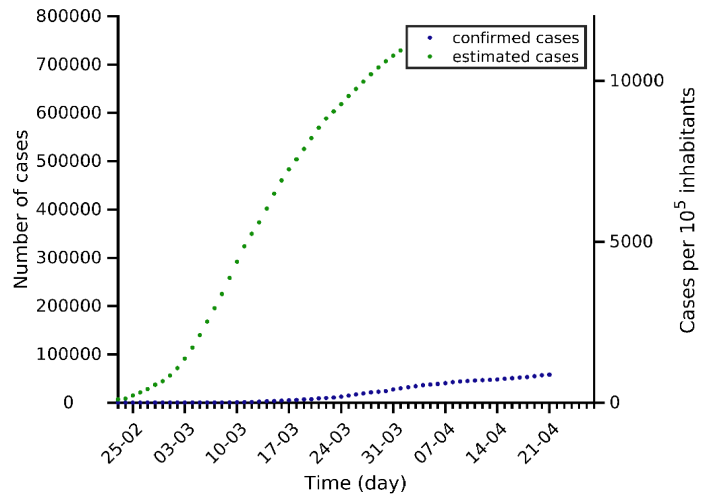
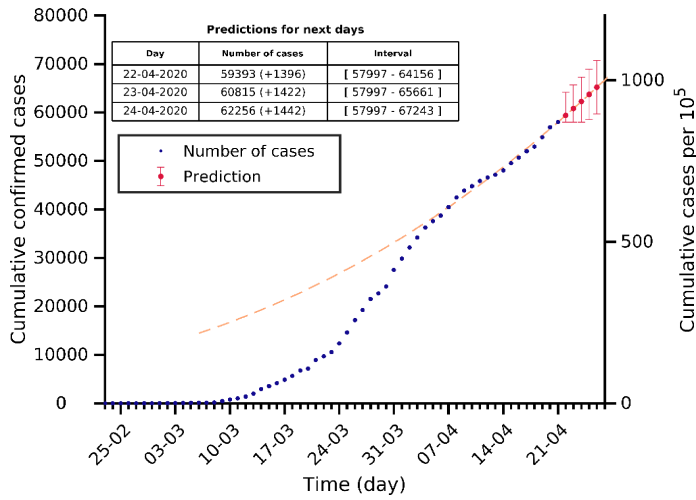
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>

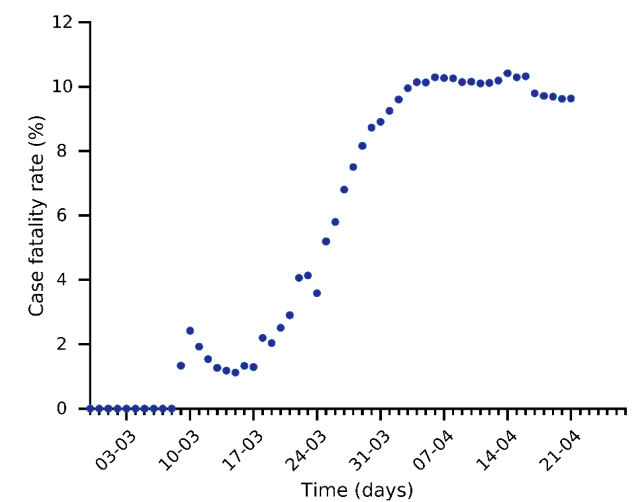
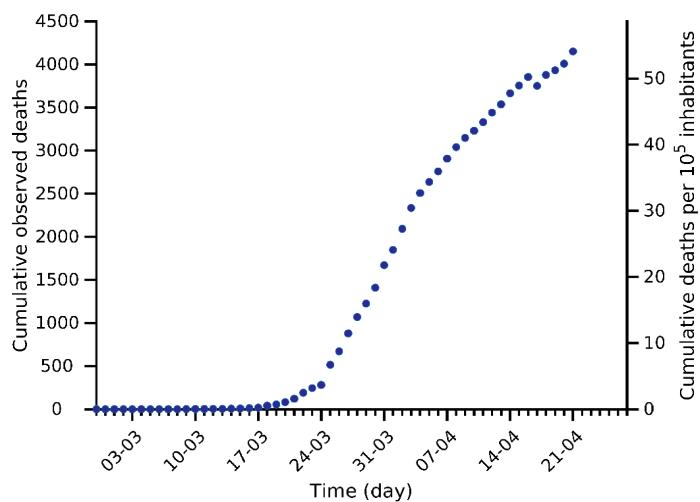
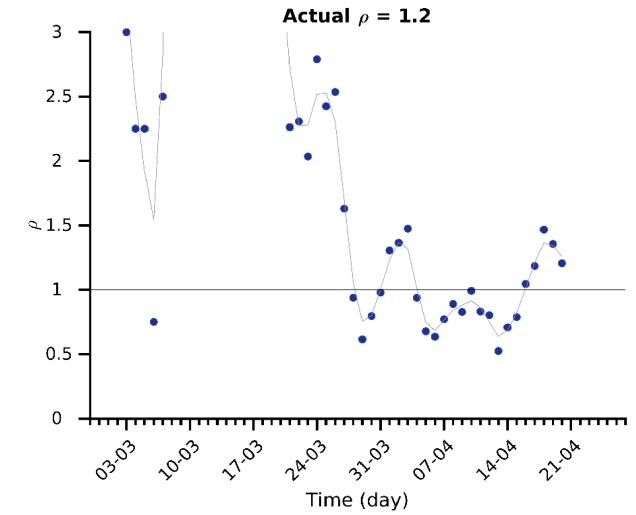
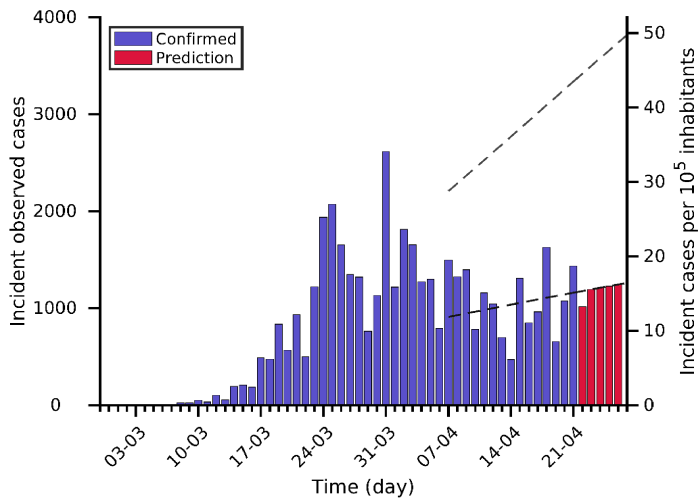
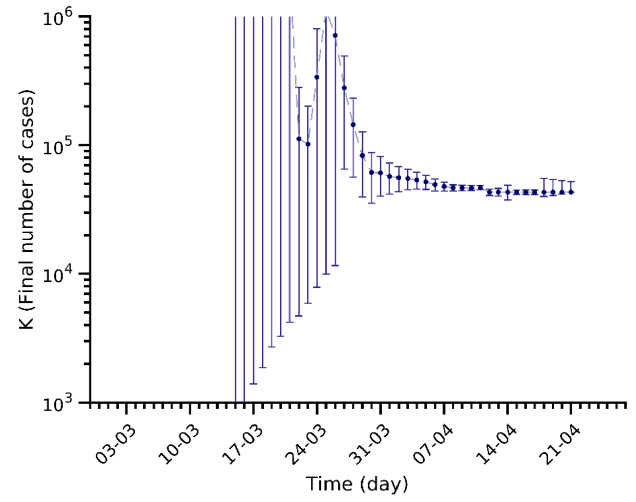
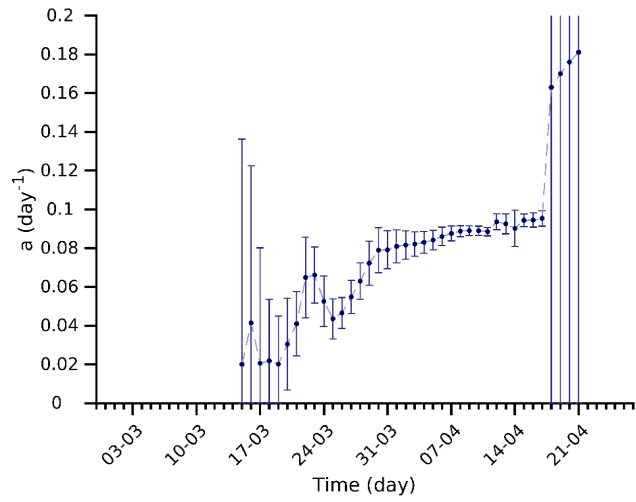
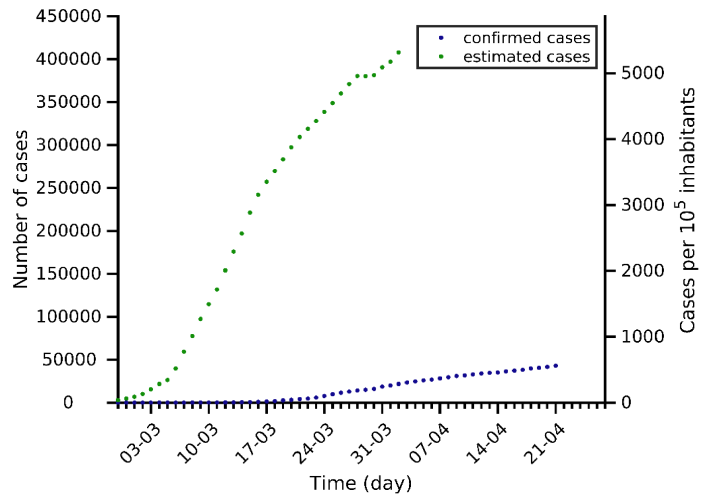
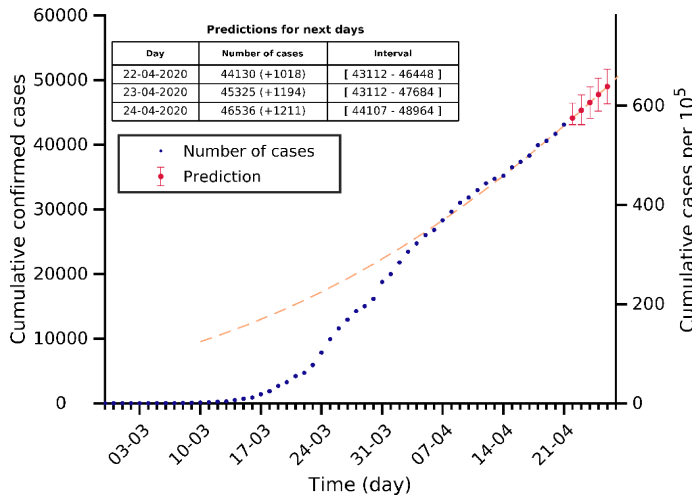
Spain 21-04-2020. Population: 47.0M. Current cumulated incidence: 434/10⁵



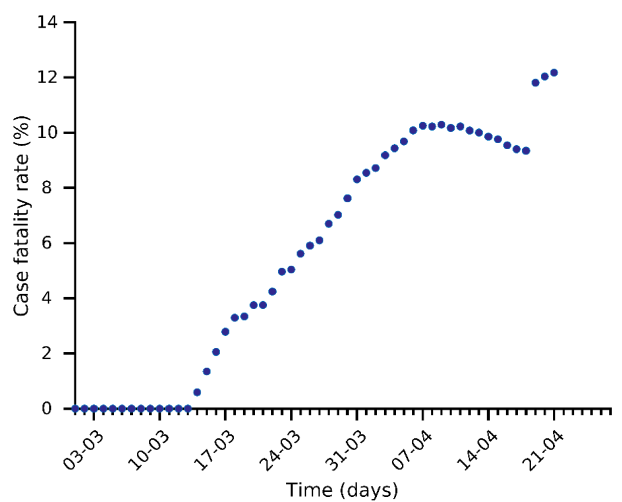
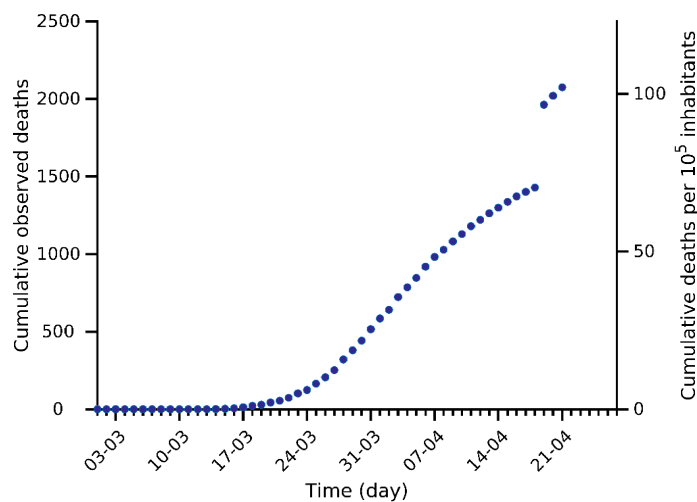
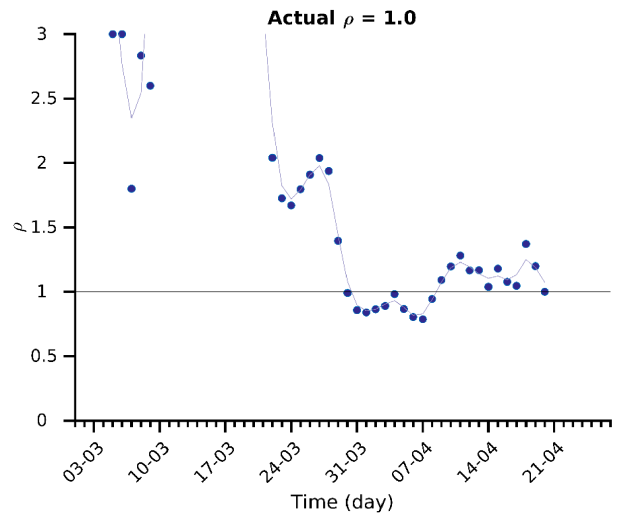
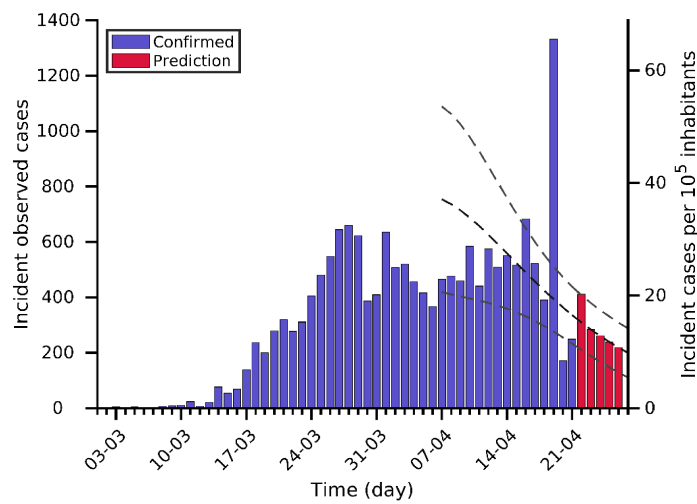
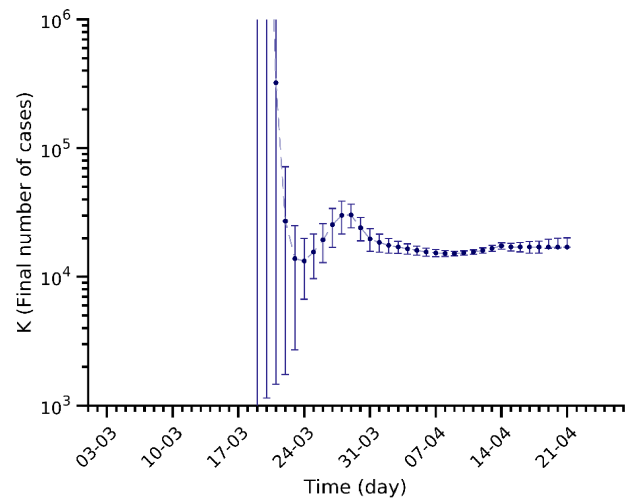
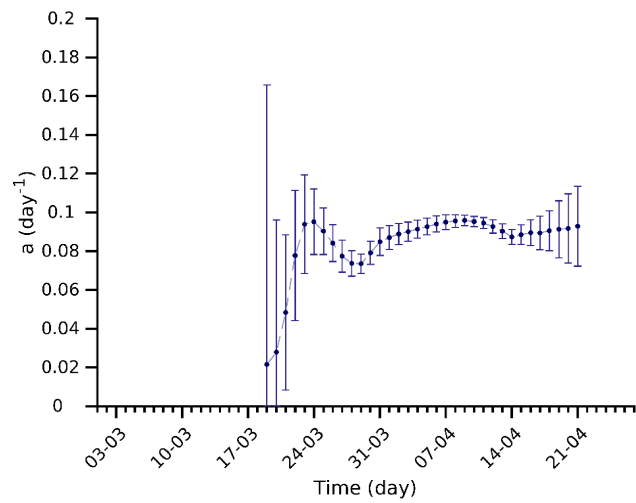
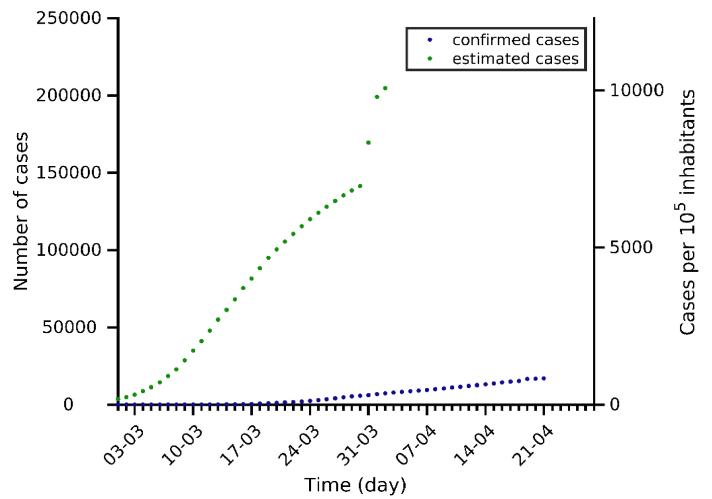
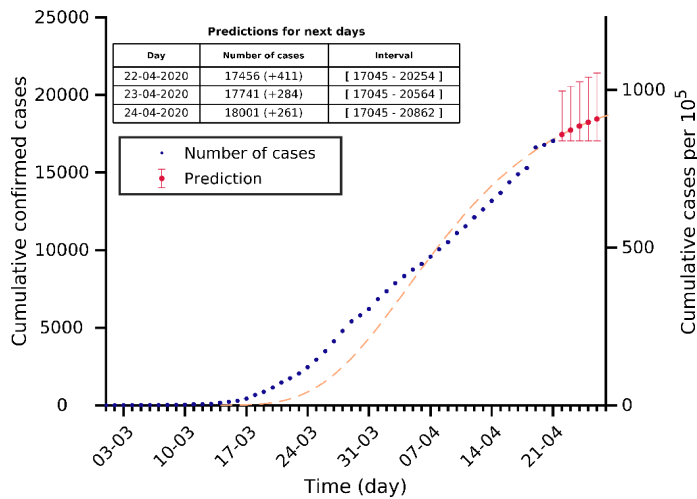
Madrid 21-04-2020. Population: 6.7M. Current cumulated incidence: 870/10⁵



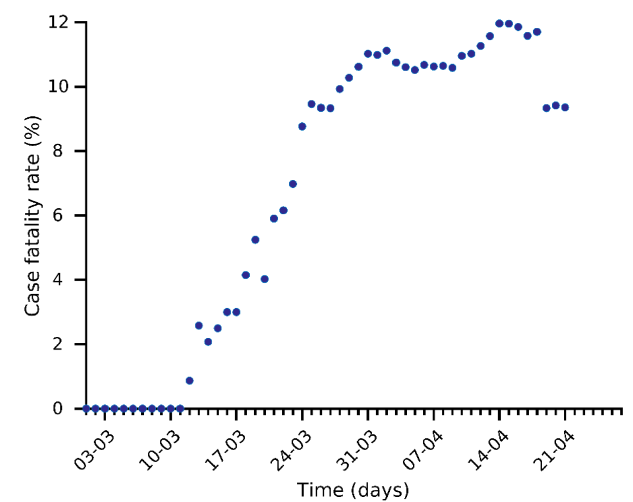
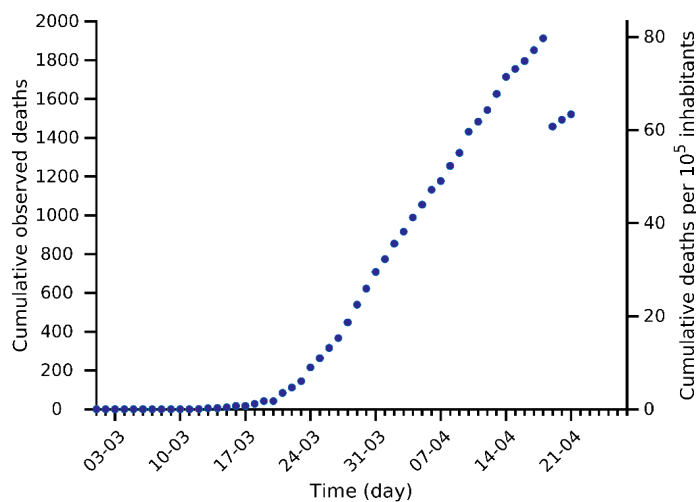
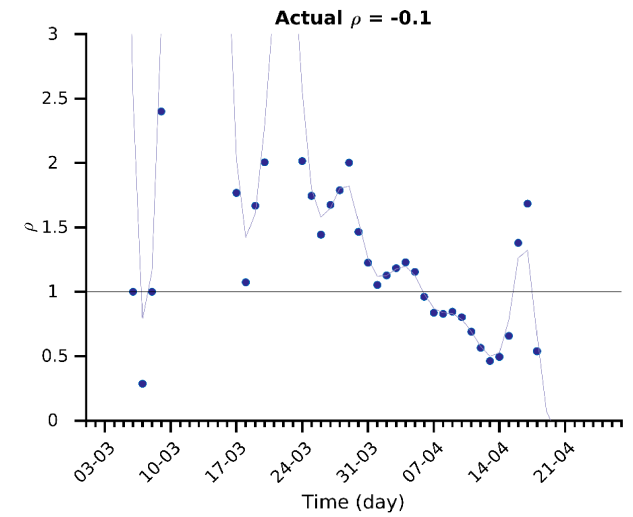
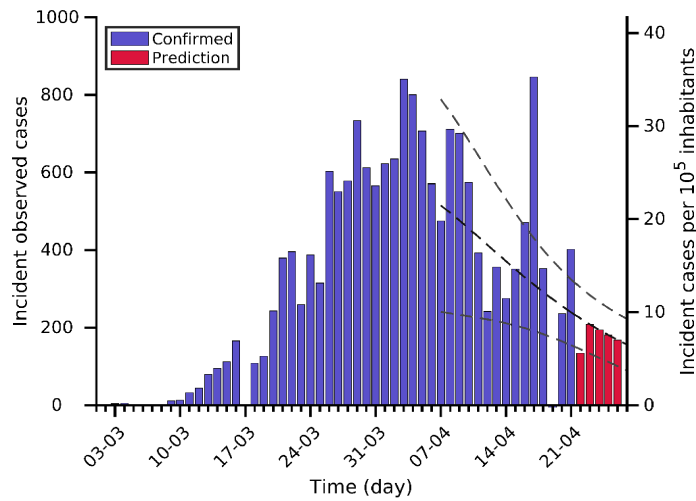
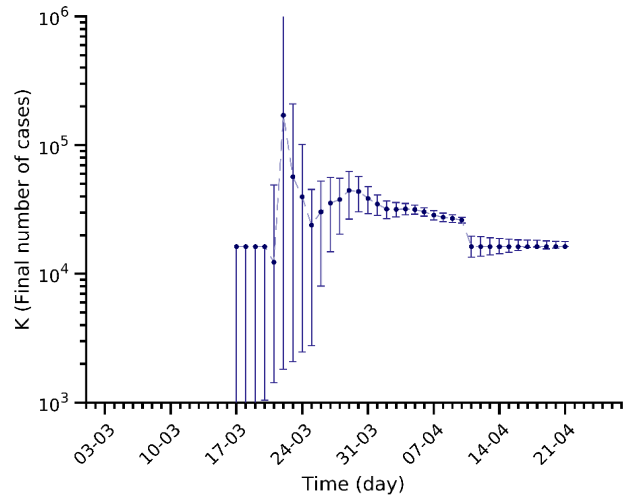
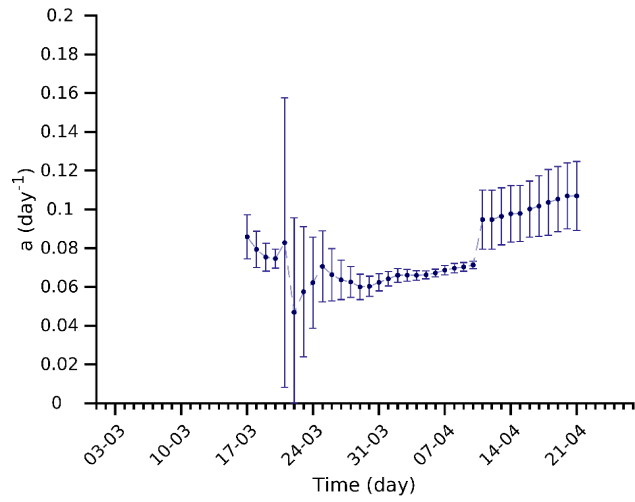
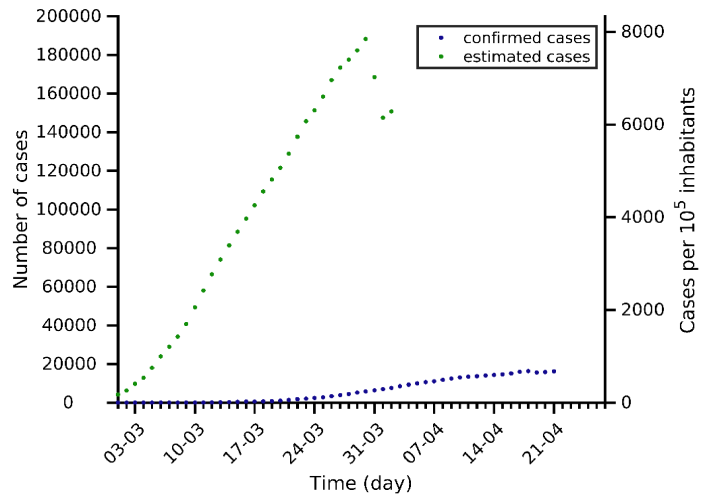
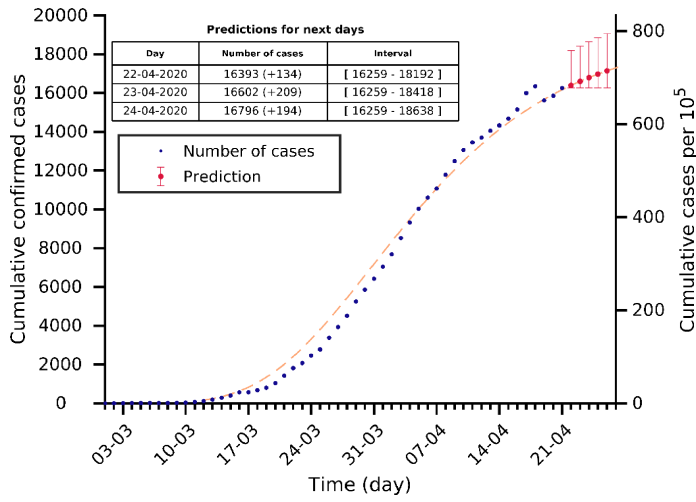
Catalunya 21-04-2020. Population: 7.7M. Current cumulated incidence: 562/10⁵



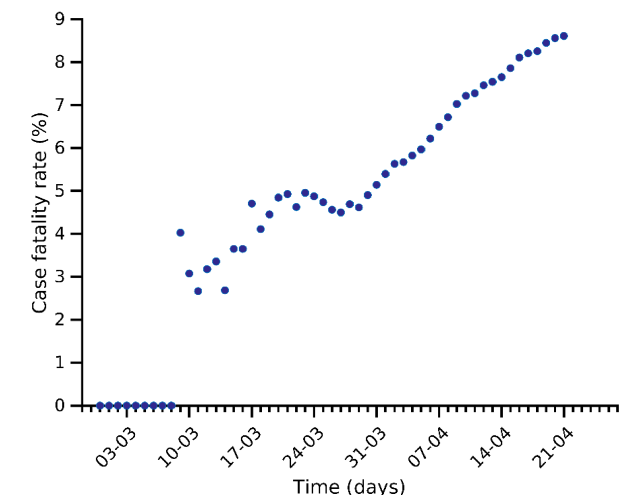
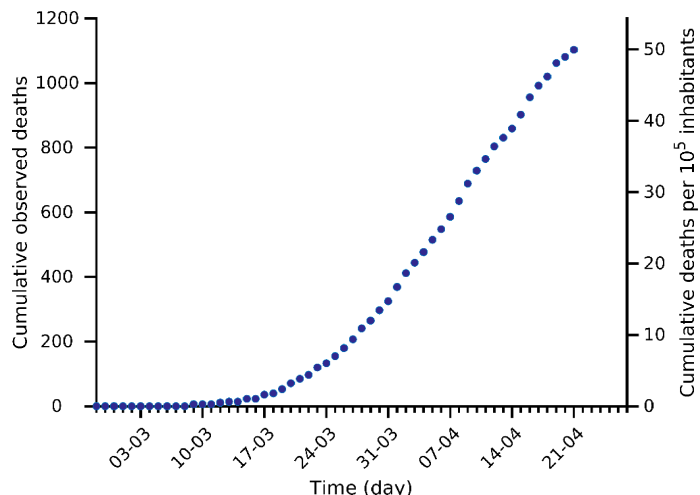
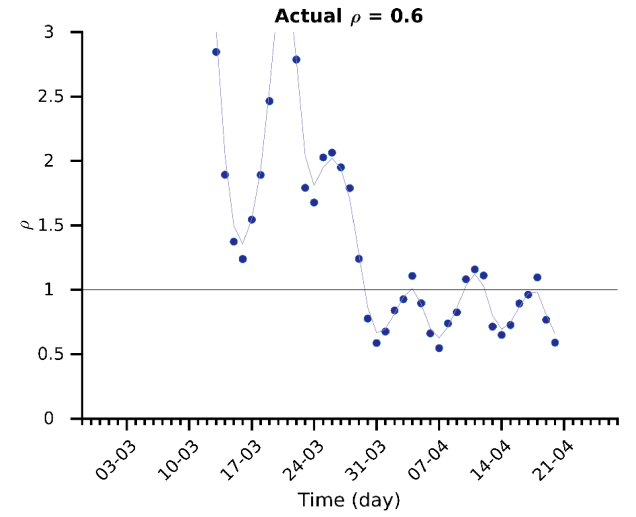
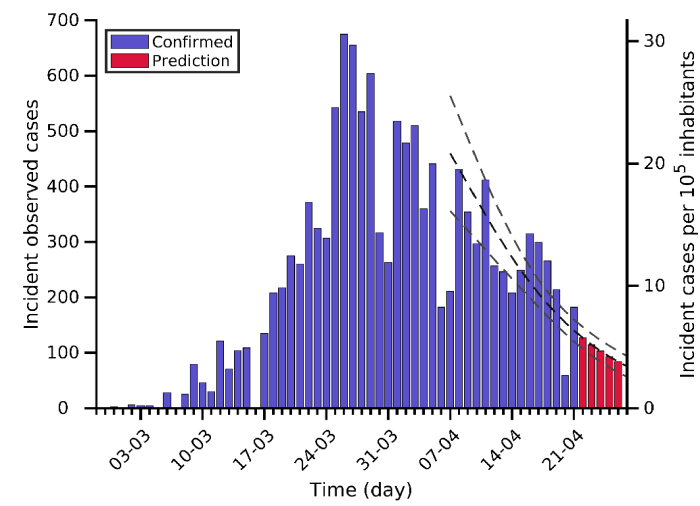
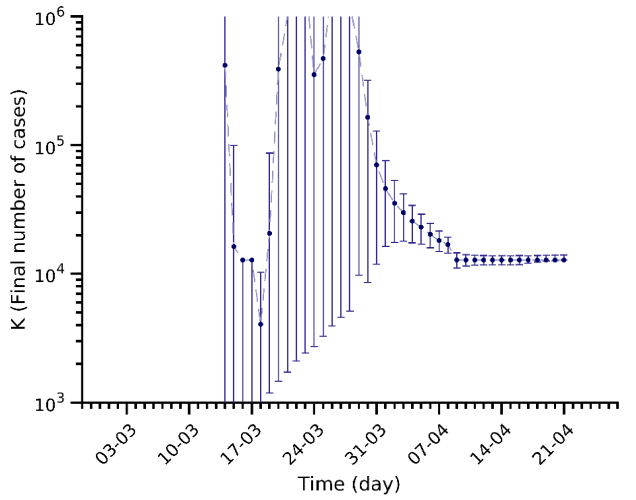
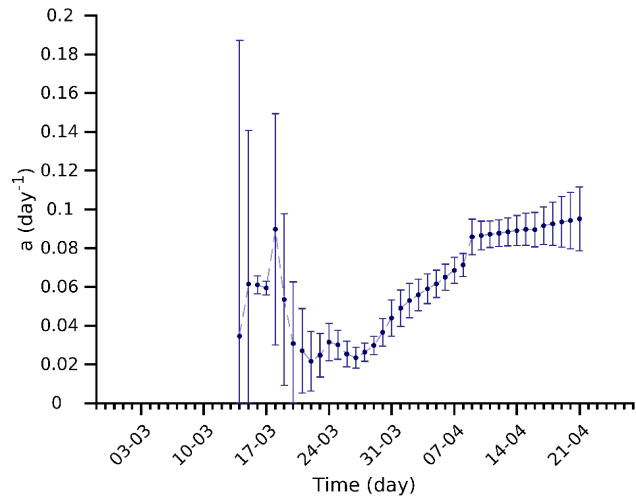
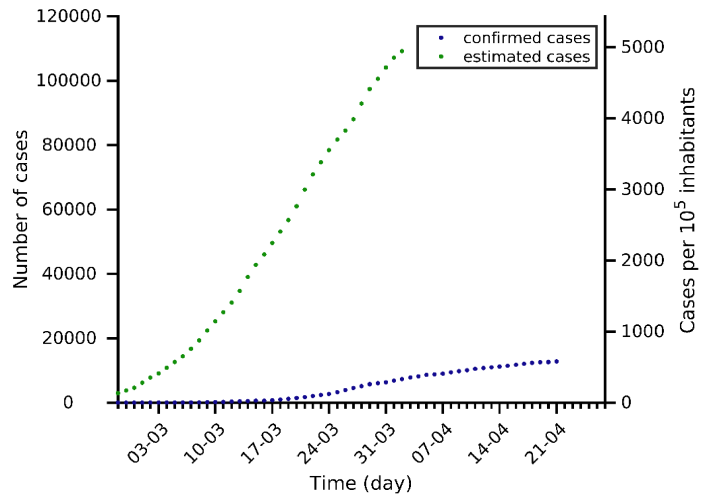
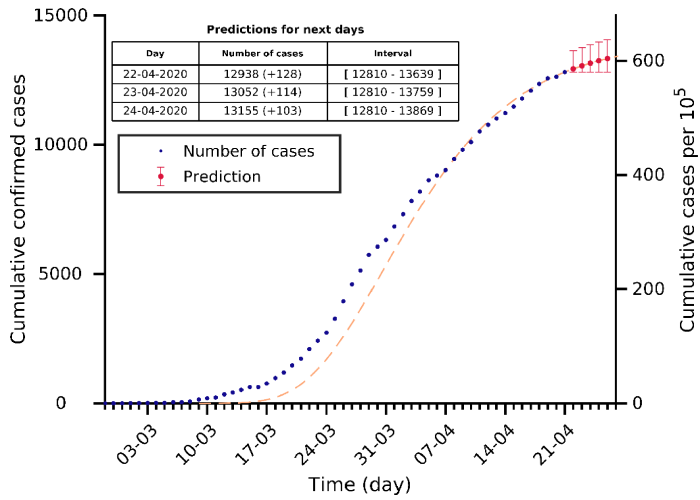
Castilla-La Mancha 21-04-2020. Population: 2.0M. Current cumulated incidence: 83



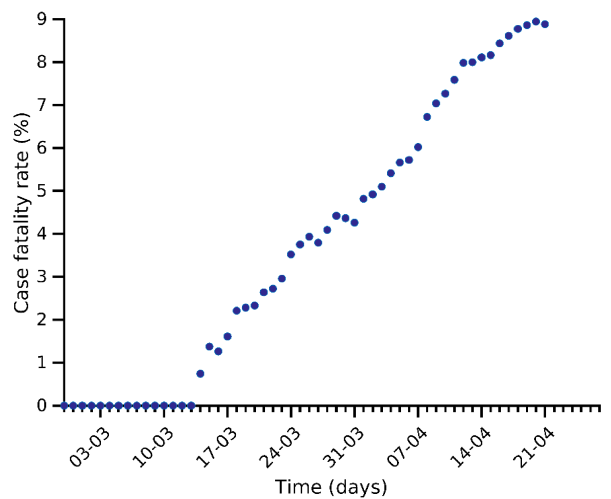
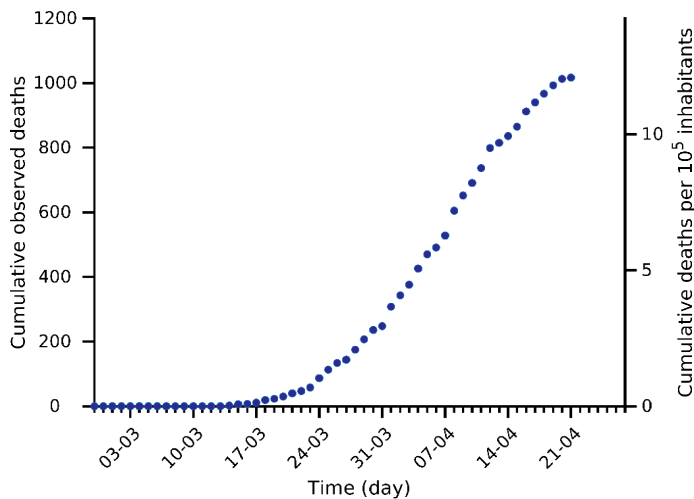
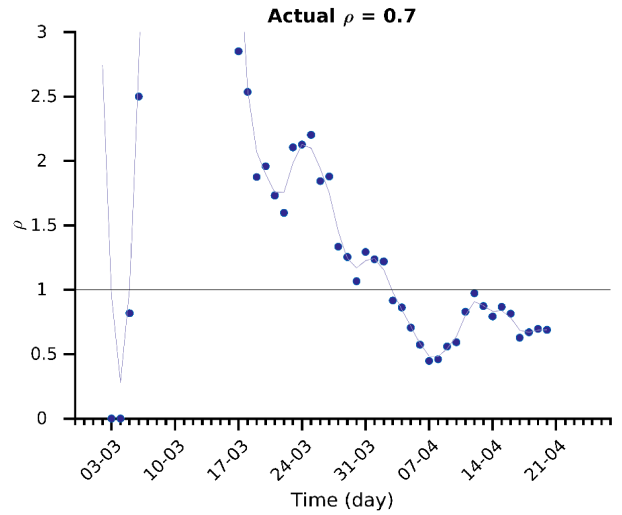
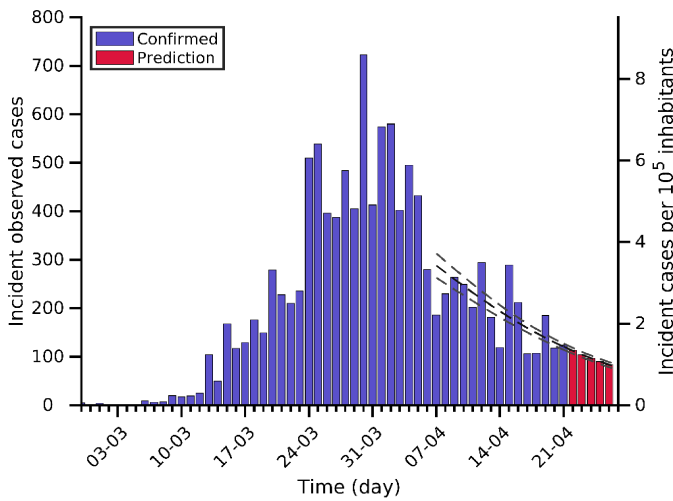
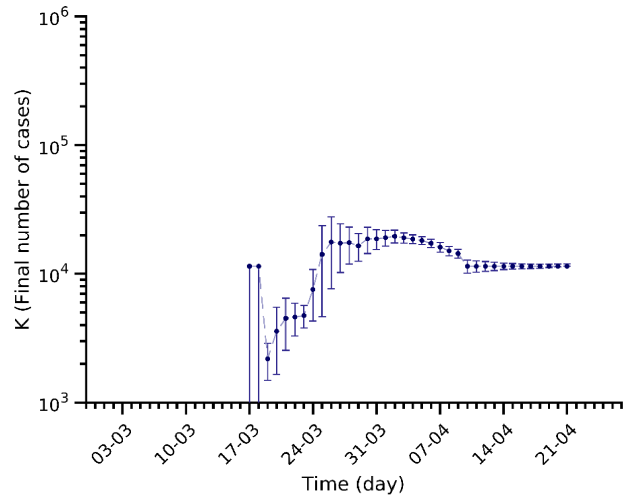
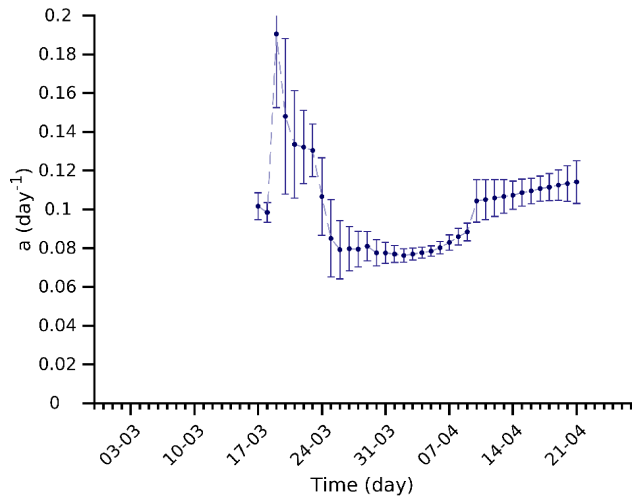
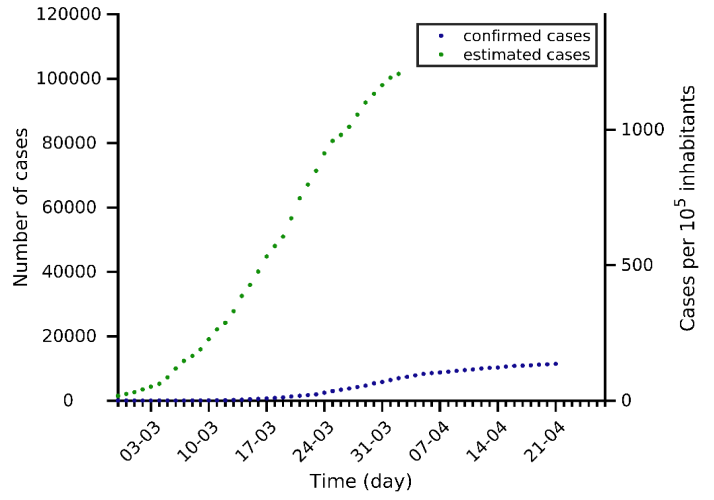
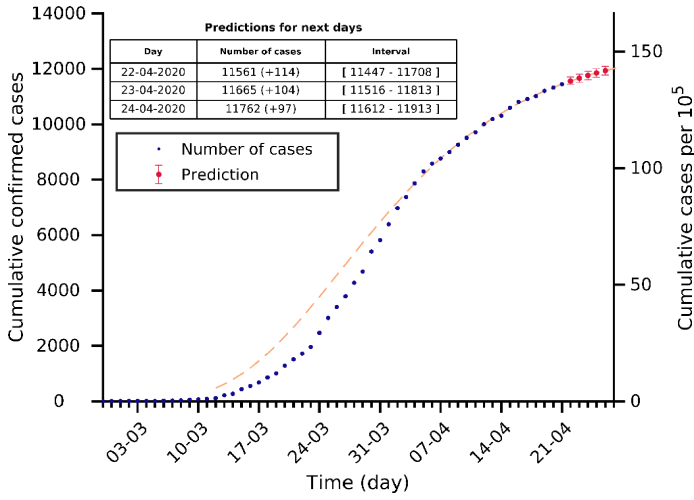
Castilla Leon 21-04-2020. Population: 2.4M. Current cumulated incidence: 678/10⁵



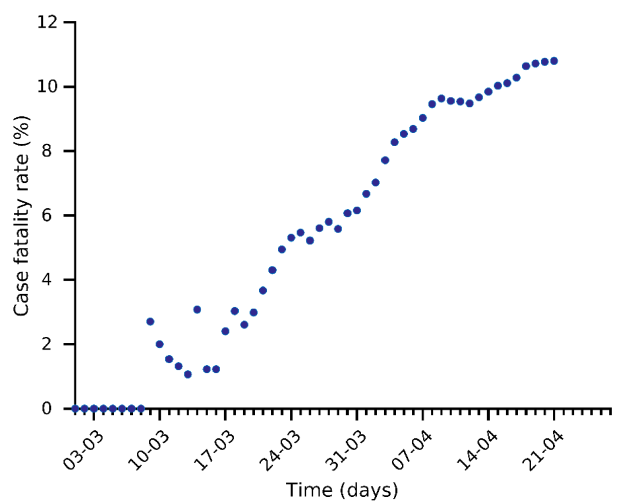
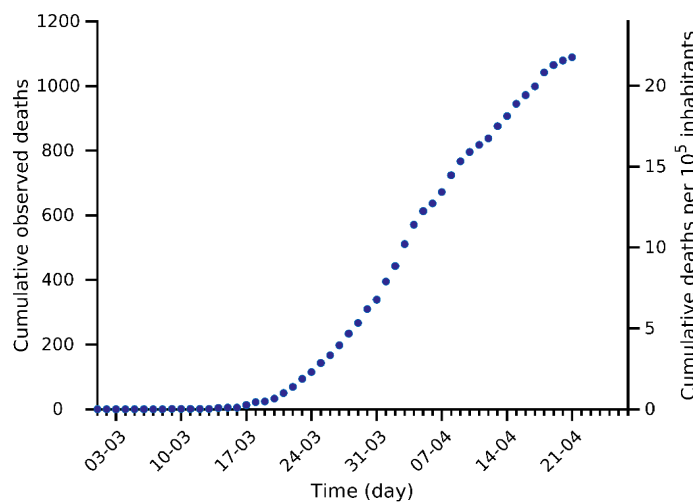
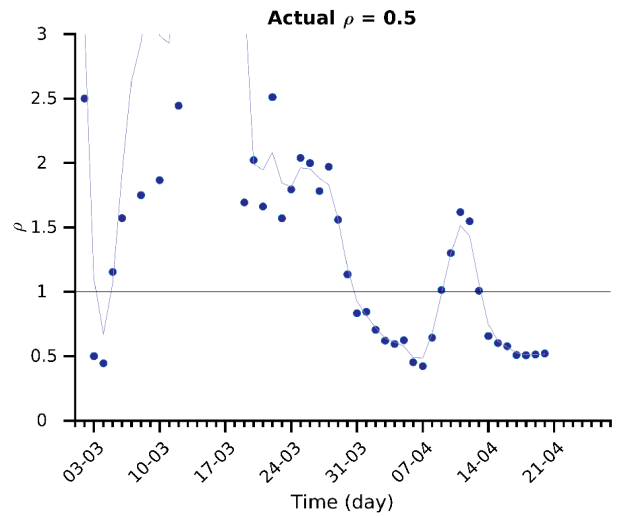
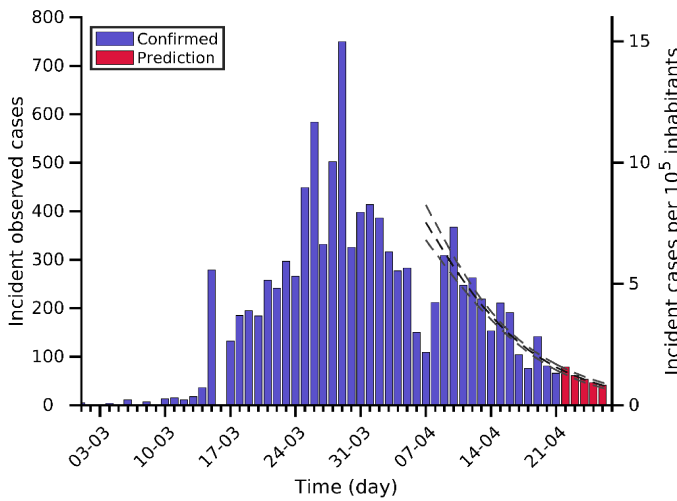
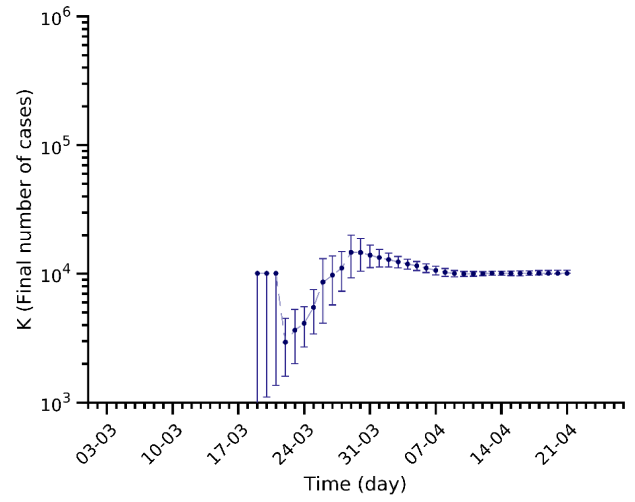
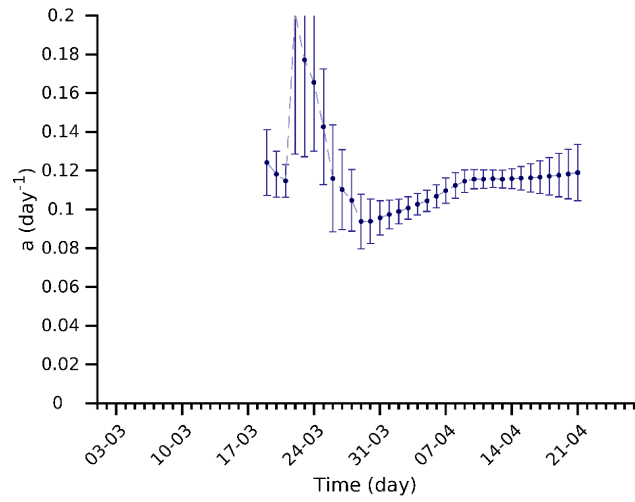
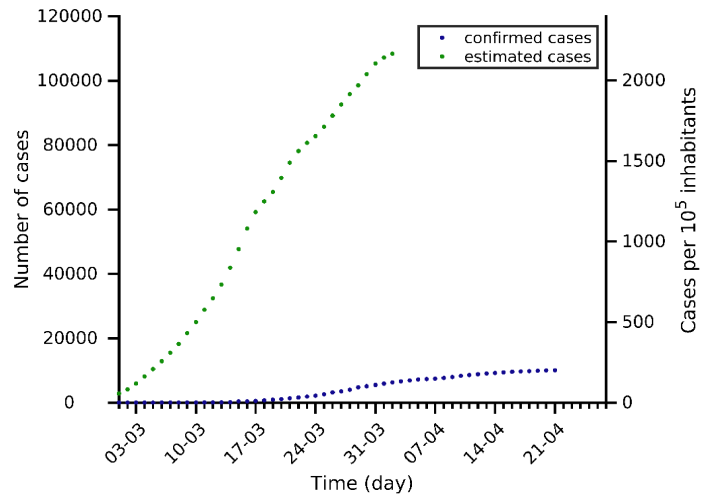
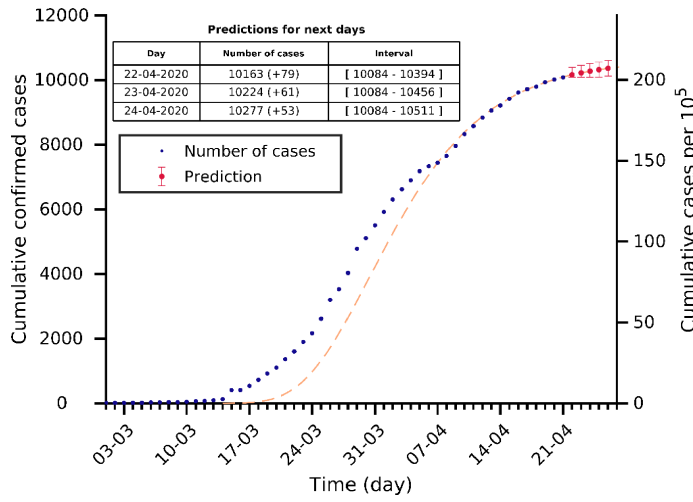
Euskadi 21-04-2020. Population: 2.2M. Current cumulated incidence: 580/10⁵



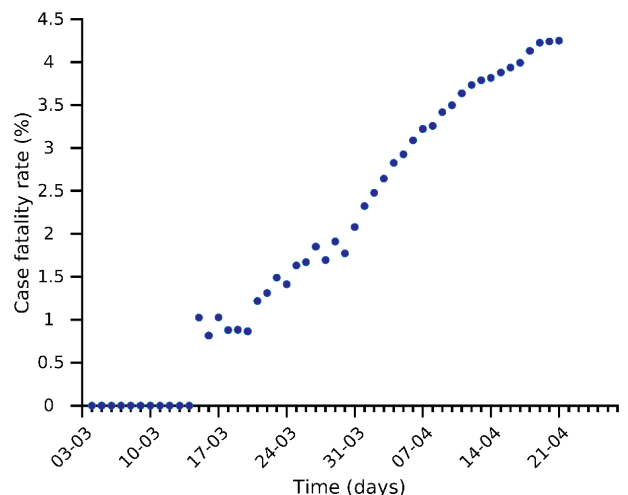
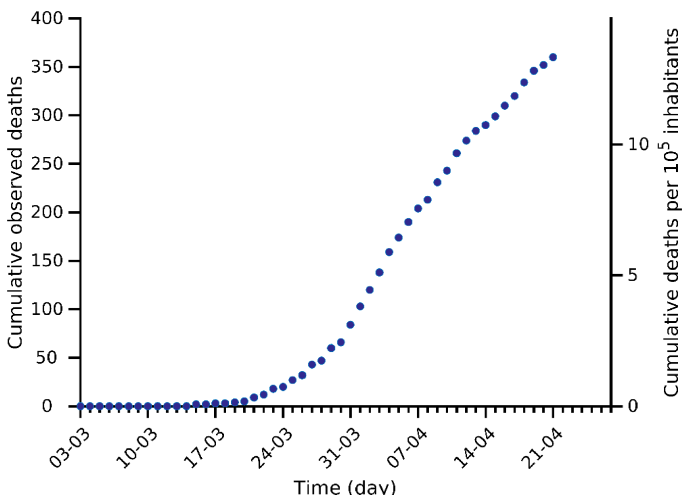
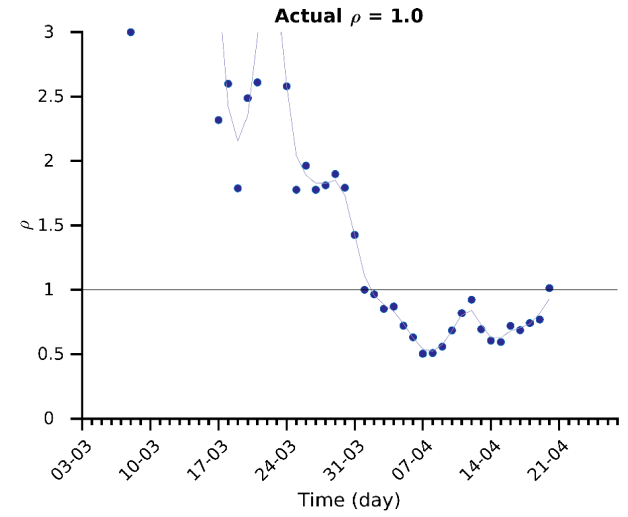
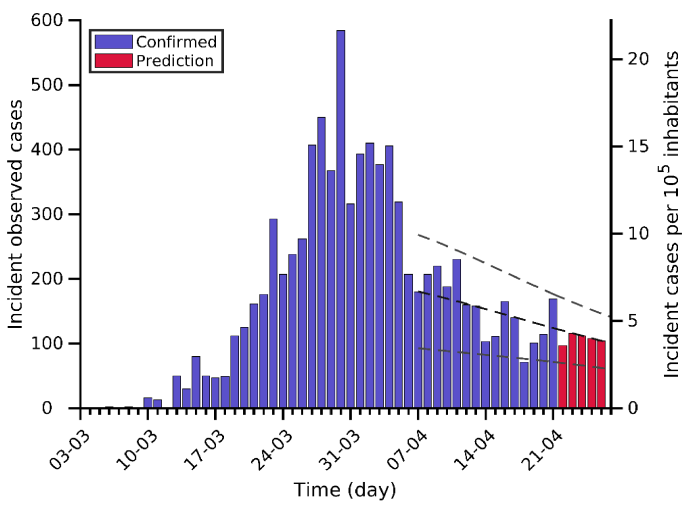
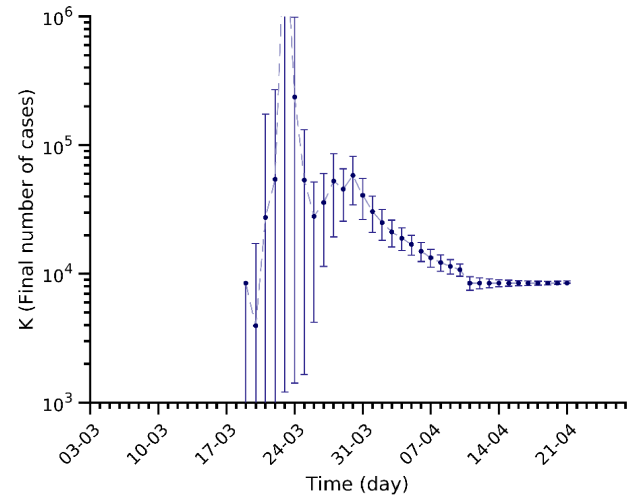
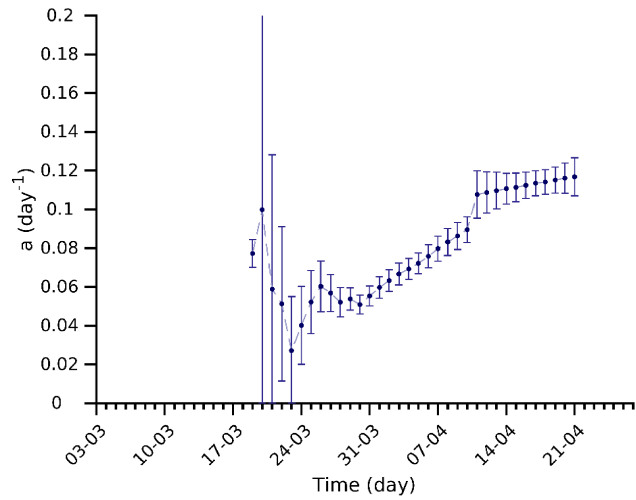
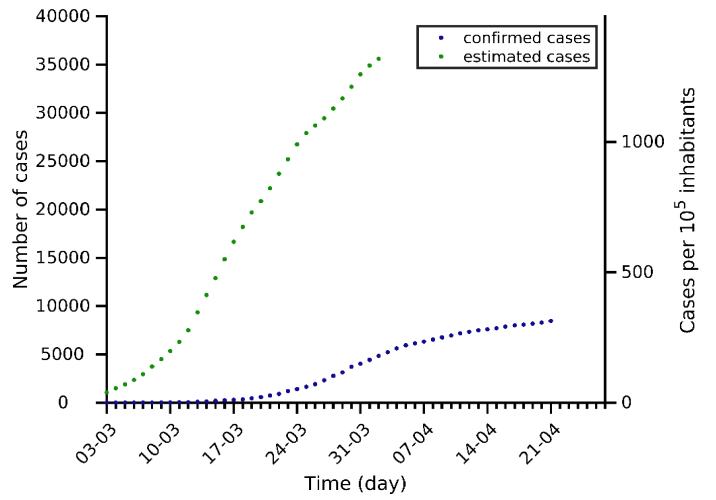
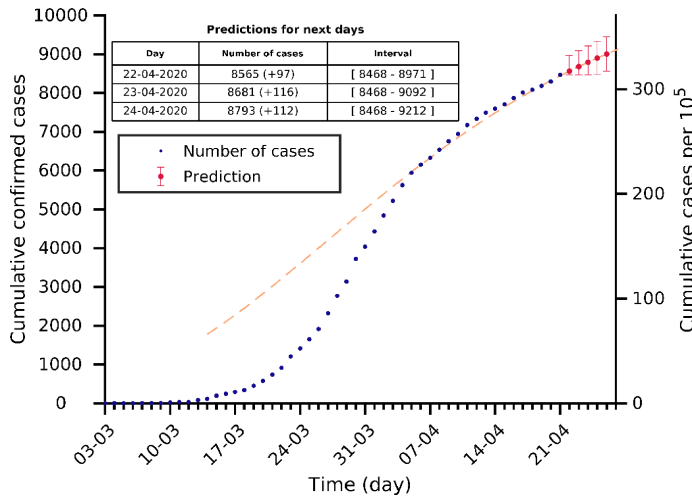
Andalucia 21-04-2020. Population: 8.4M. Current cumulated incidence: 136/10⁵



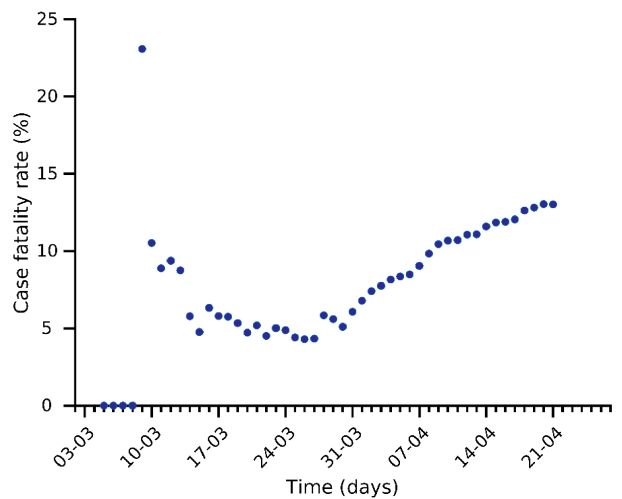
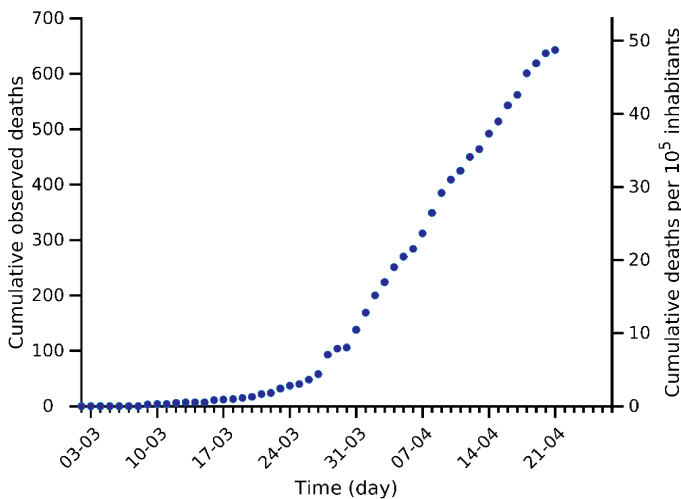
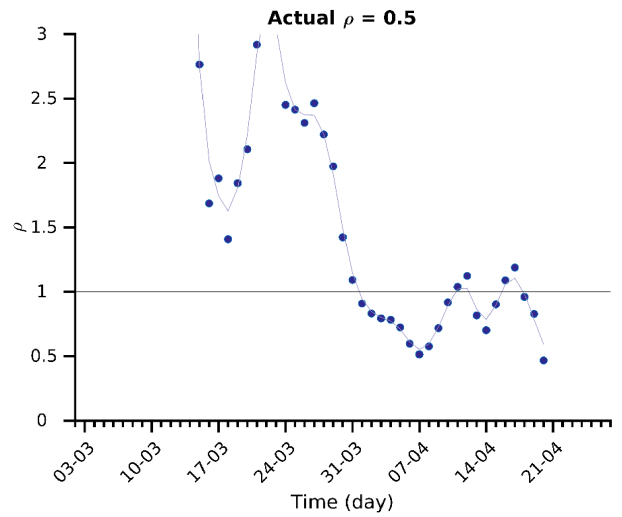
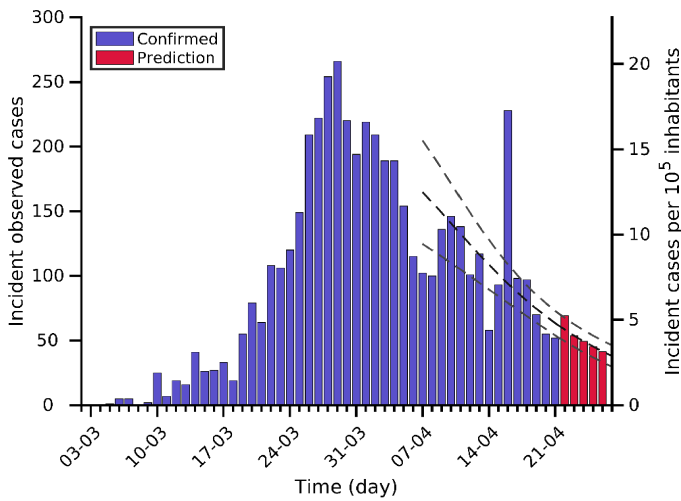
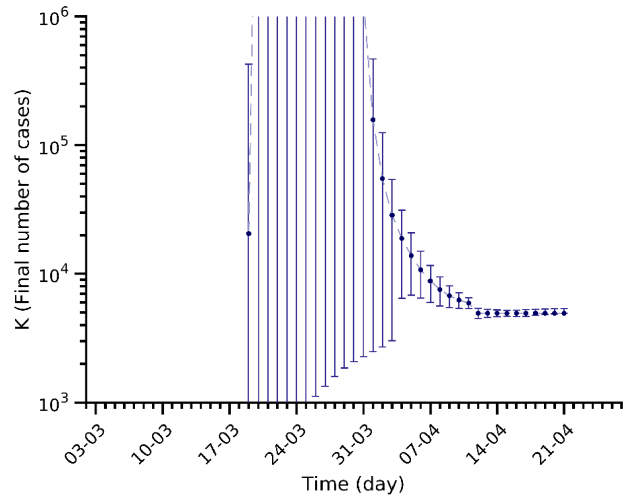
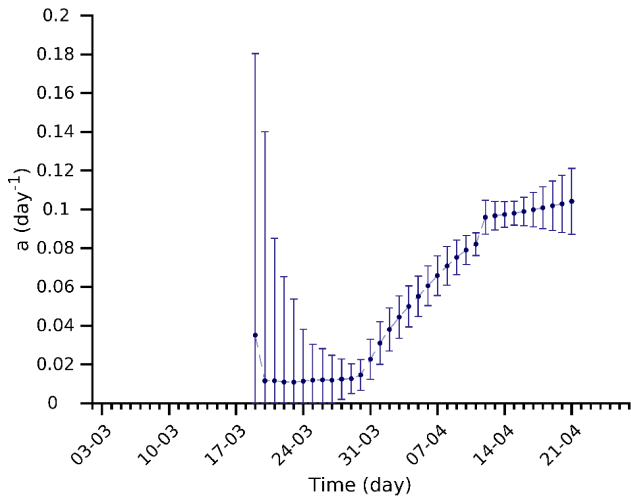
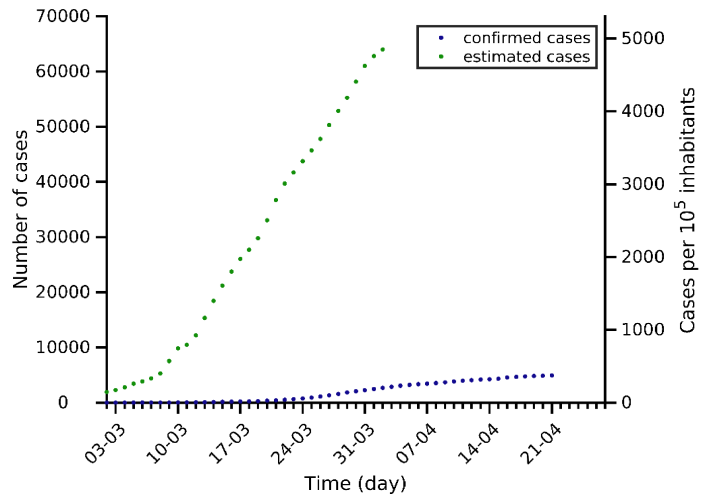
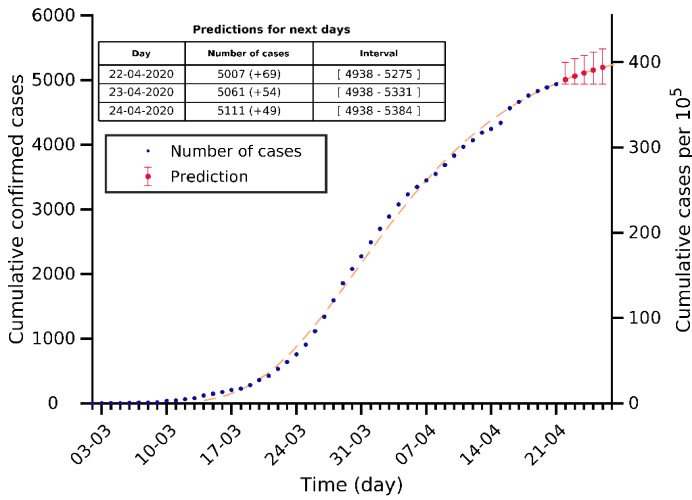
C Valenciana 21-04-2020. Population: 5.0M. Current cumulated incidence: 202/10⁵



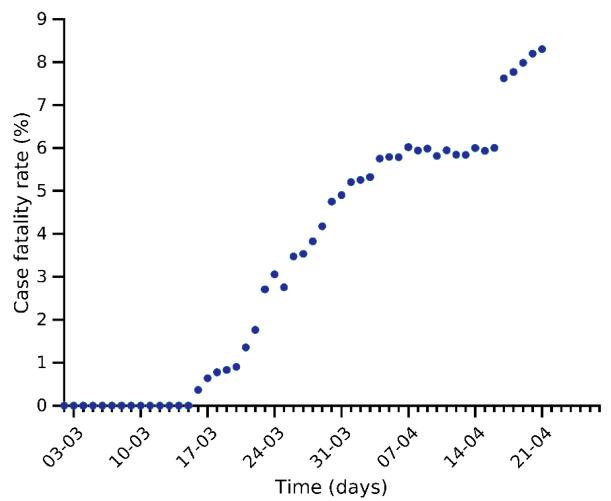
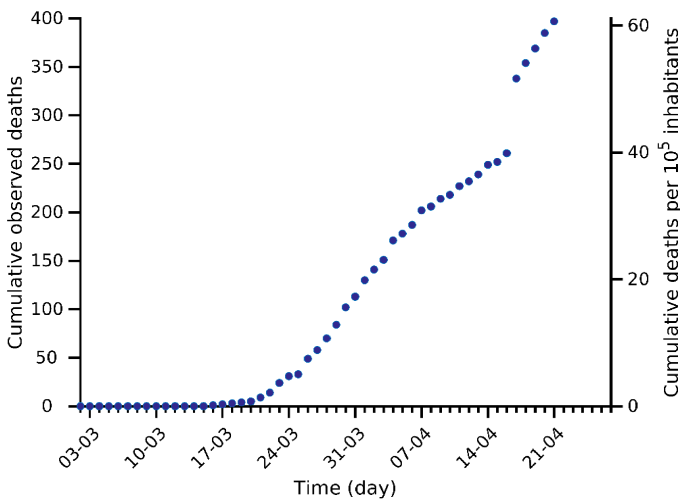
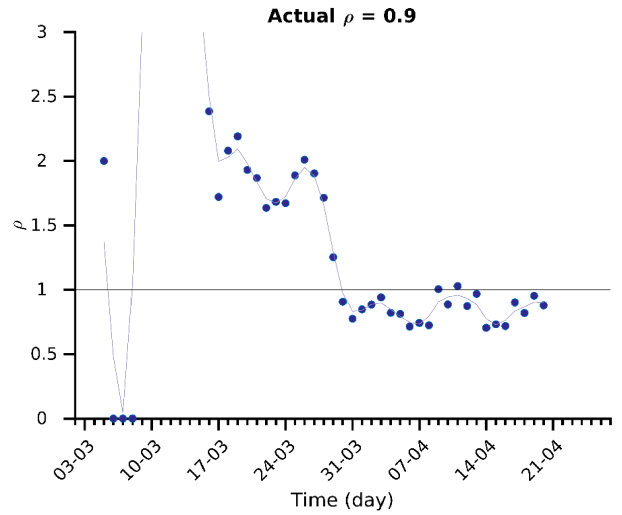
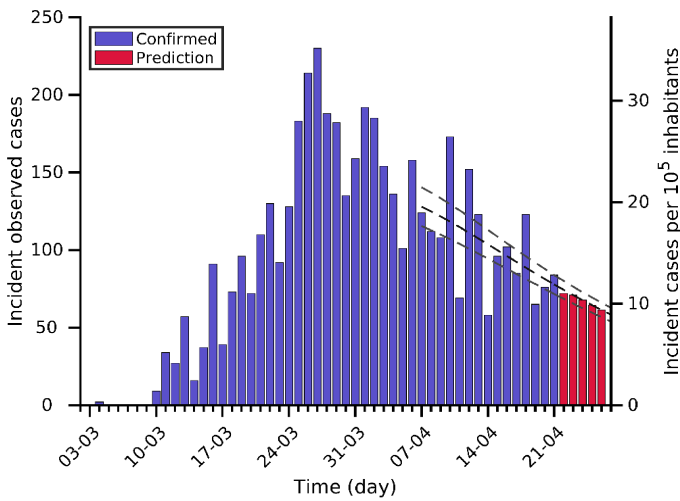
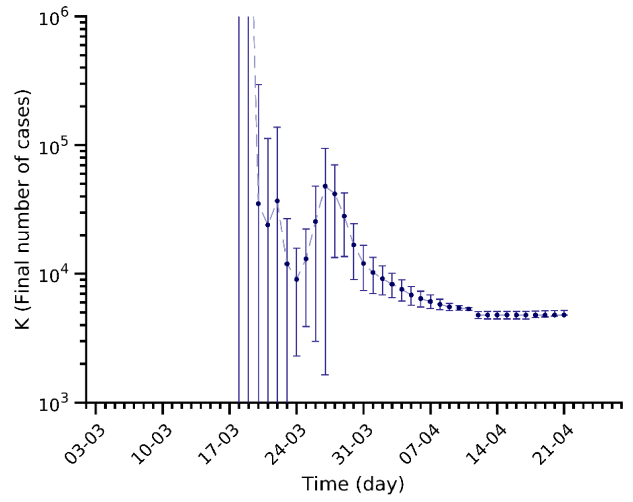
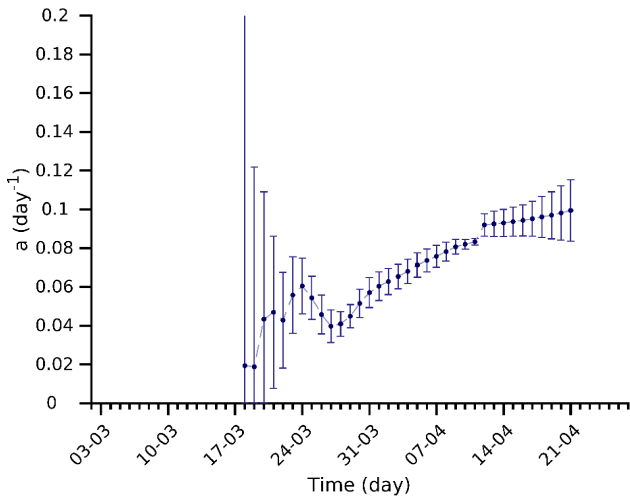
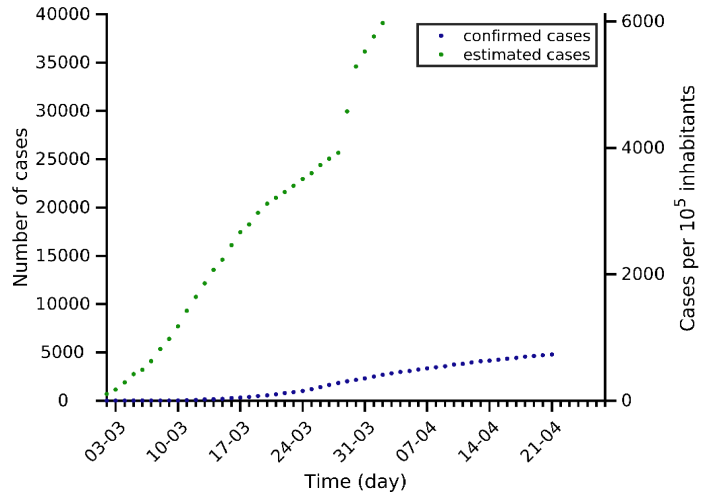
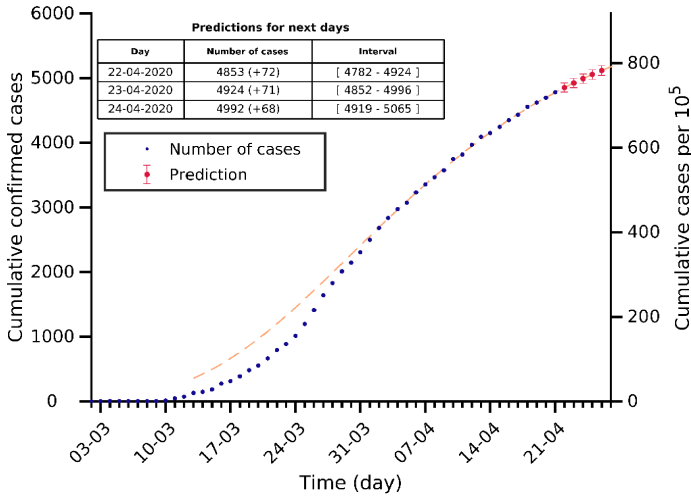
Galicia 21-04-2020. Population: 2.7M. Current cumulated incidence: 314/10⁵



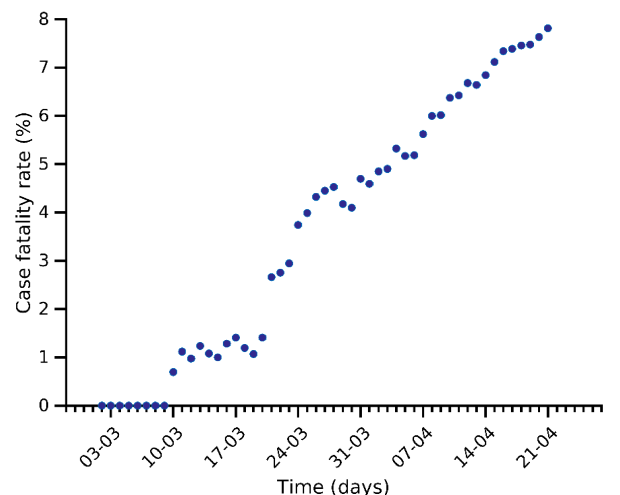
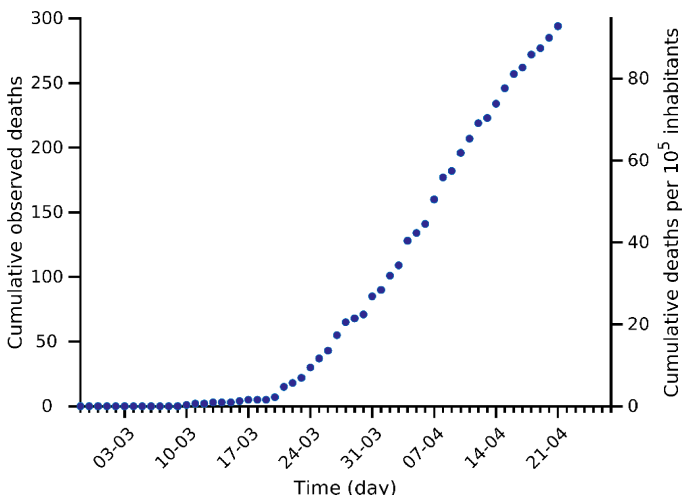
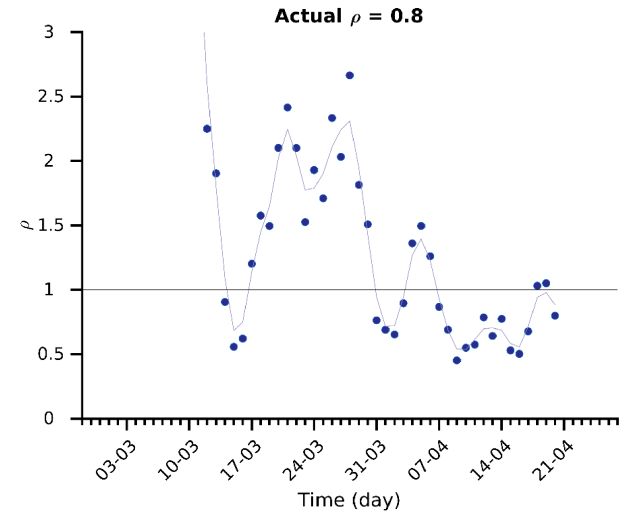
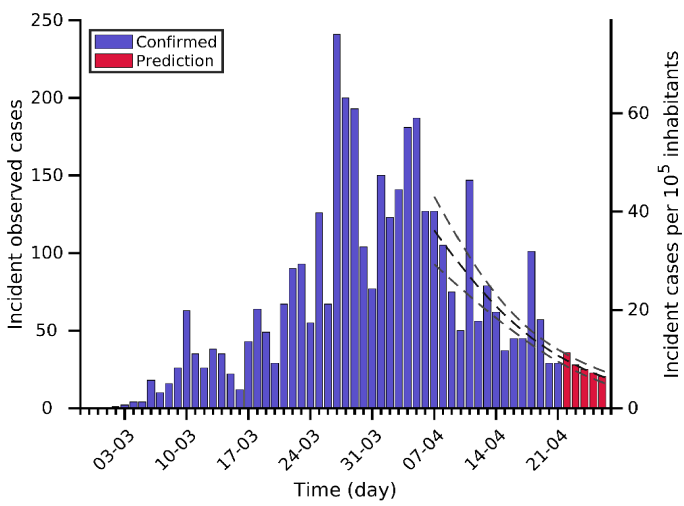
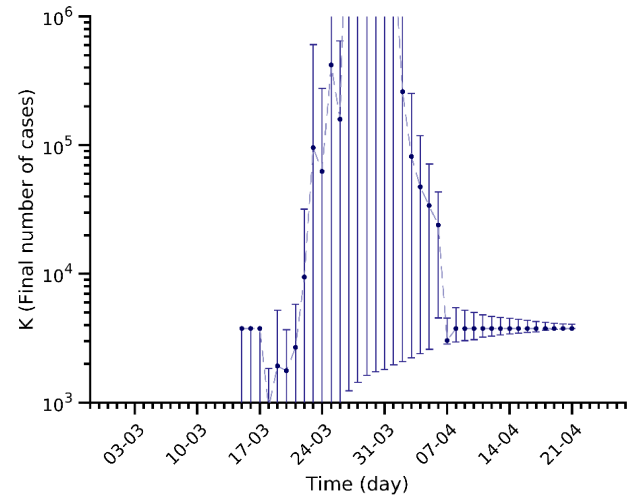
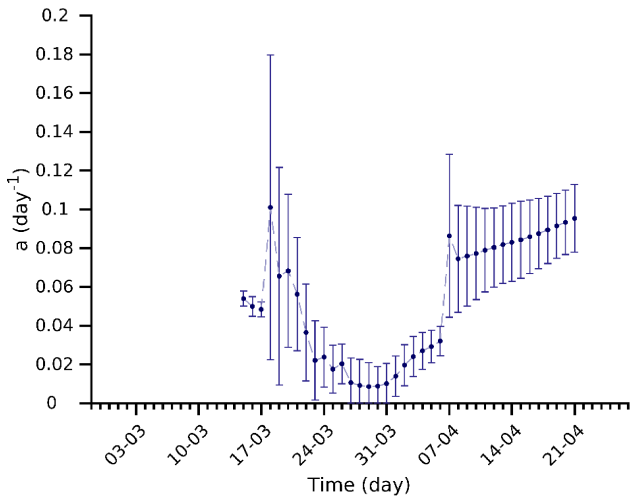
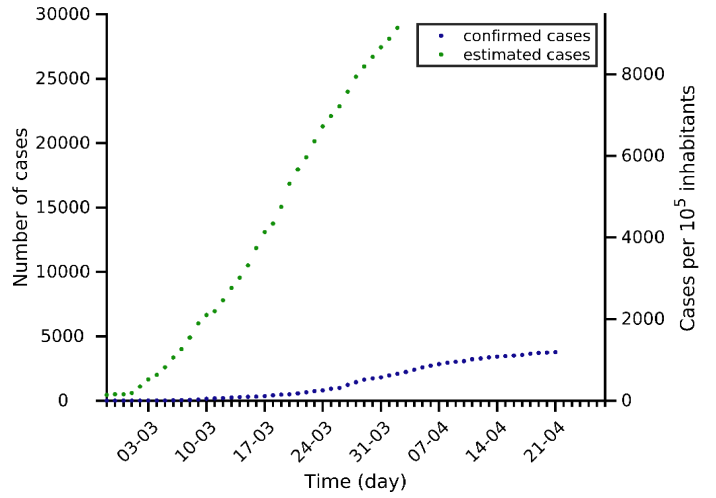
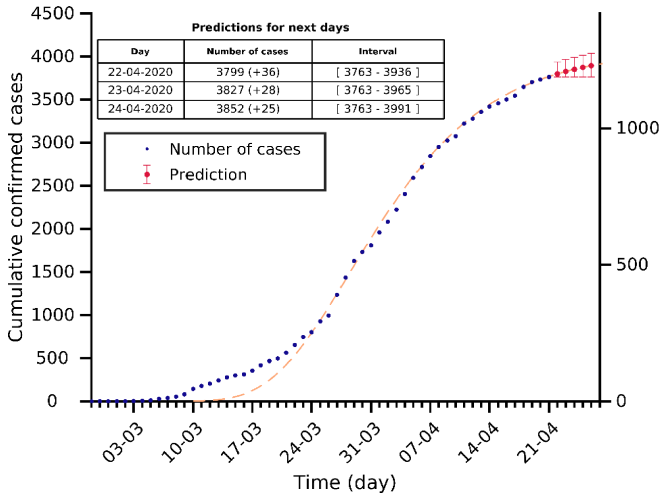
Aragon 21-04-2020. Population: 1.3M. Current cumulated incidence: 374/10⁵



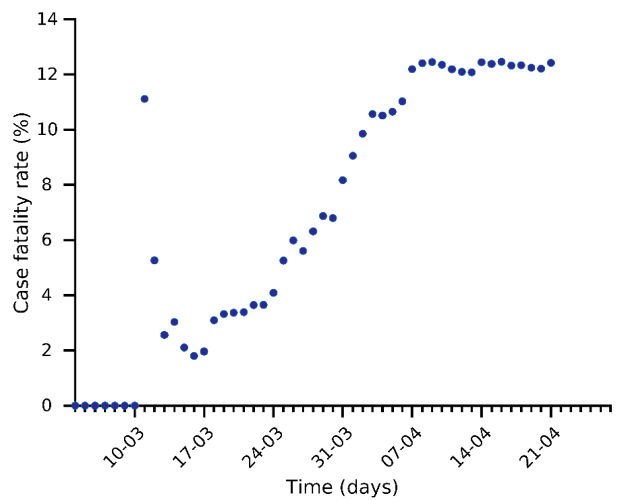
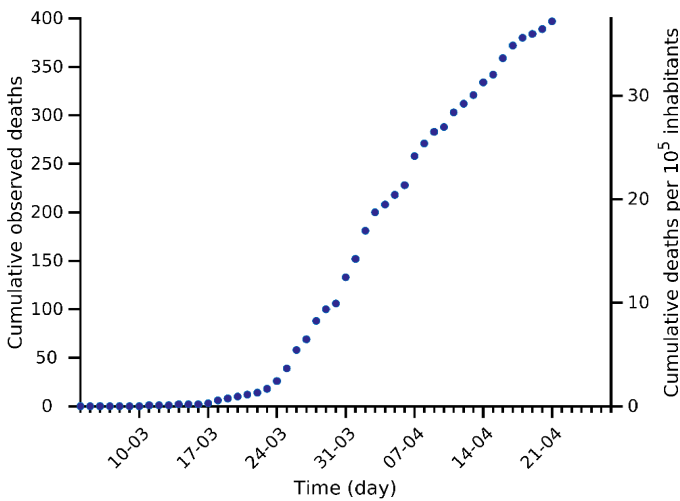
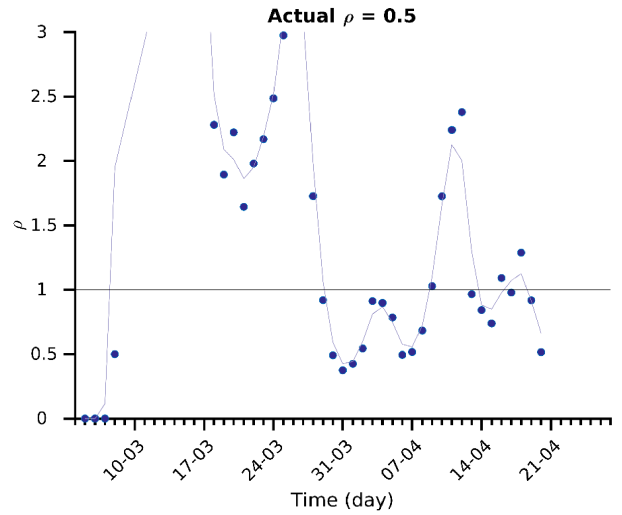
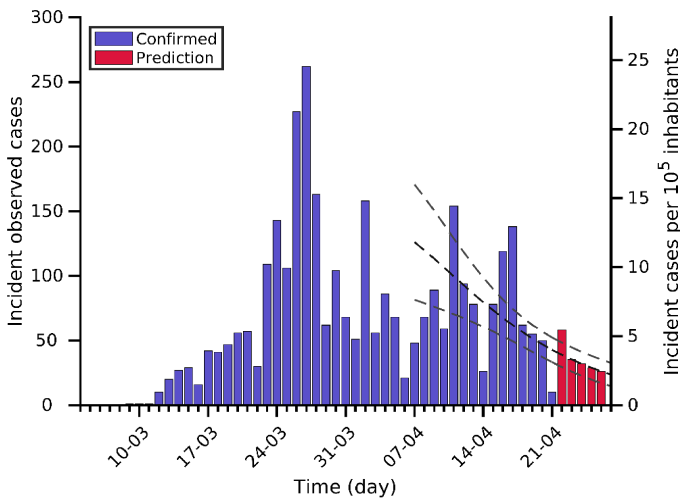
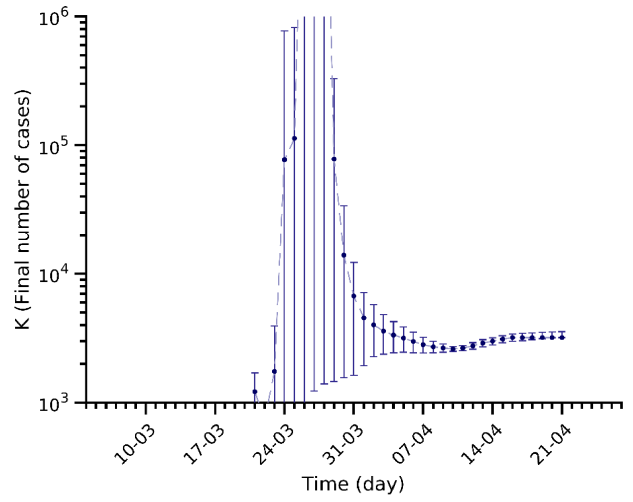
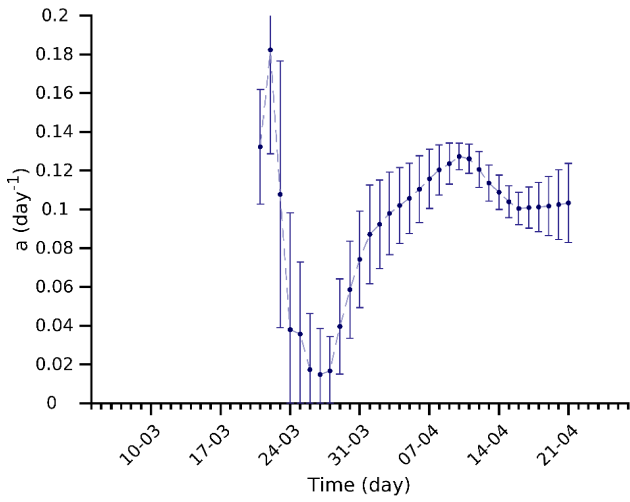
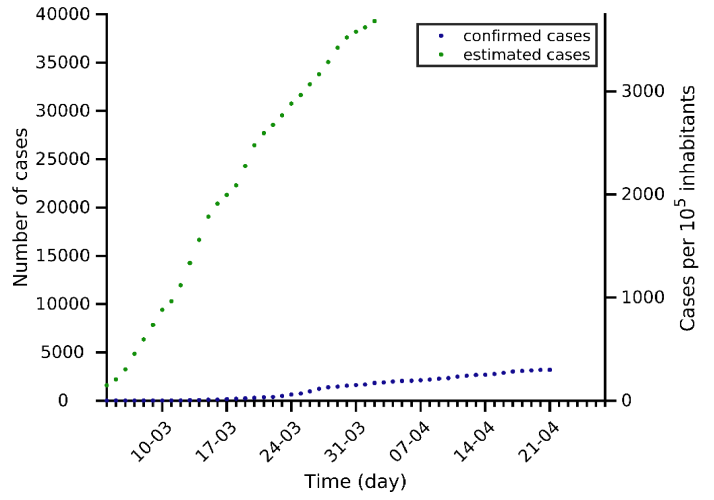
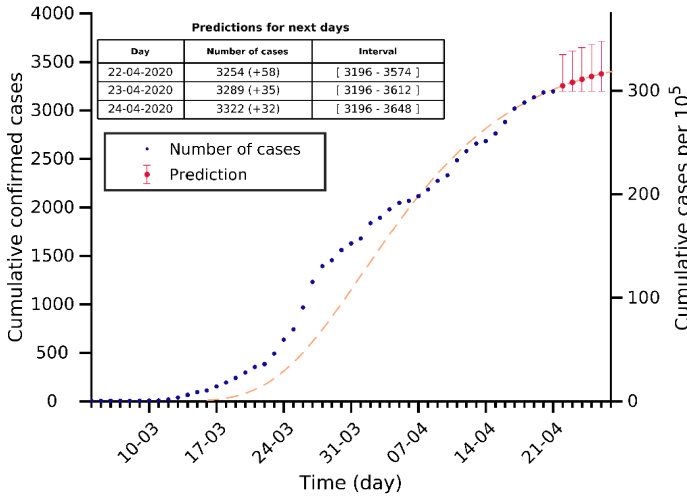
Navarra 21-04-2020. Population: 0.7M. Current cumulated incidence: 731/10⁵



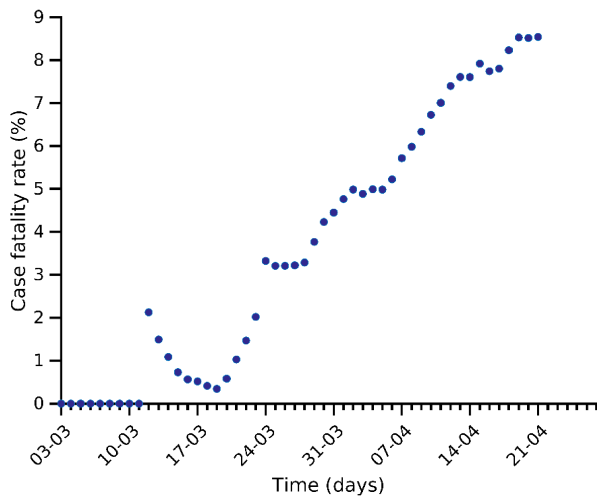
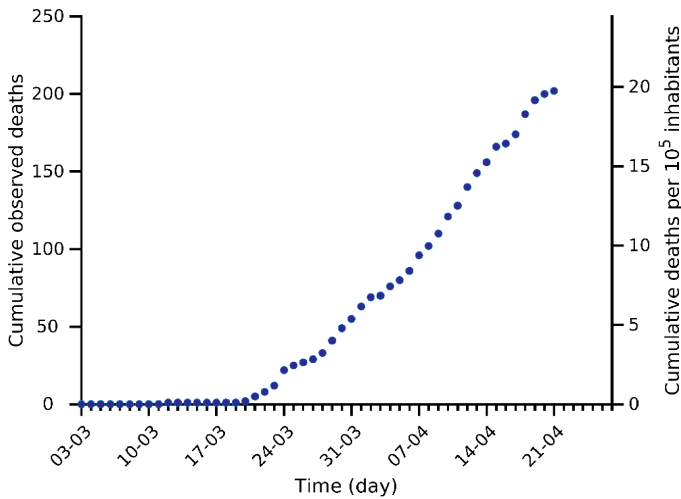
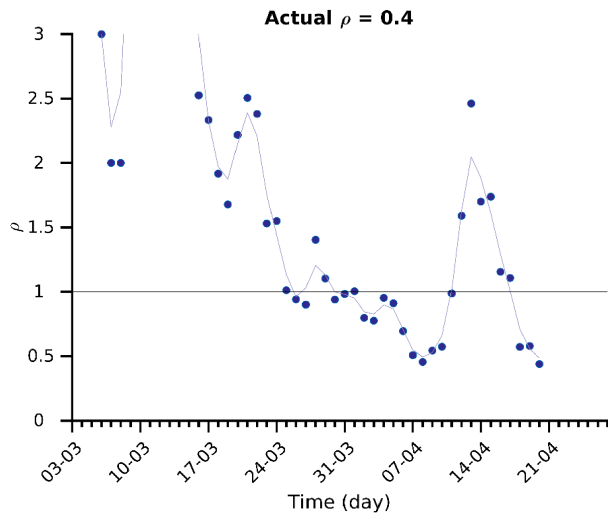
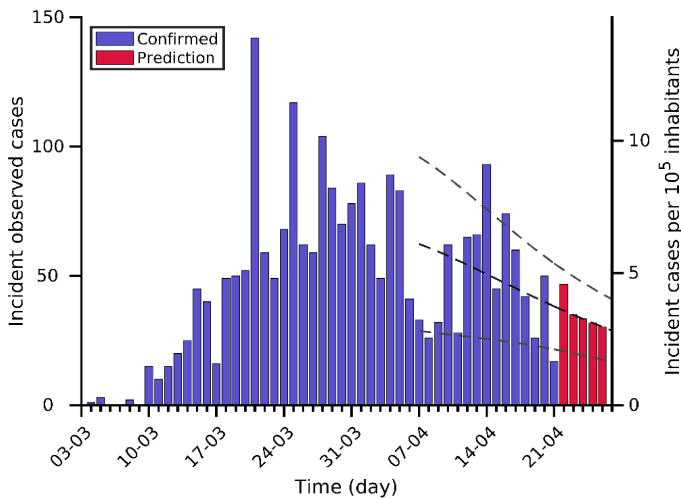
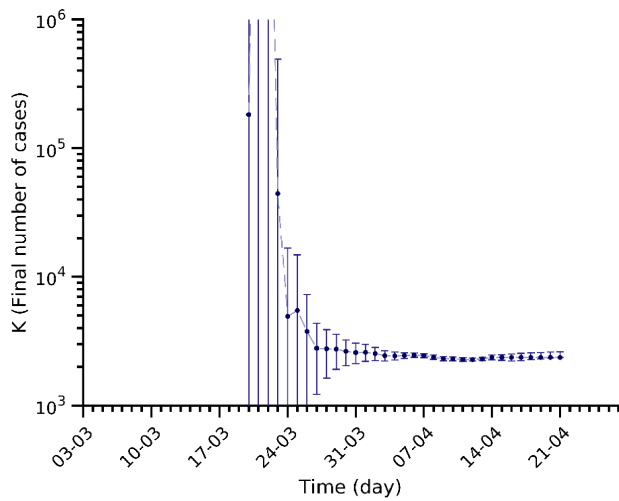
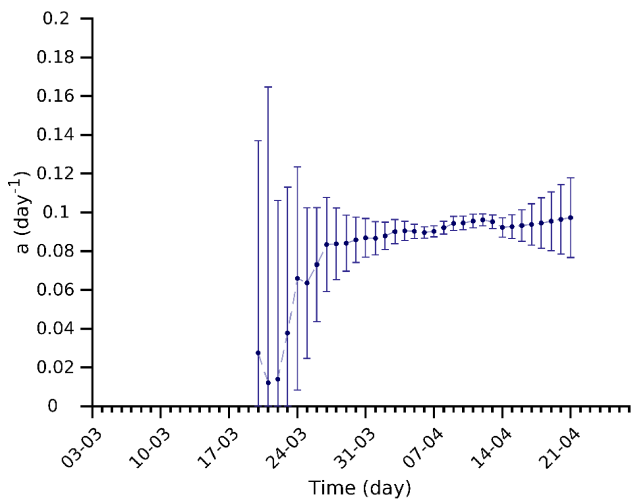
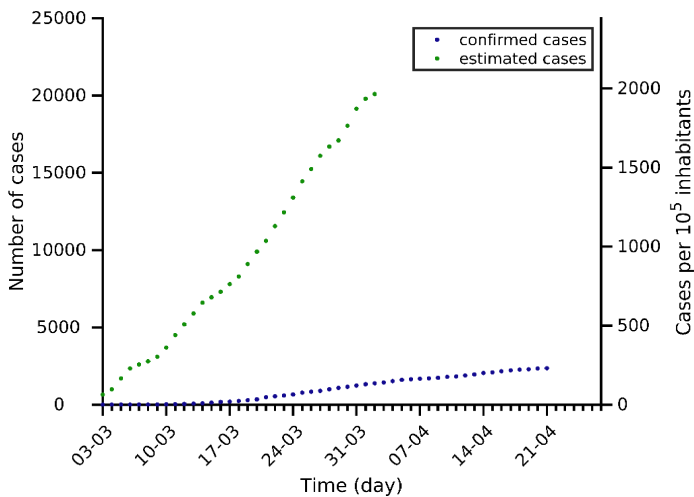
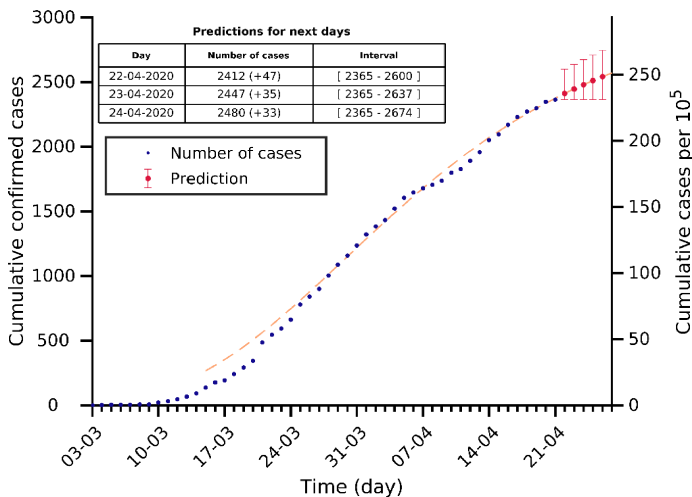
La Rioja 21-04-2020. Population: 0.3M. Current cumulated incidence: 1188/10⁵



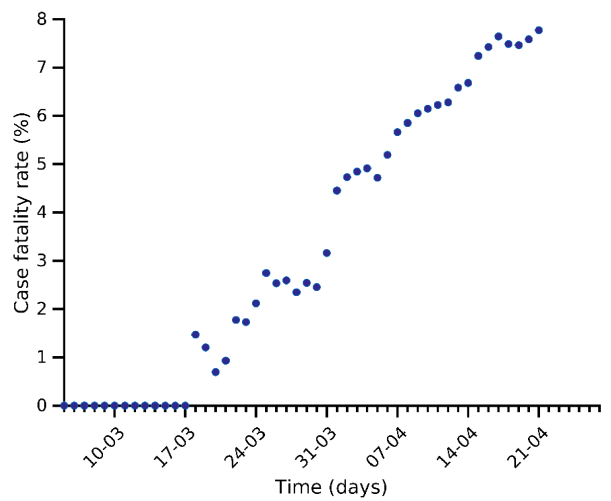
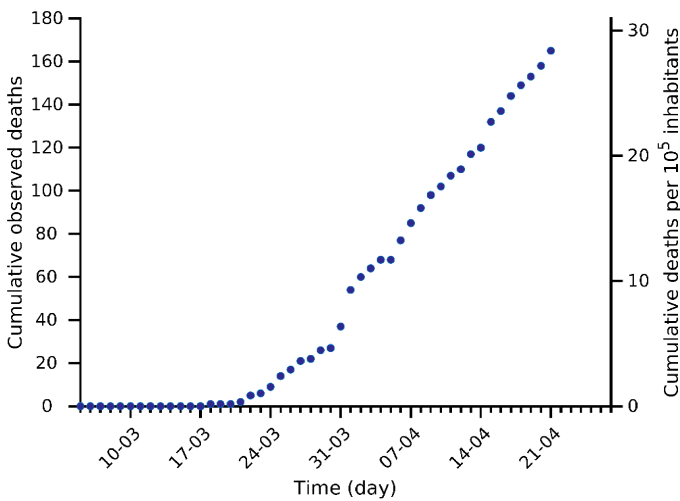
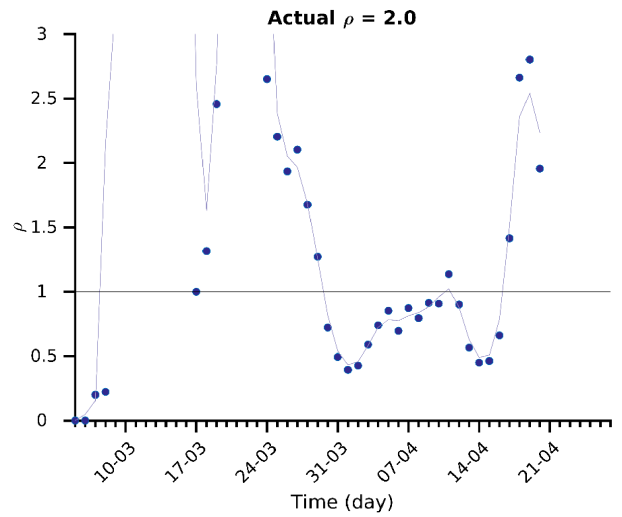
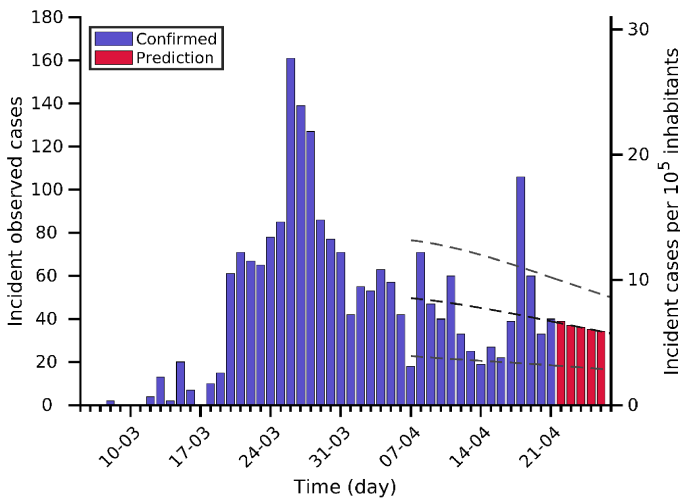
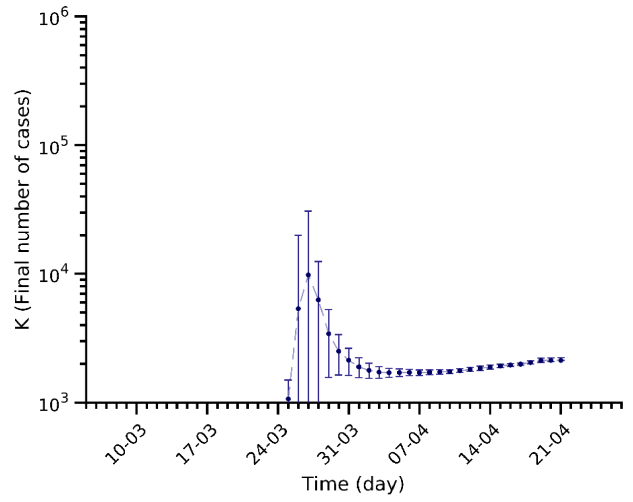
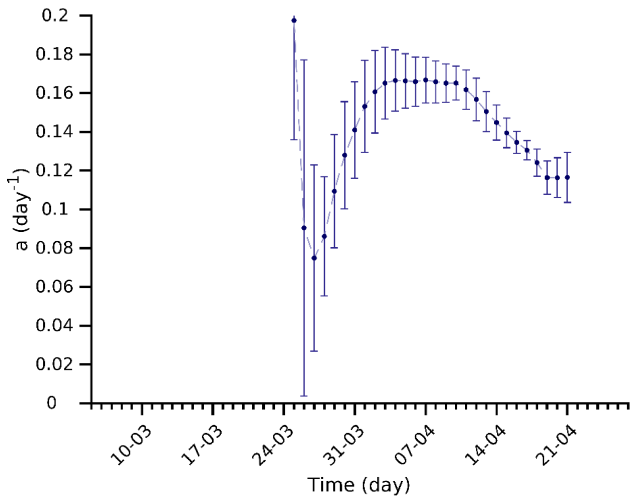
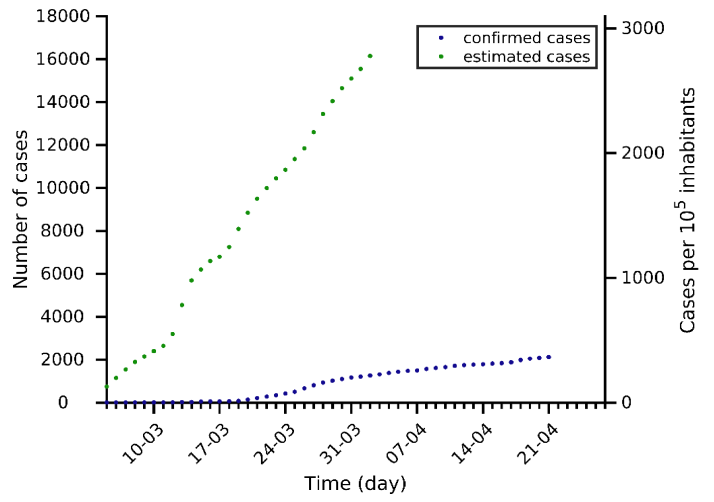
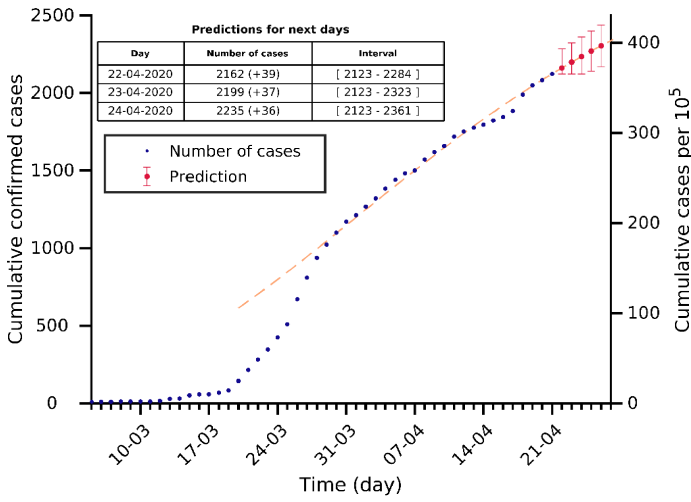
Extremadura 21-04-2020. Population: 1.1M. Current cumulated incidence: 299/10⁵



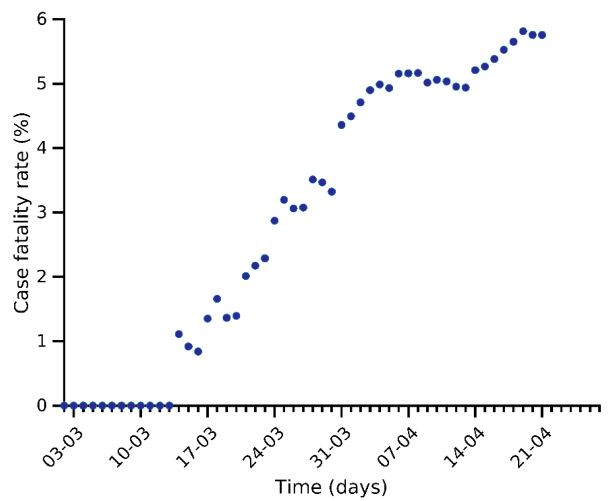
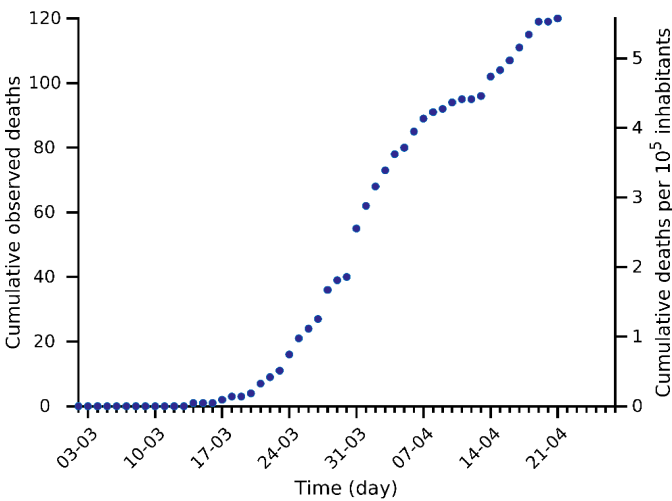
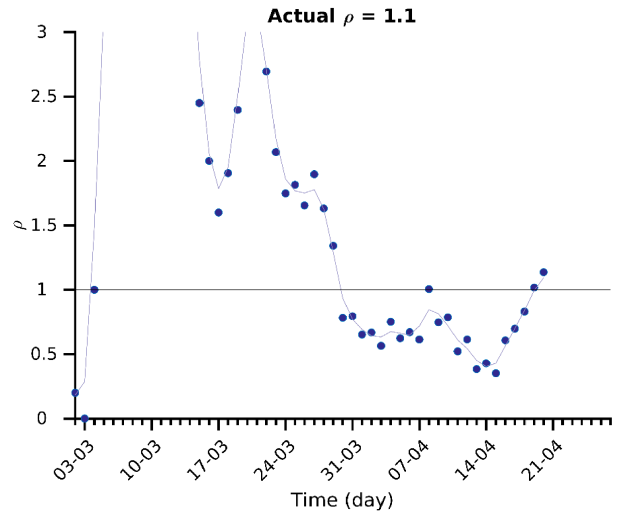
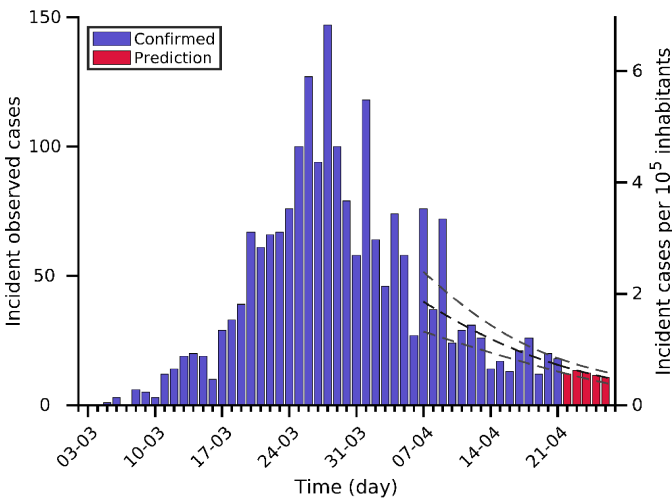
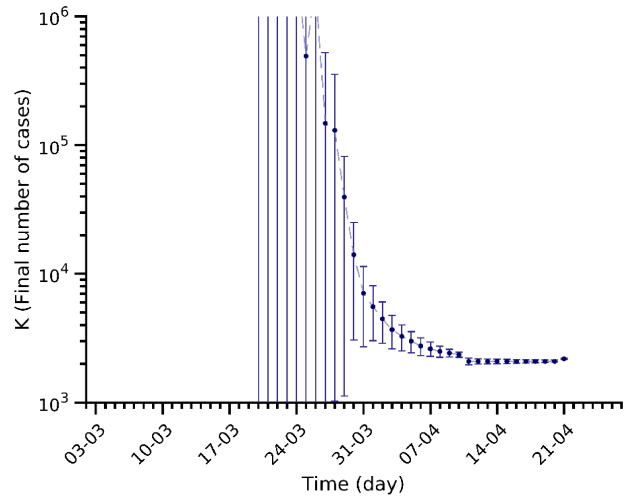
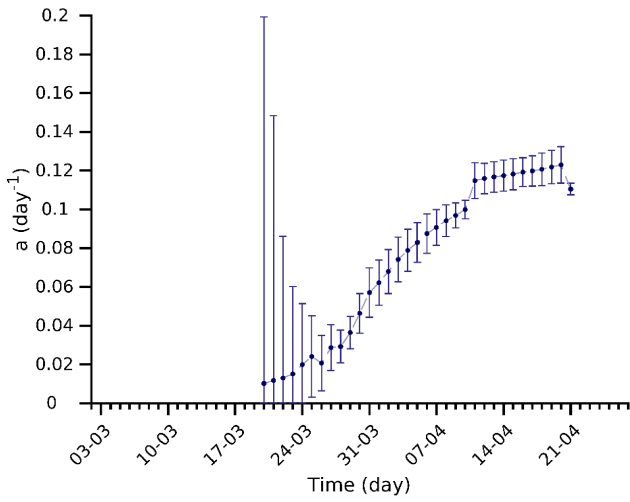
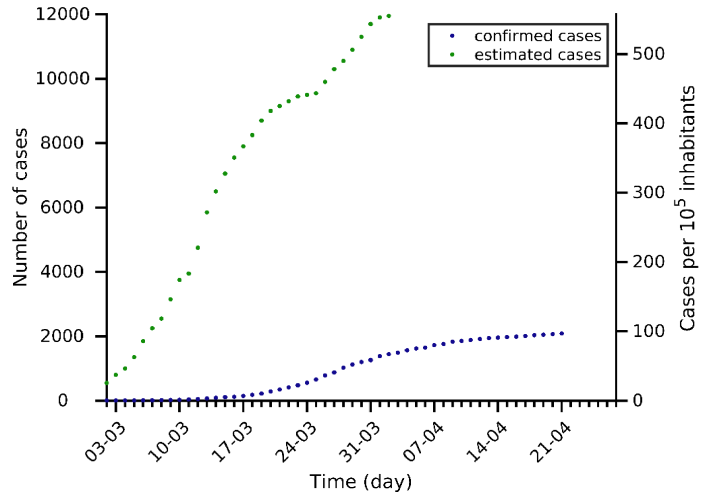
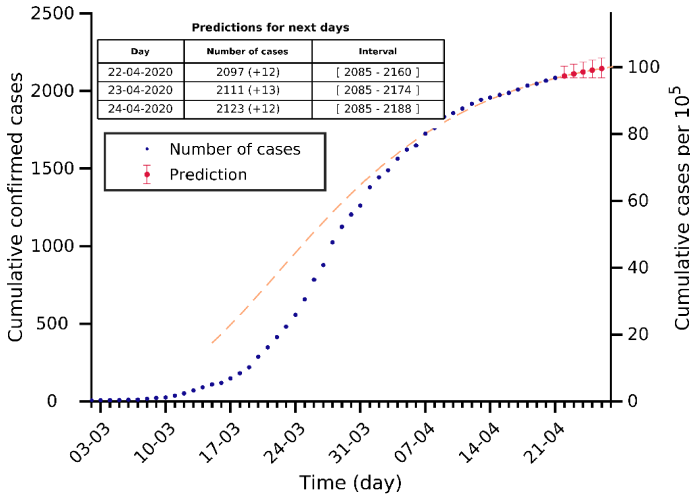
Asturias 21-04-2020. Population: 1.0M. Current cumulated incidence: 231/10⁵



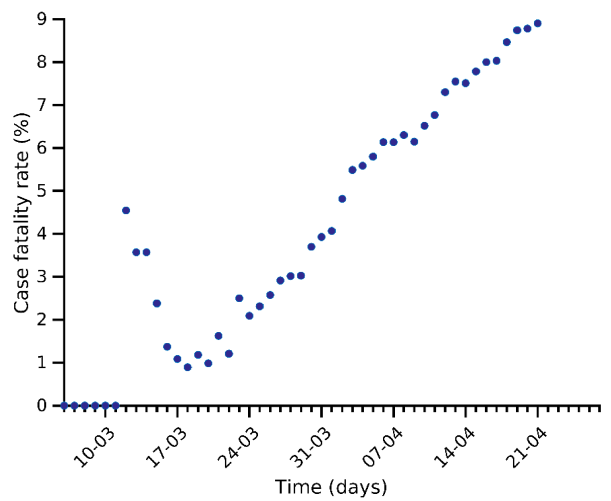
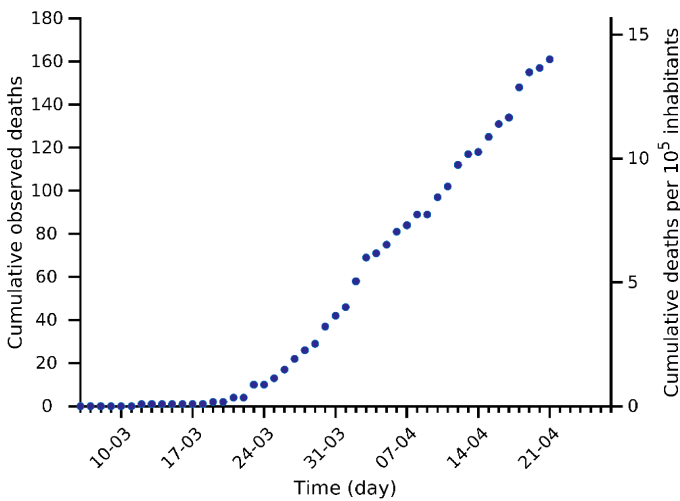
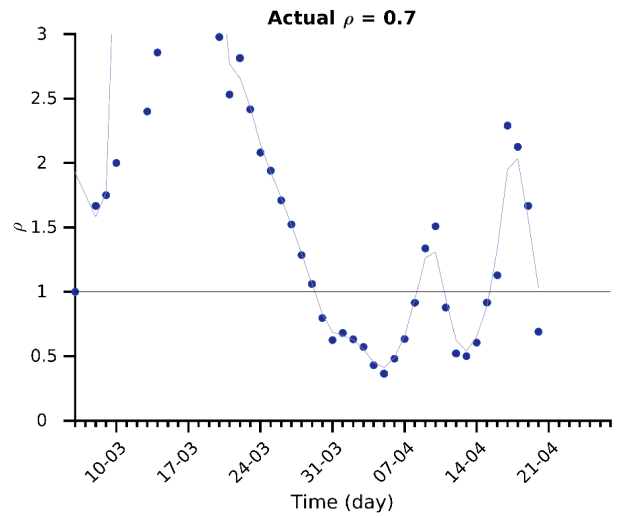
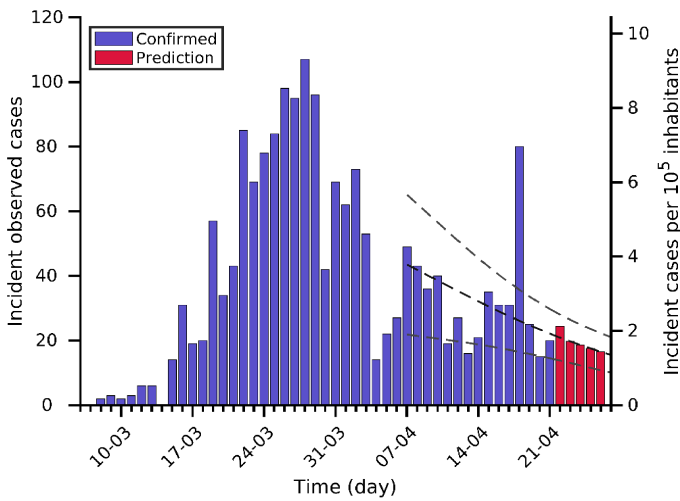
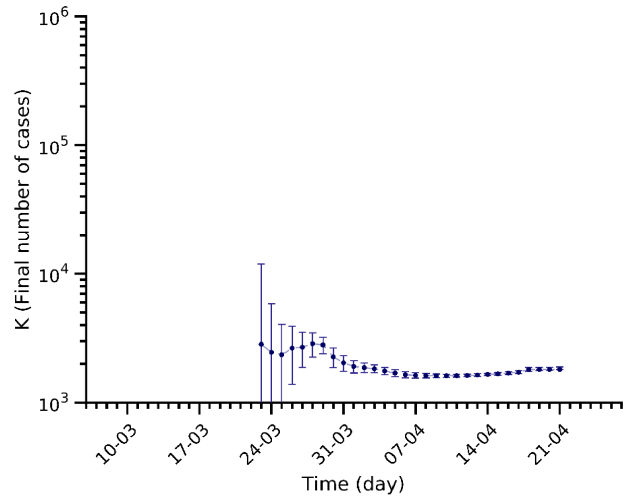
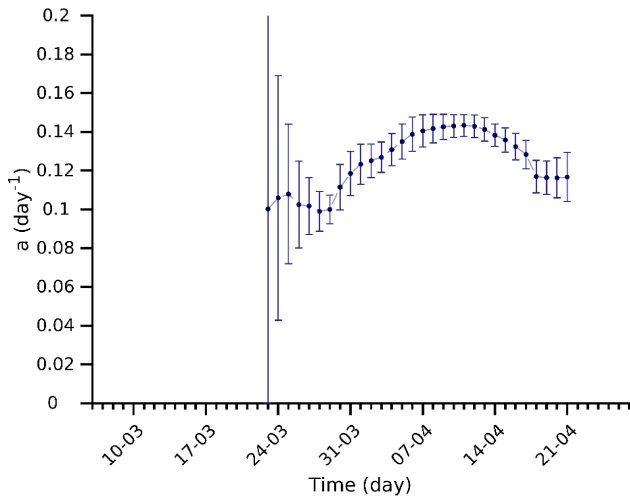
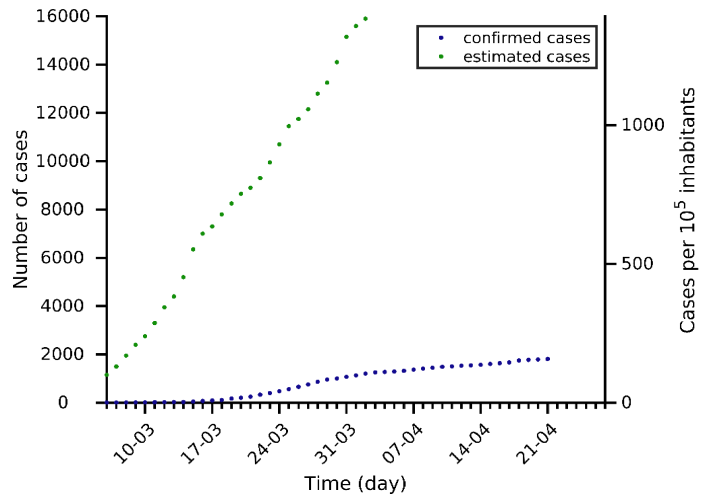
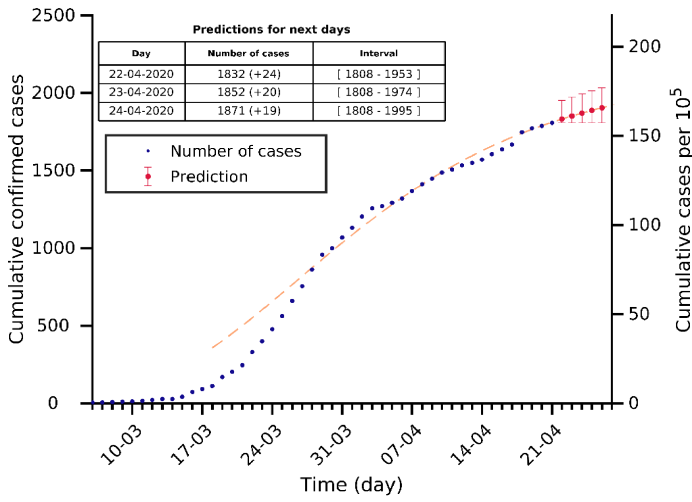
Cantabria 21-04-2020. Population: 0.6M. Current cumulated incidence: 365/10⁵



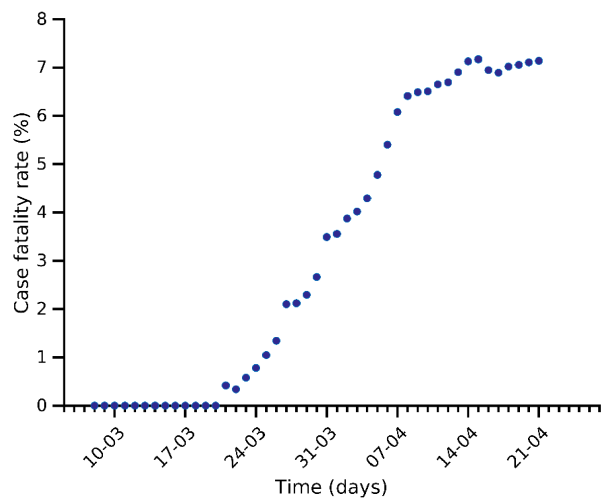
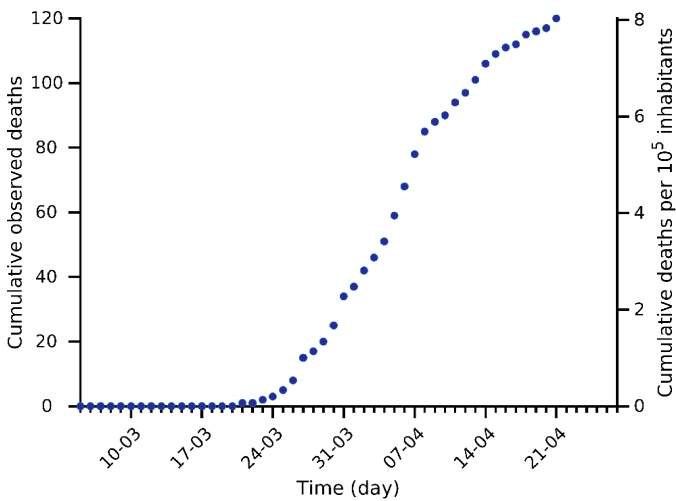
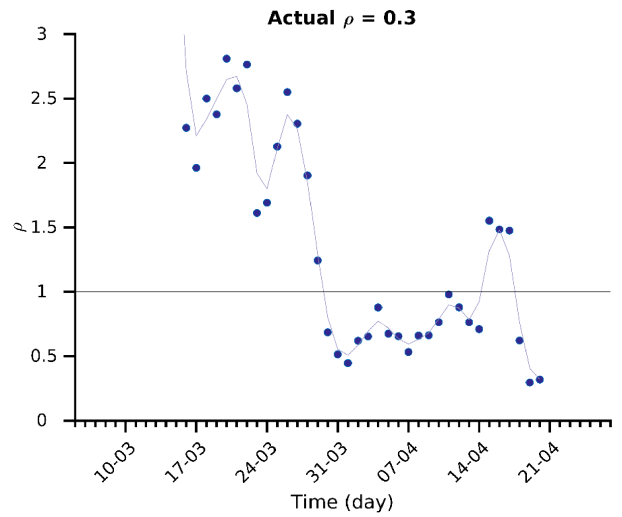
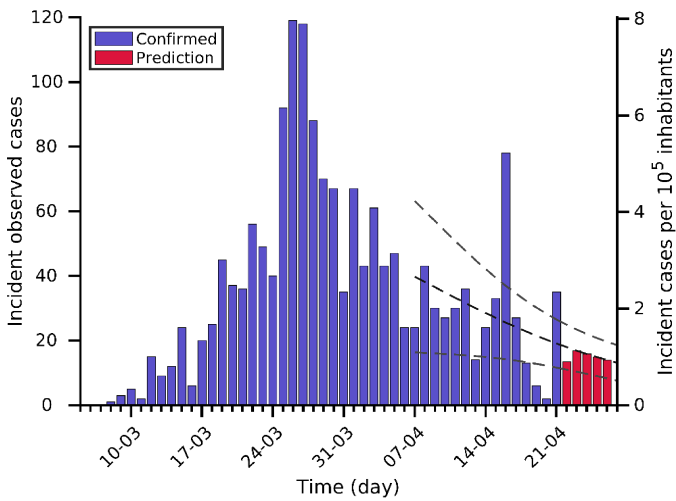
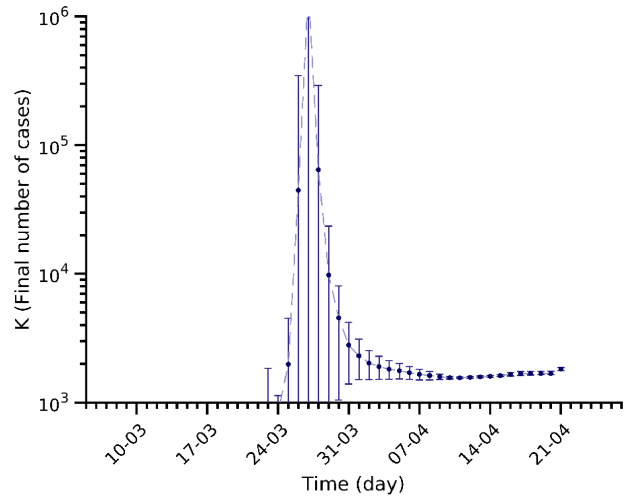
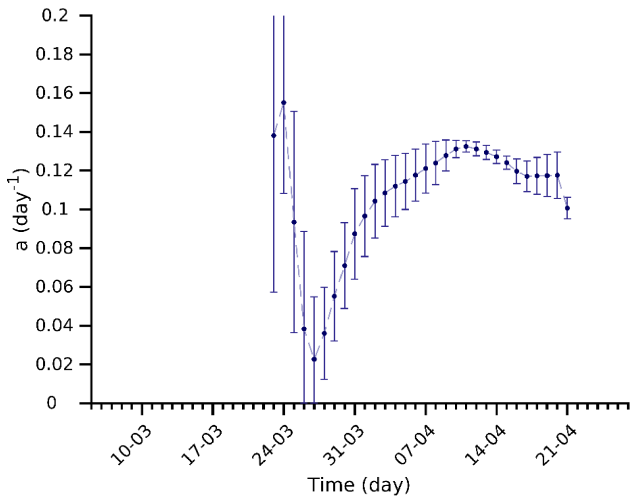
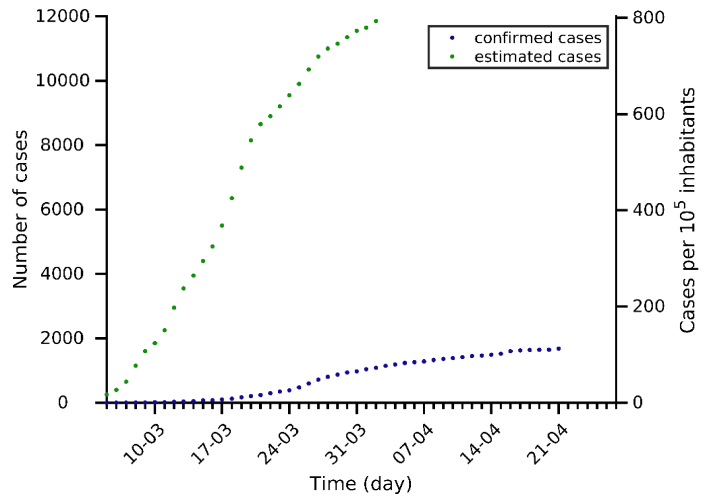
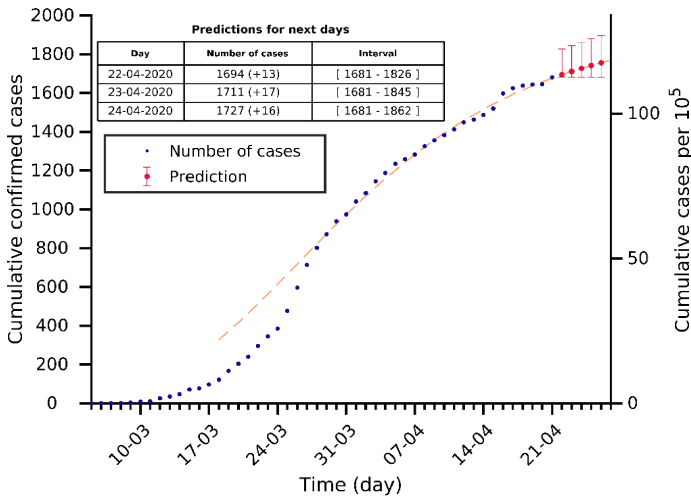
Canarias 21-04-2020. Population: 2.2M. Current cumulated incidence: 97/10⁵



Baleares 21-04-2020. Population: 1.1M. Current cumulated incidence: 157/10⁵



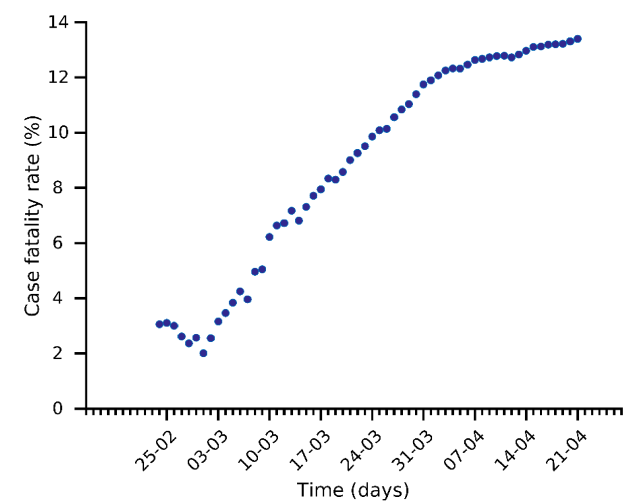
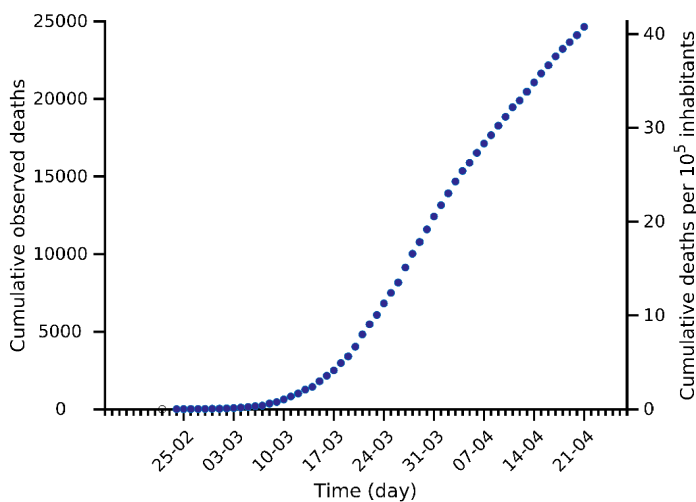
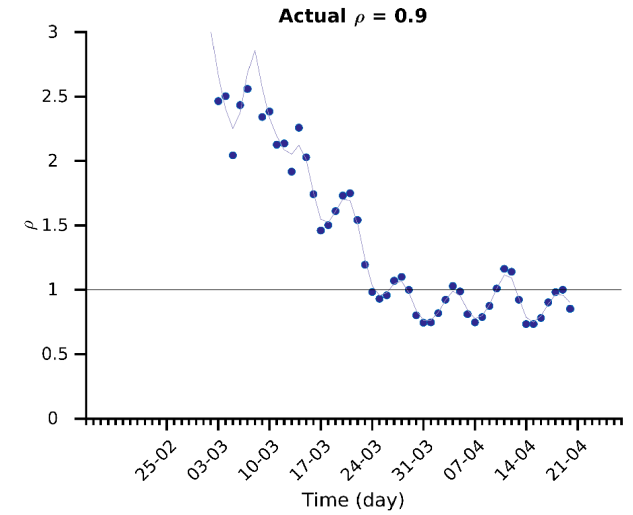
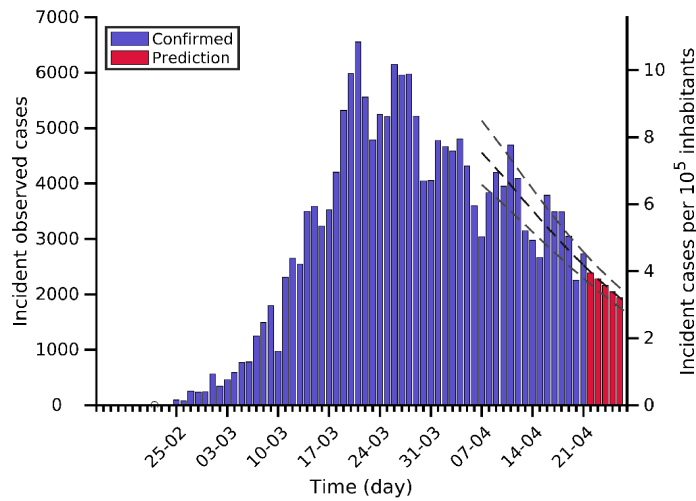
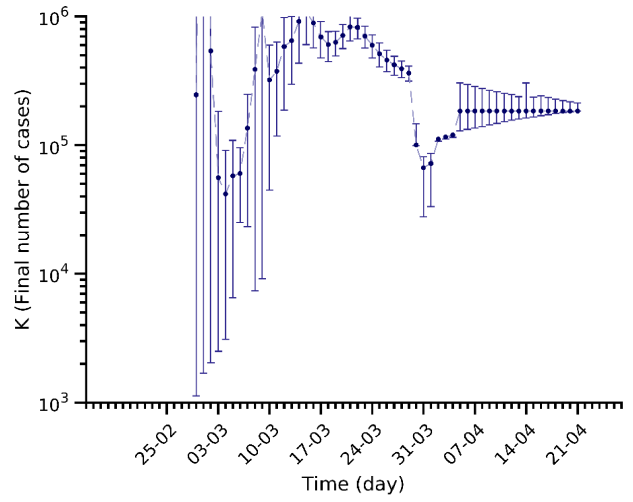
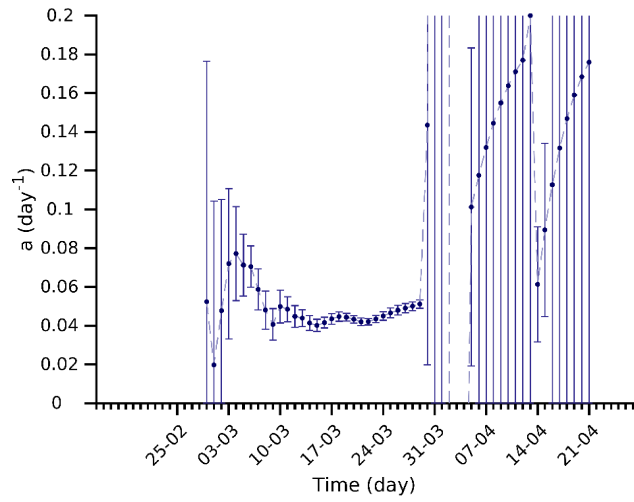
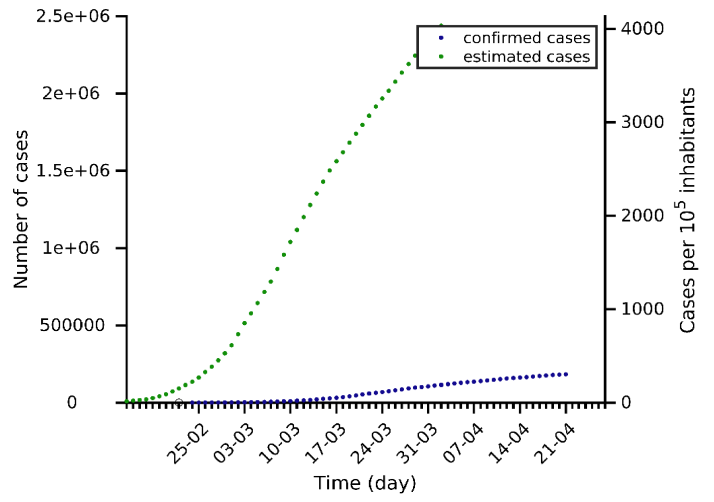
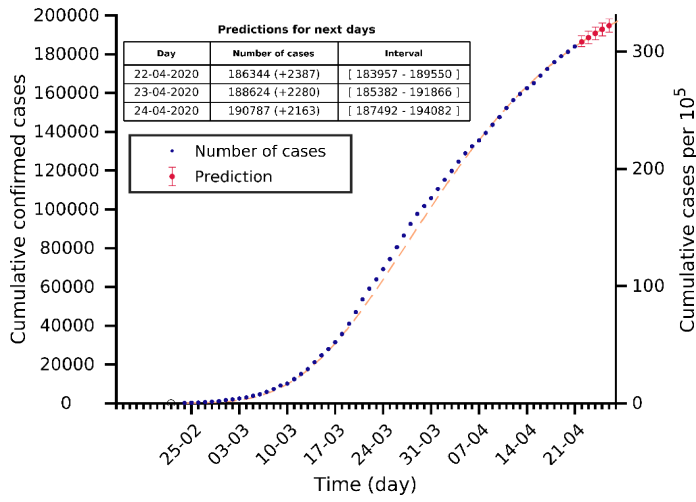
Murcia 21-04-2020. Population: 1.5M. Current cumulated incidence: 113/10⁵



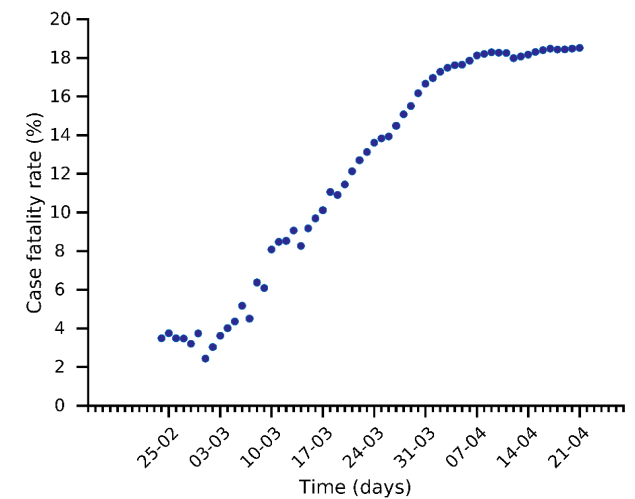
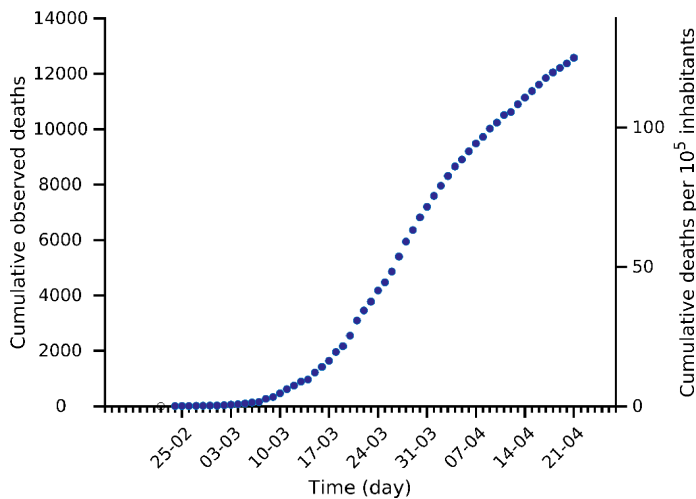
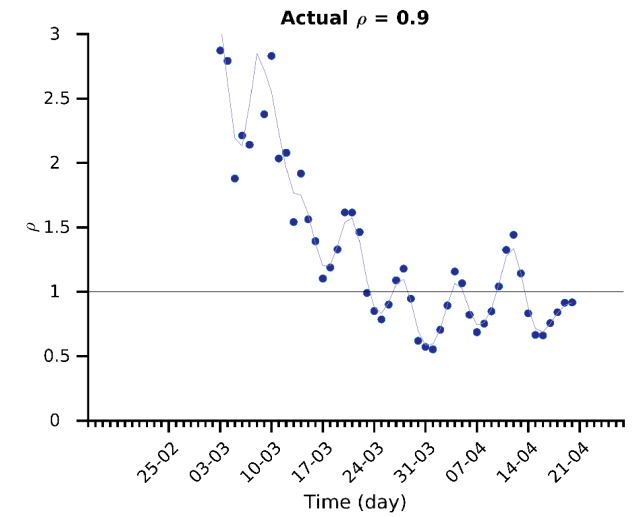
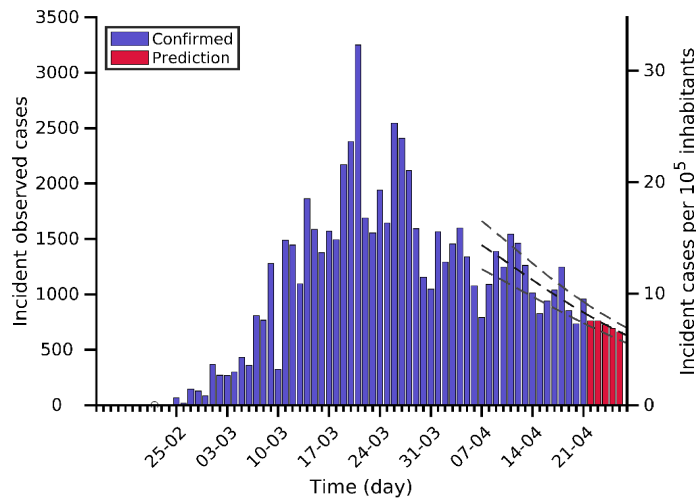
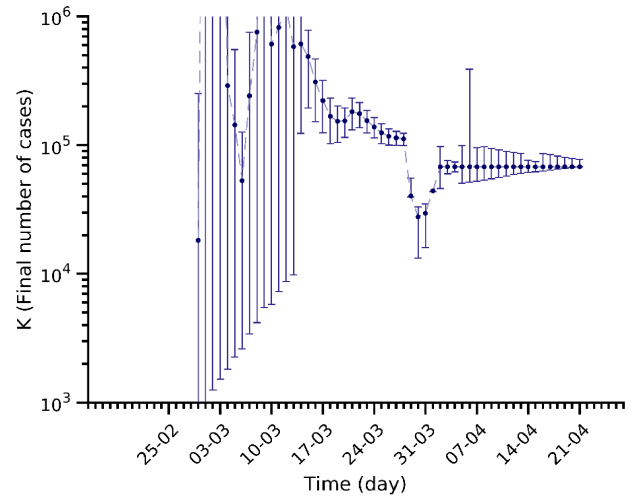
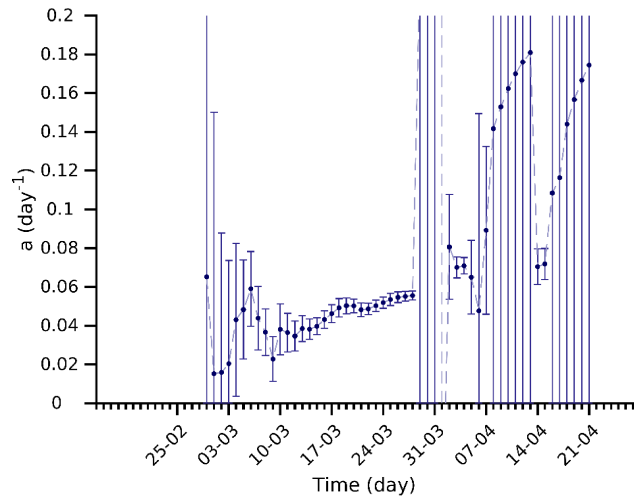
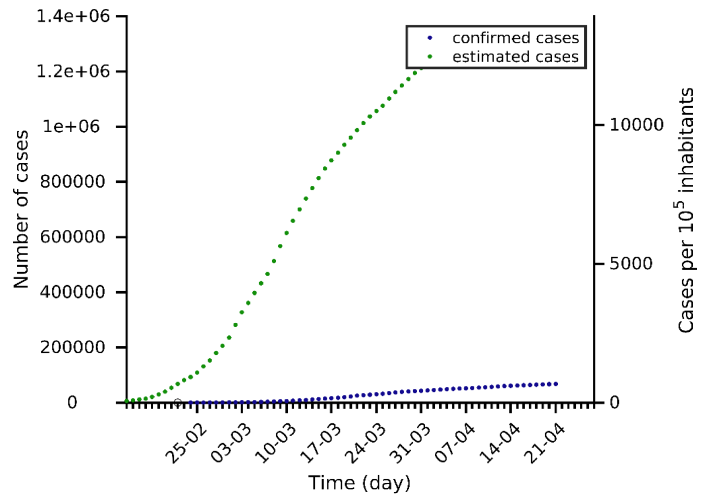
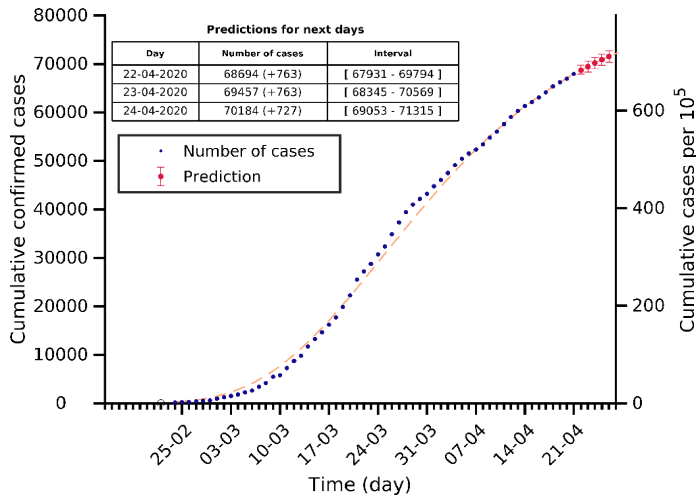
(4) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

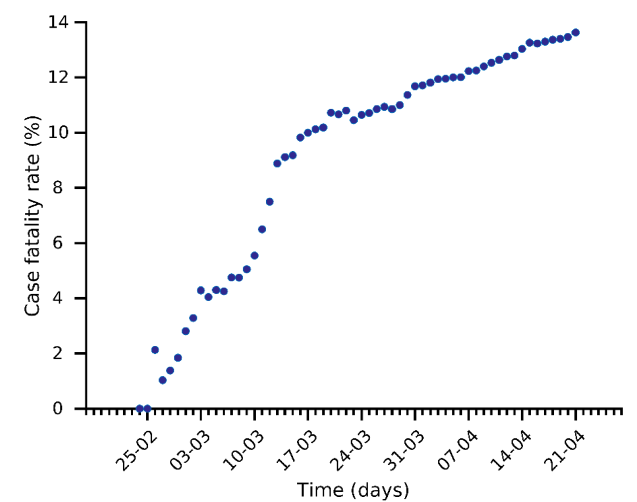
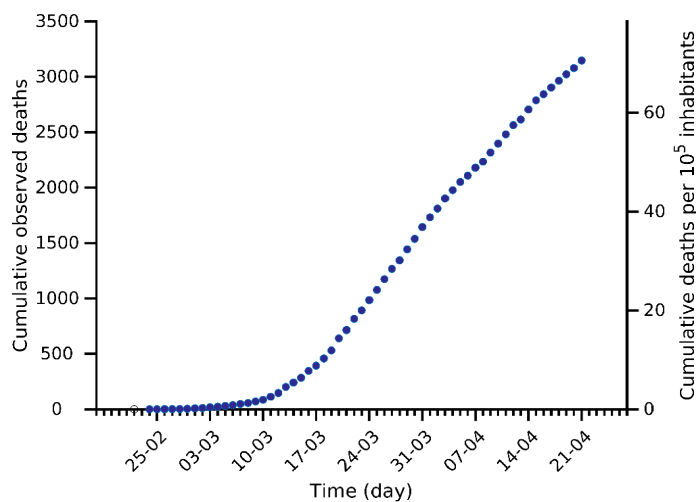
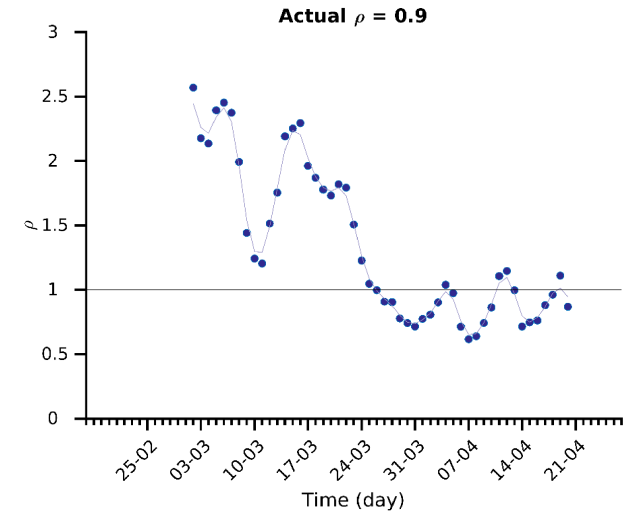
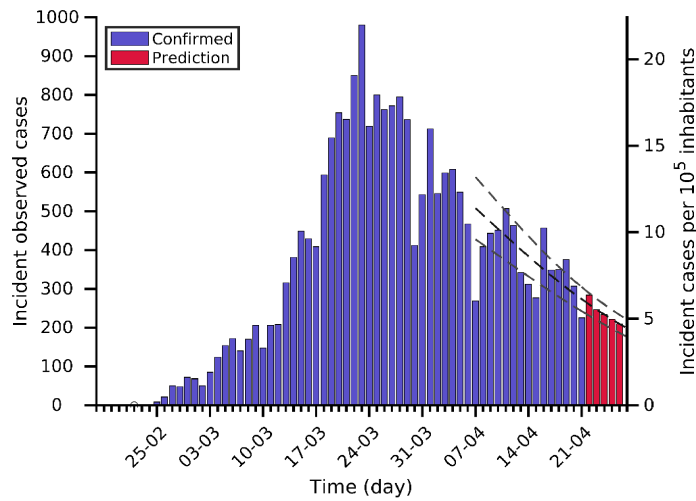
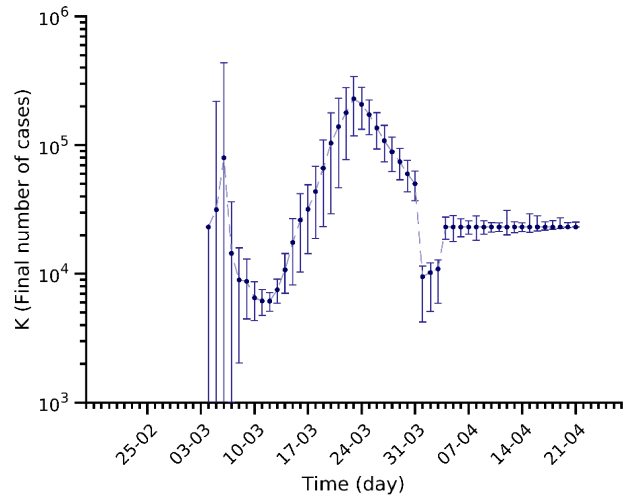
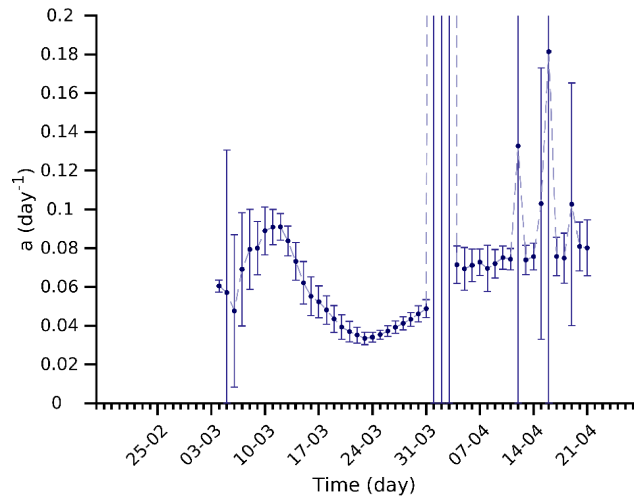
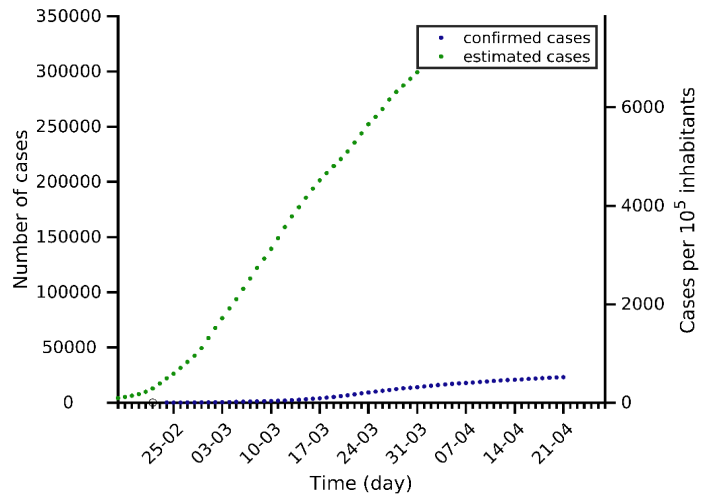
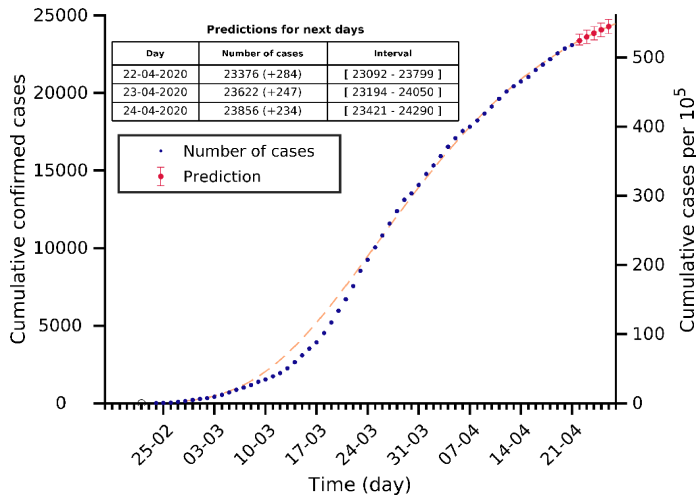
Italy 21-04-2020. Population: 60.5M. Current cumulated incidence: 304/10⁵



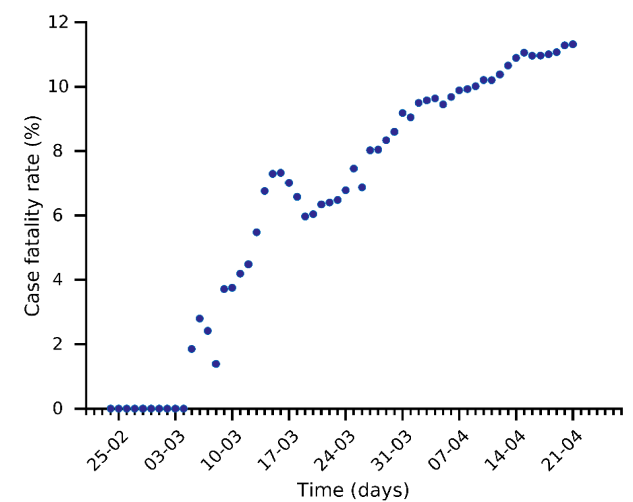
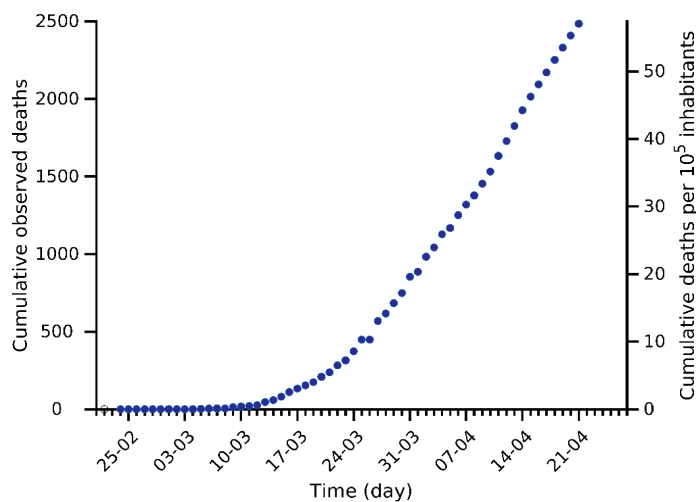
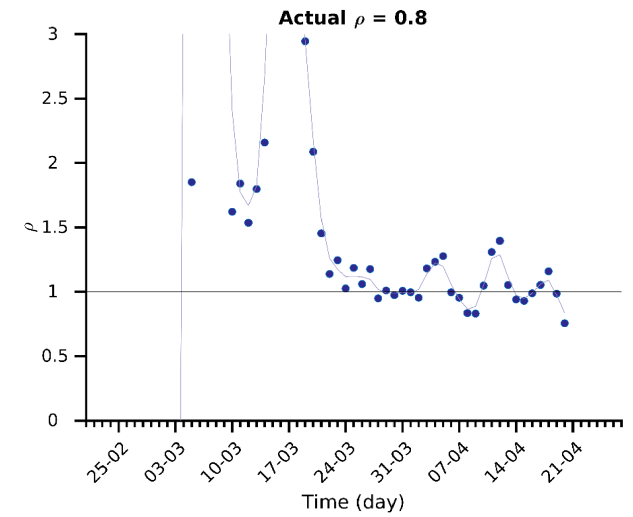
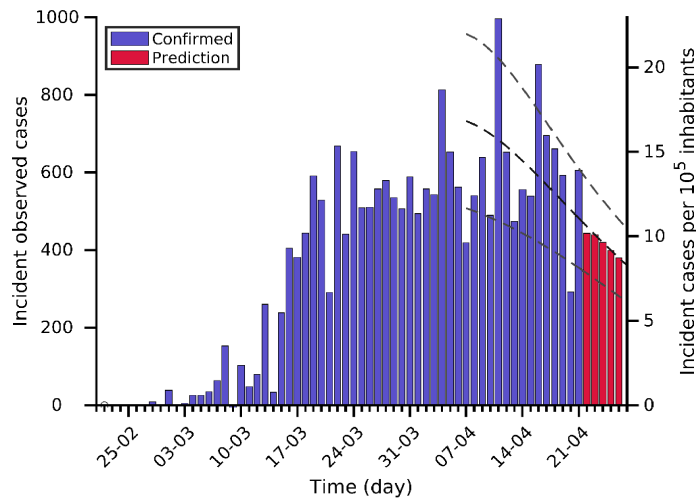
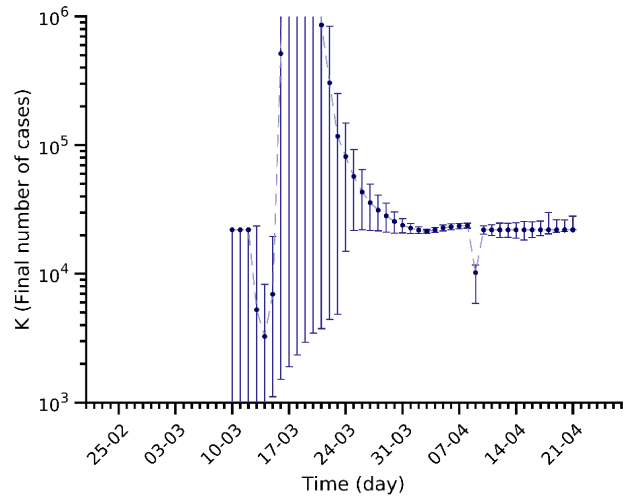
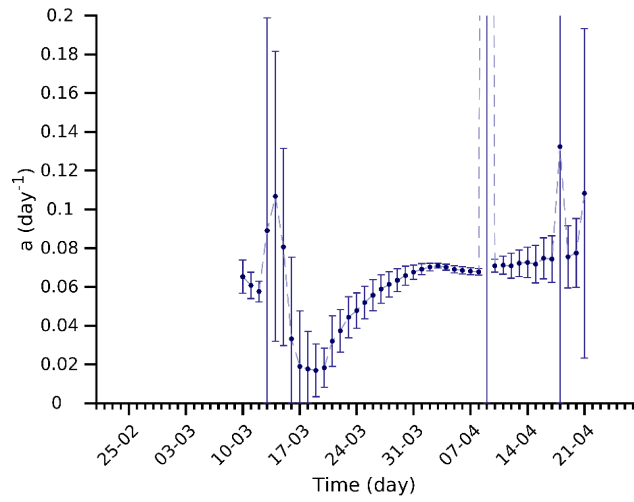
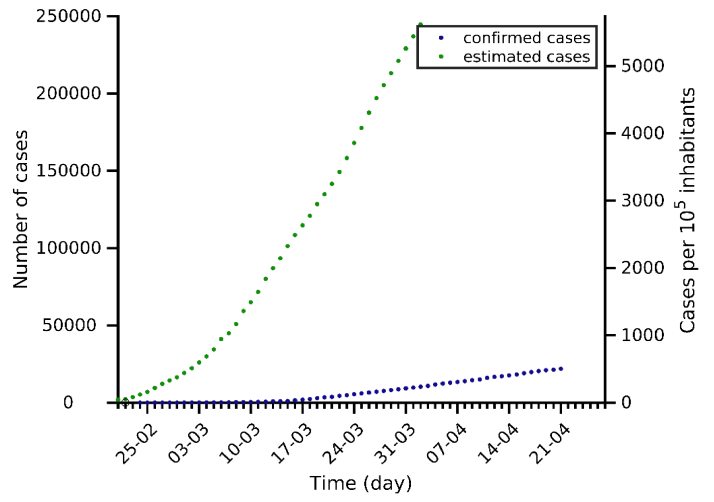
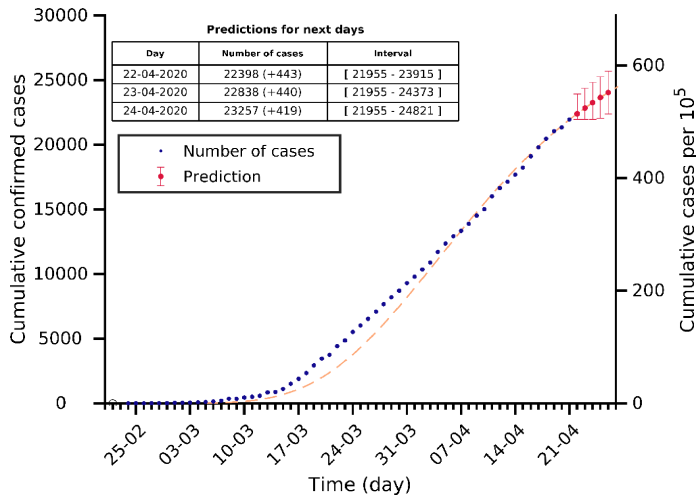
Lombardia 21-04-2020. Population: 10.1M. Current cumulated incidence: 675/10⁵



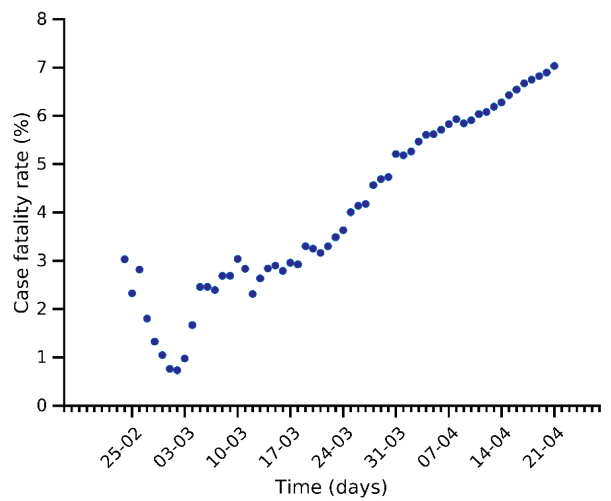
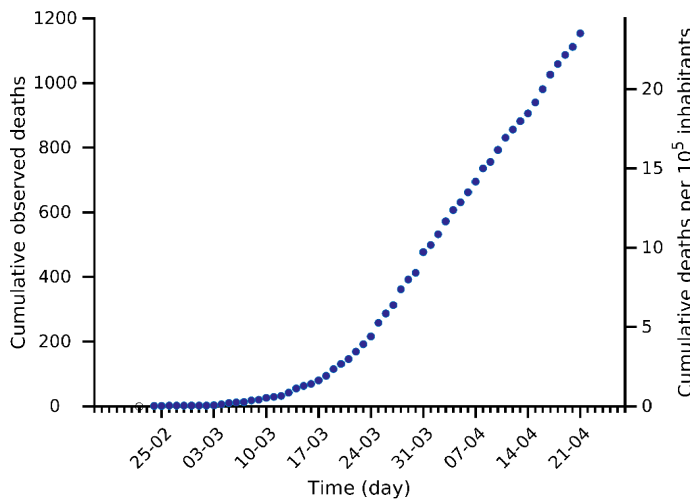
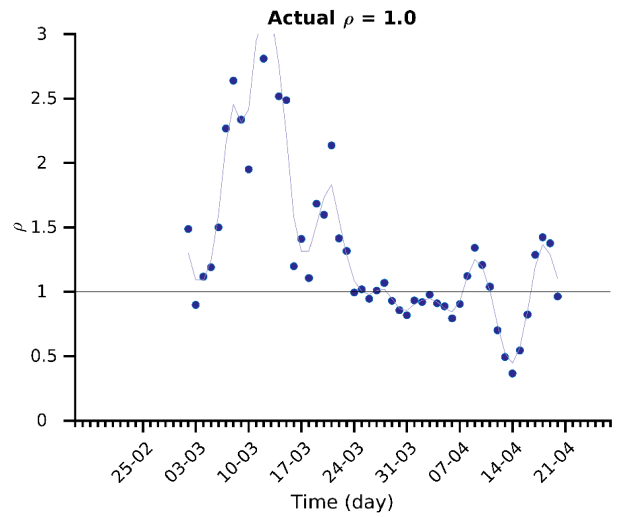
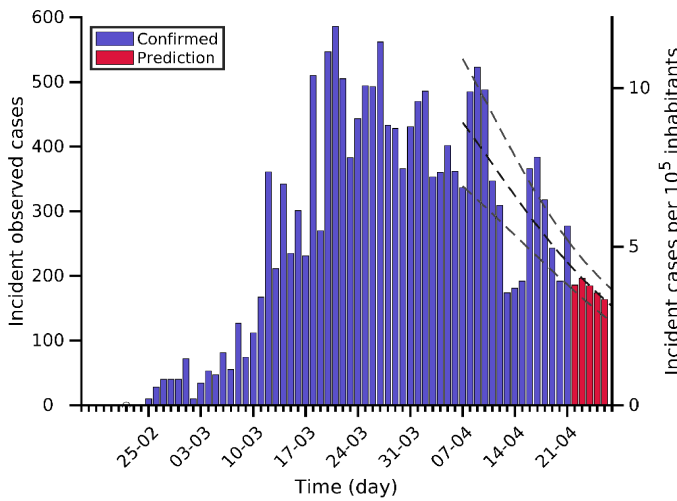
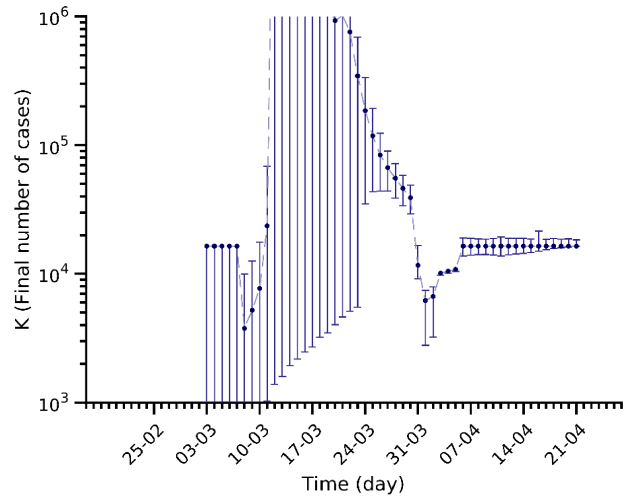
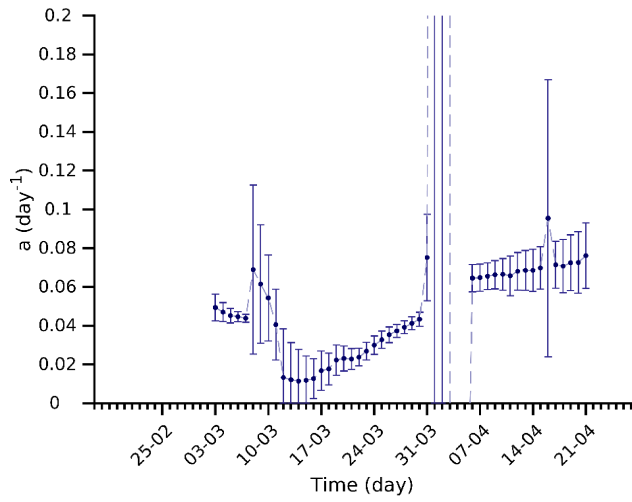
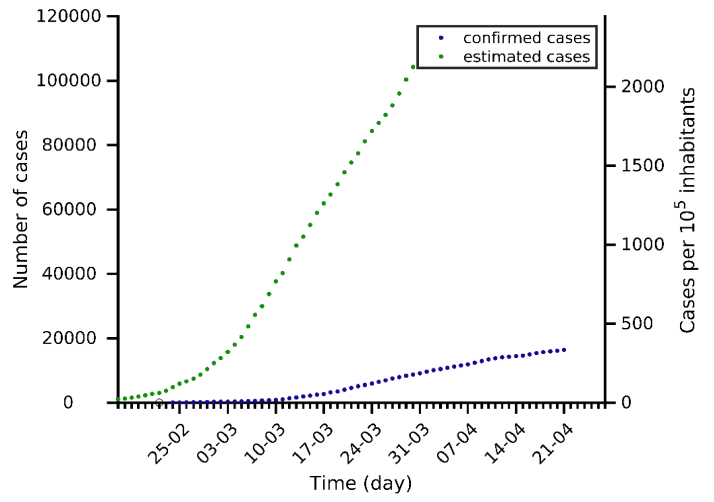
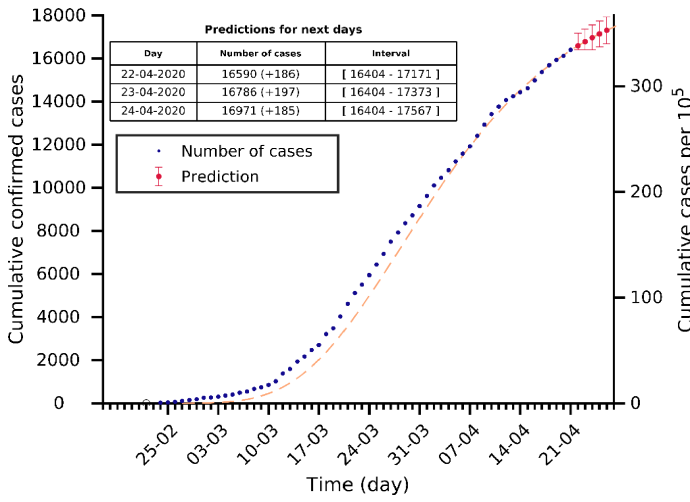
Emilia Romagna 21-04-2020. Population: 4.5M. Current cumulated incidence: 518/10⁵



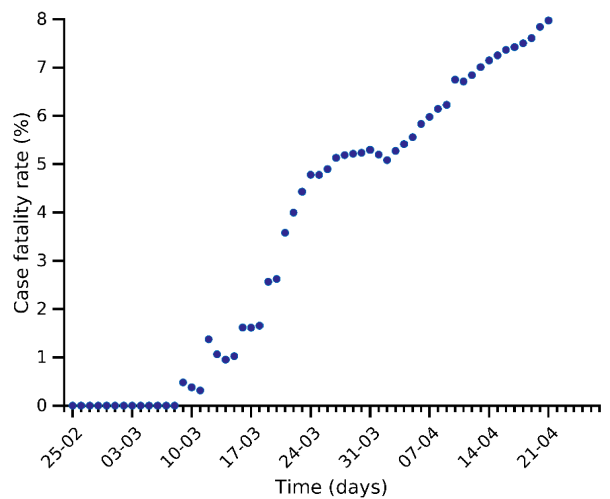
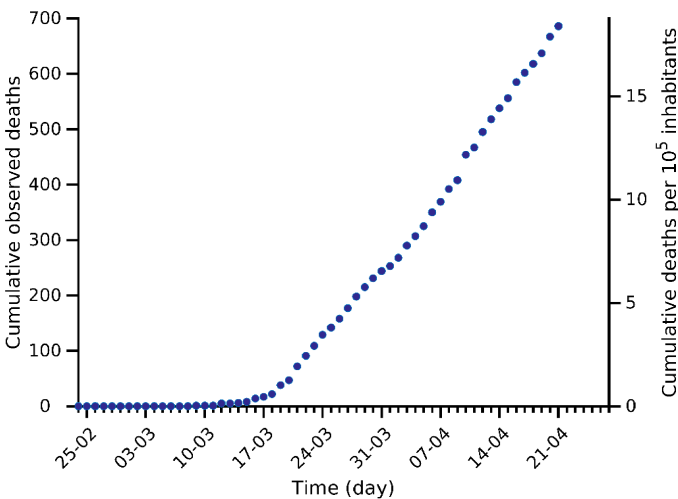
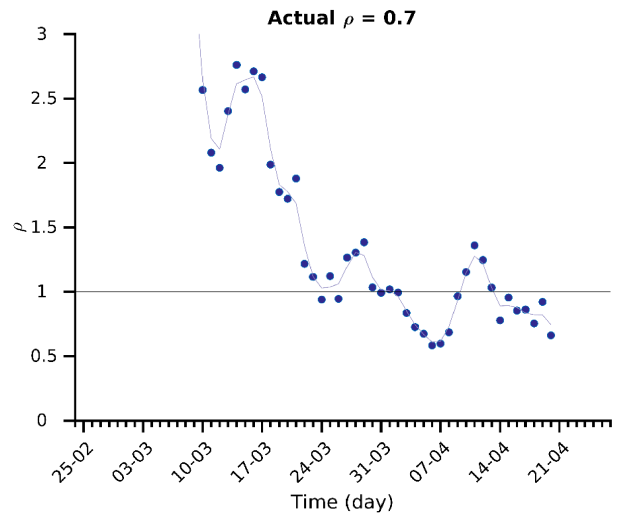
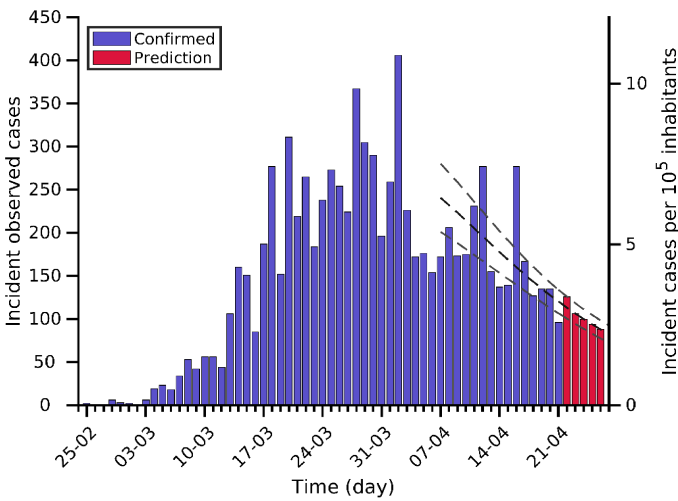
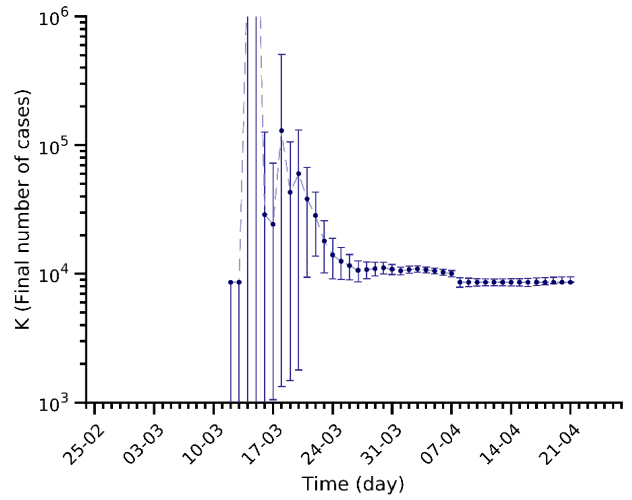
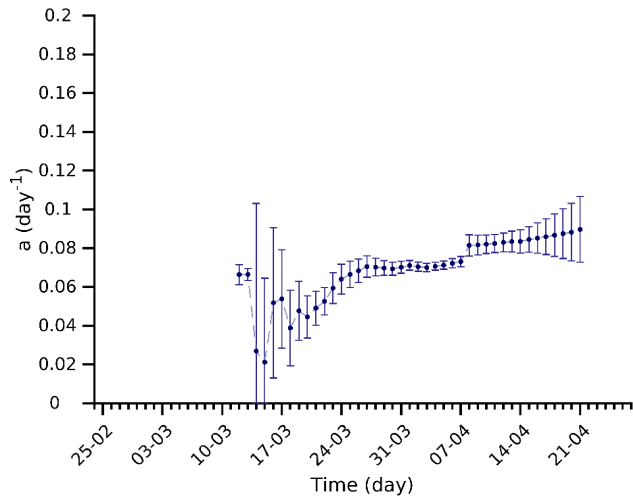
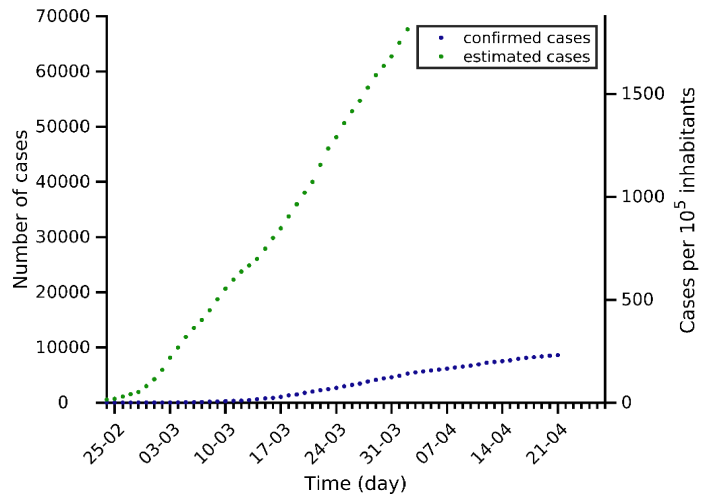
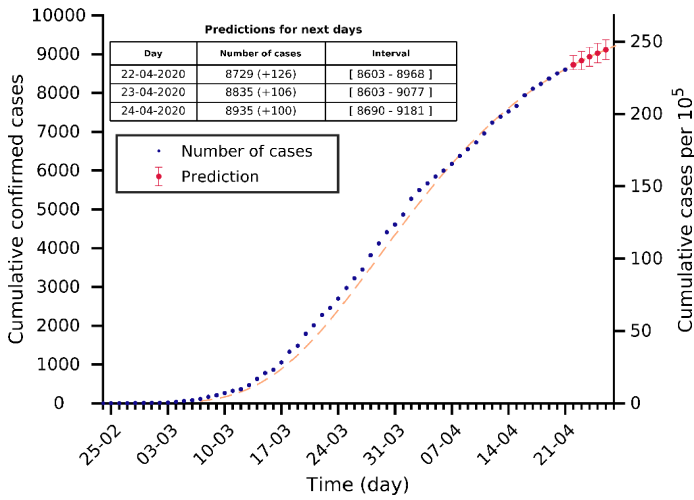
Piemonte 21-04-2020. Population: 4.4M. Current cumulated incidence: 504/10⁵



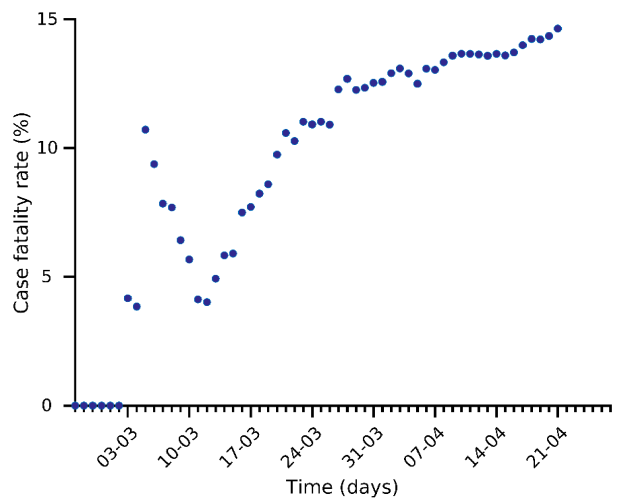
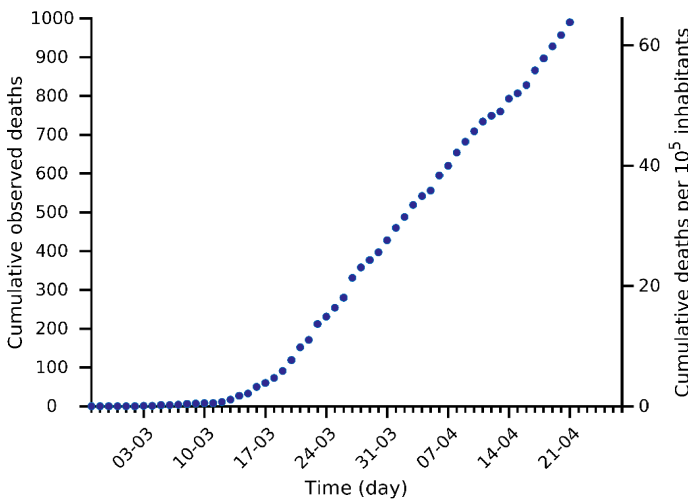
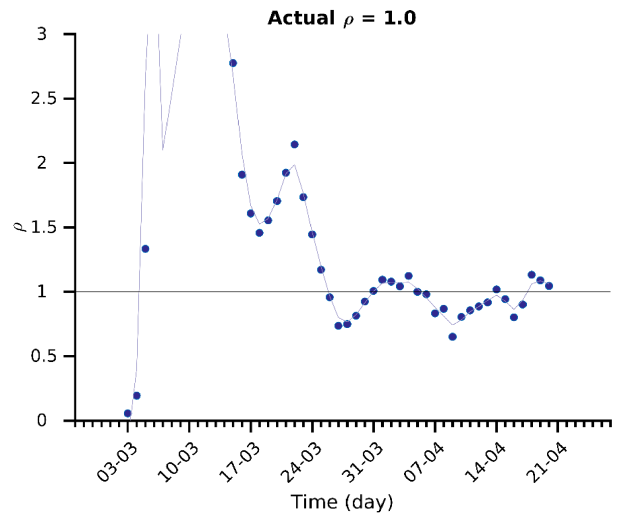
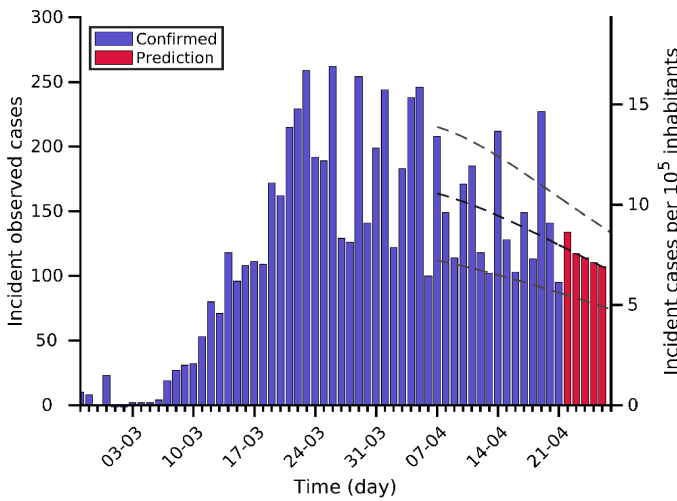
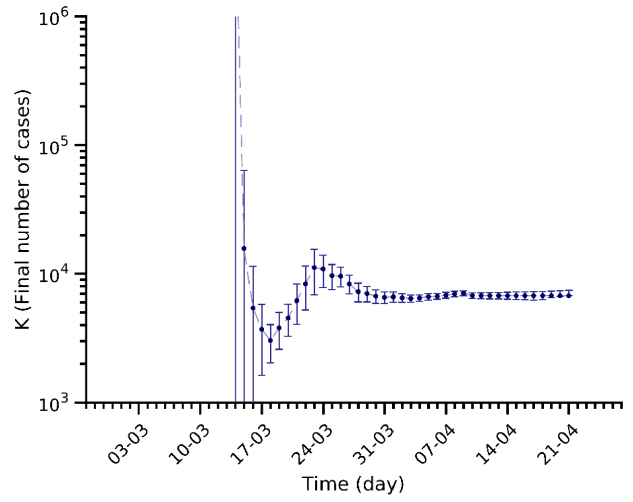
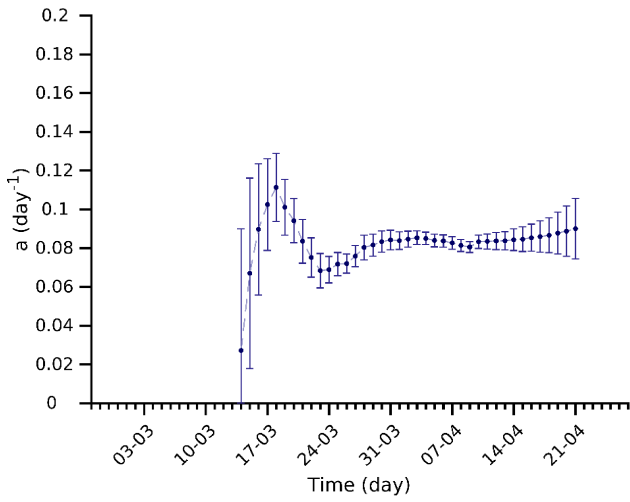
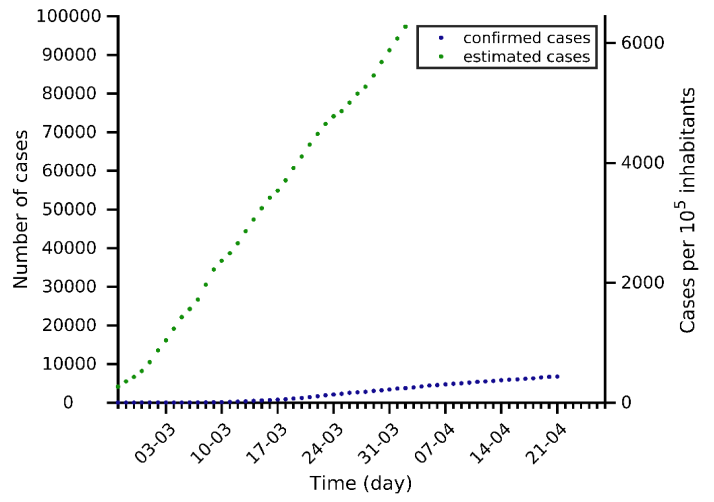
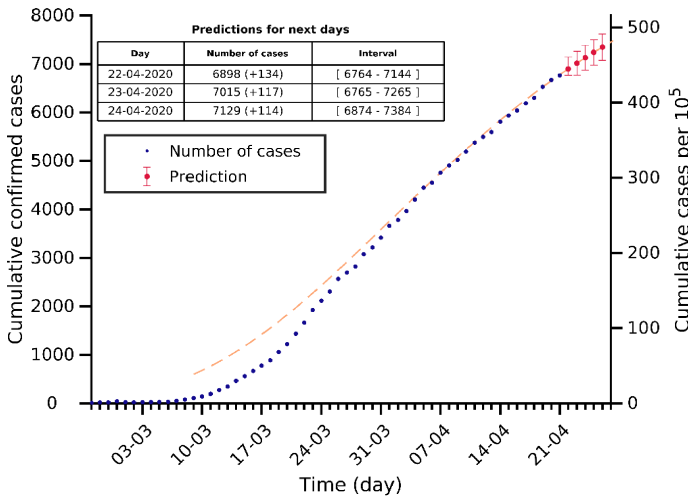
Veneto 21-04-2020. Population: 4.9M. Current cumulated incidence: 334/10⁵



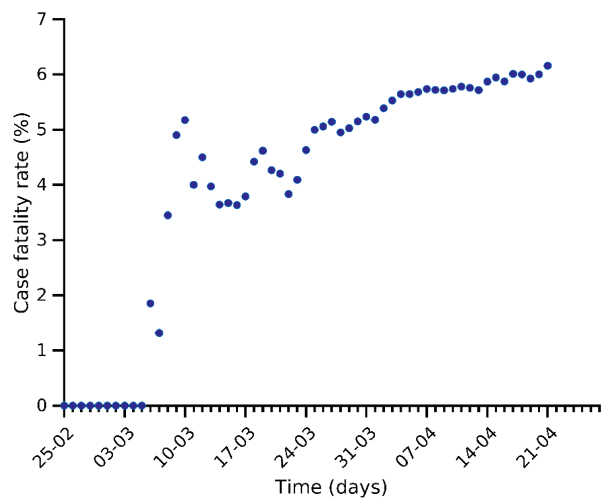
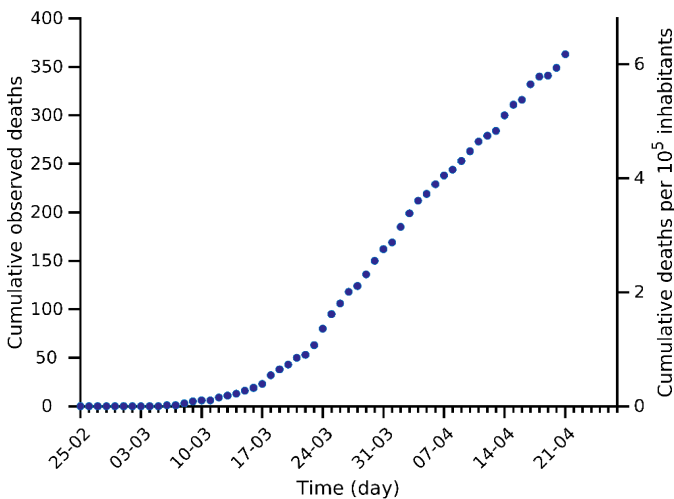
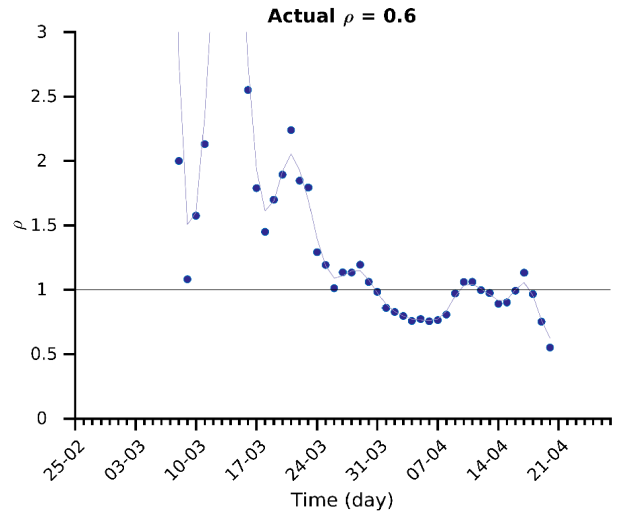
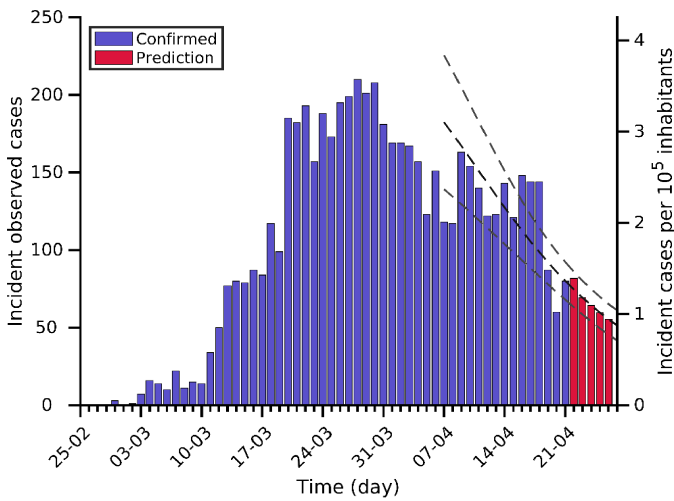
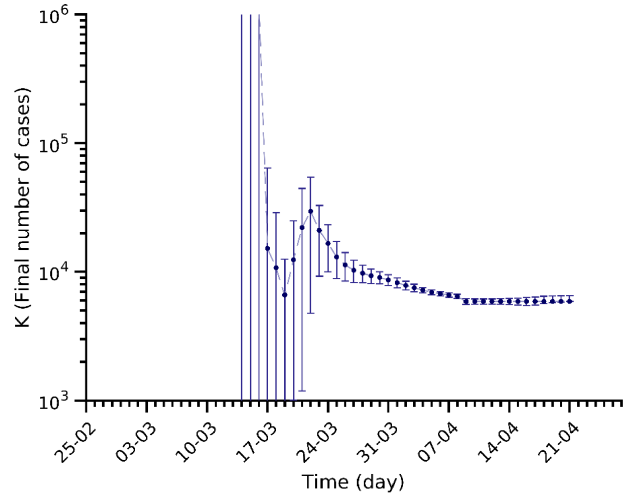
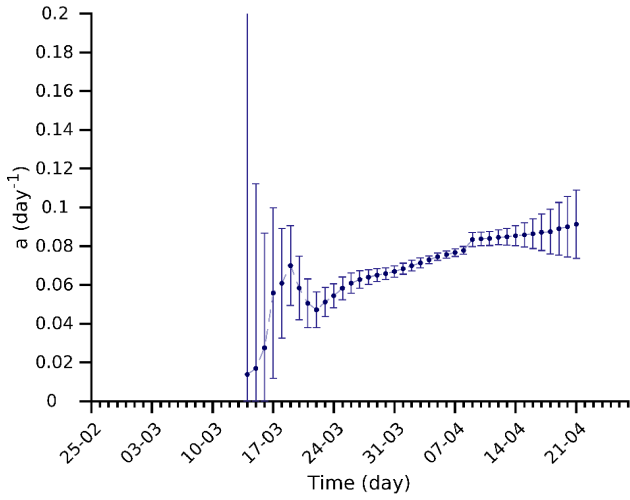
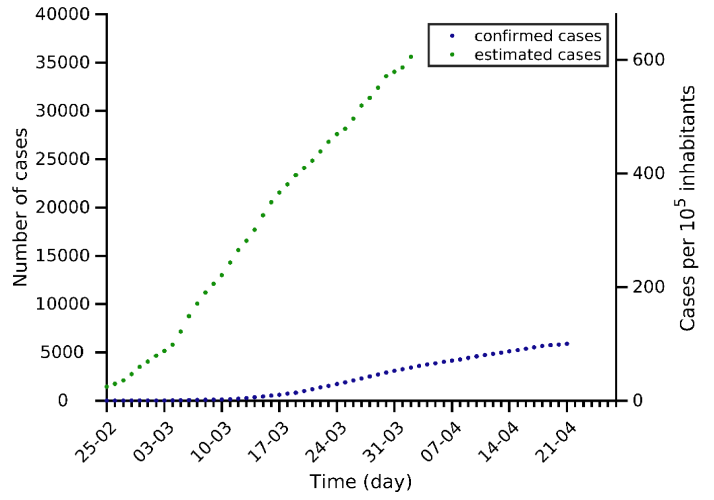
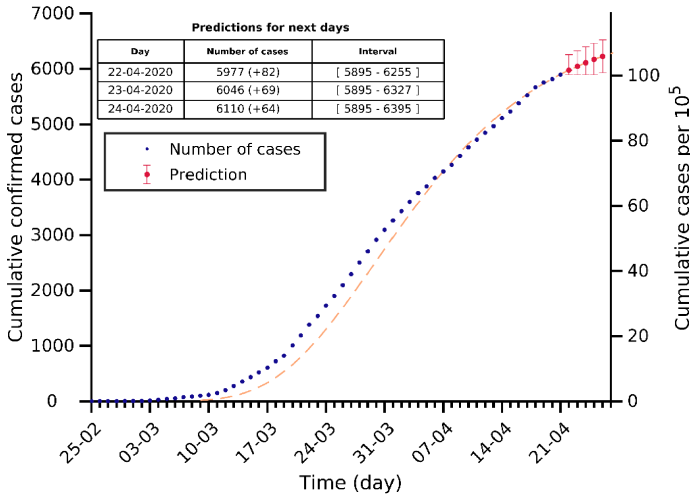
Toscana 21-04-2020. Population: 3.7M. Current cumulated incidence: 231/10⁵



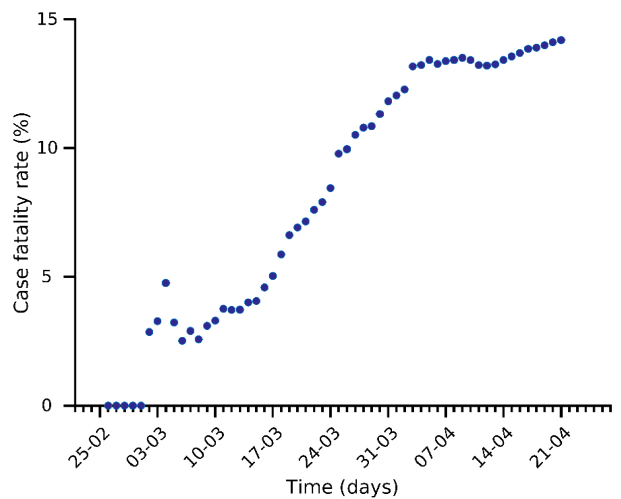
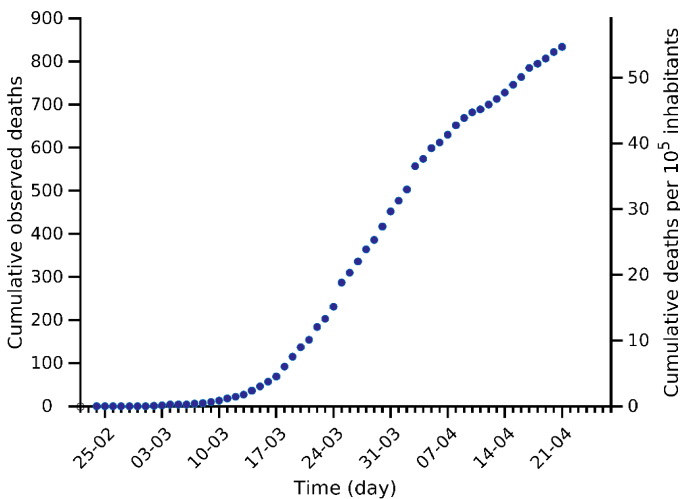
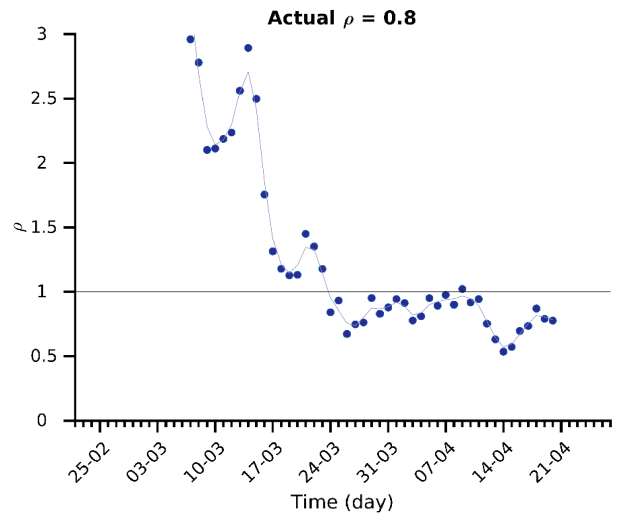
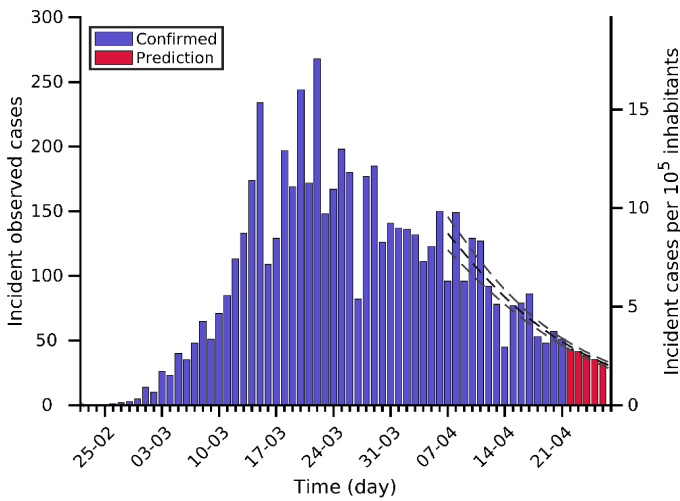
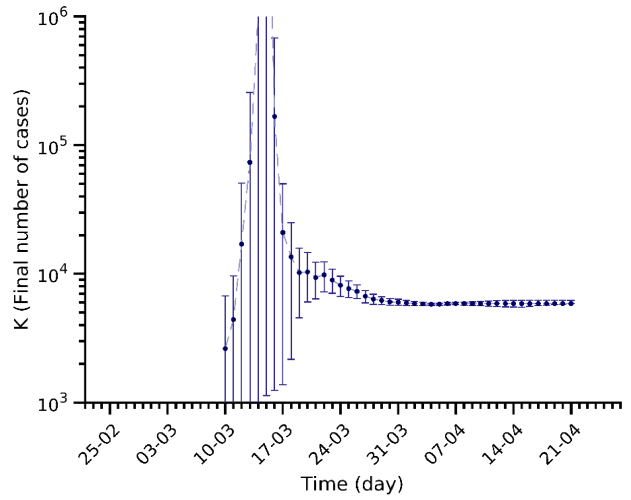
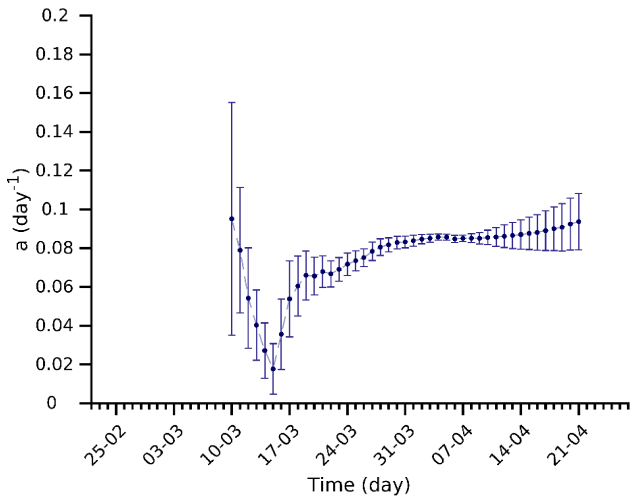
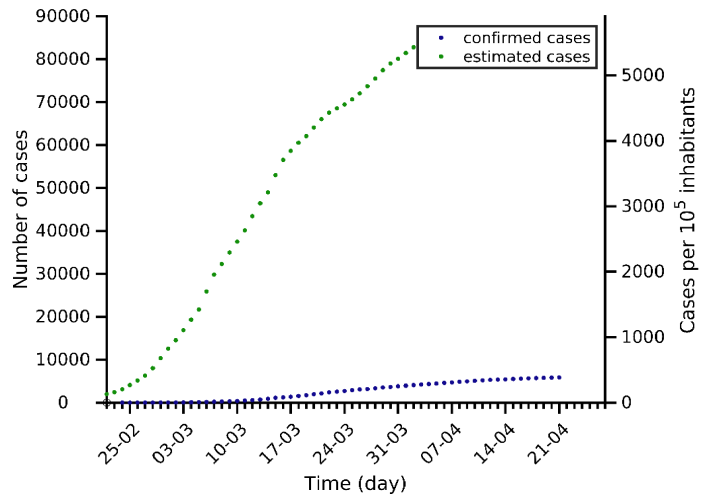
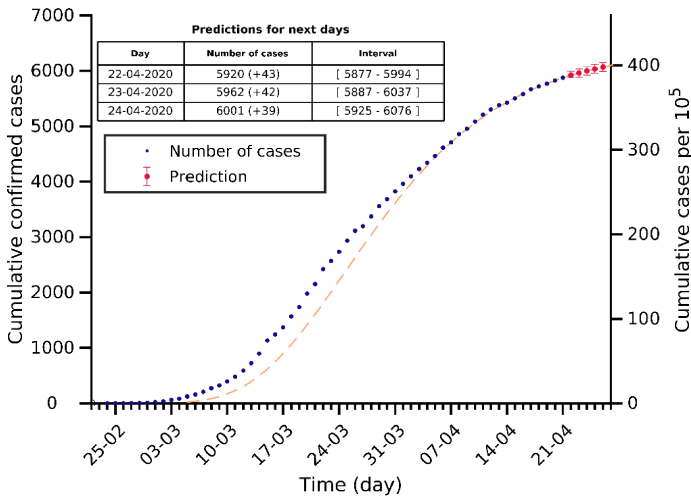
Liguria 21-04-2020. Population: 1.6M. Current cumulated incidence: 436/10⁵



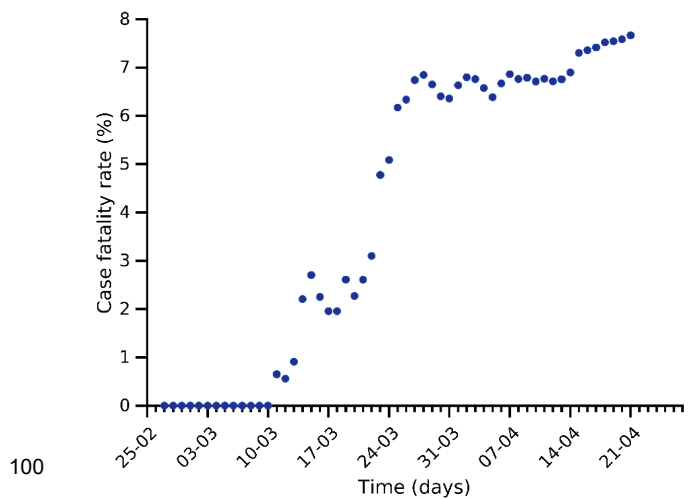
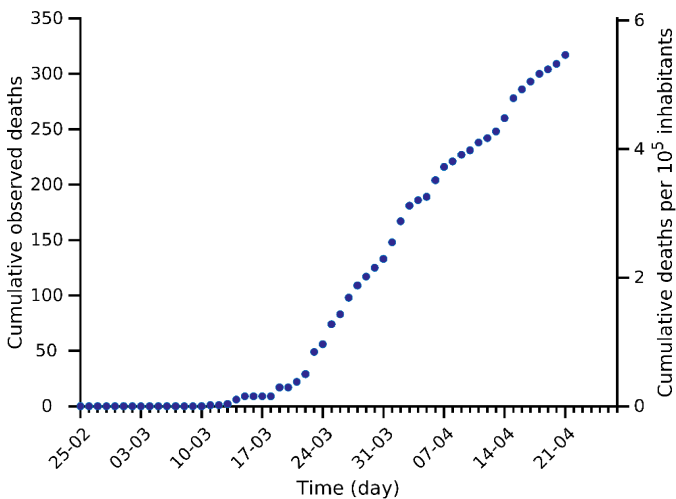
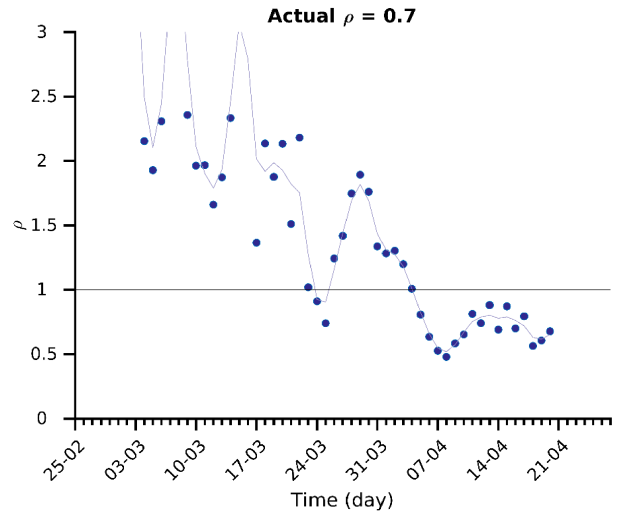
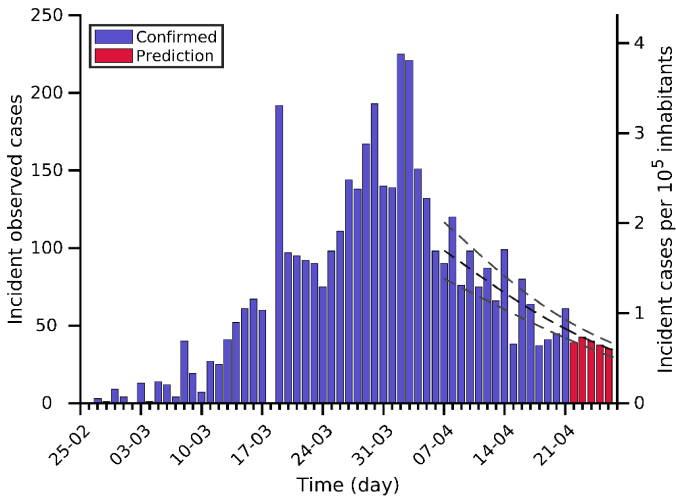
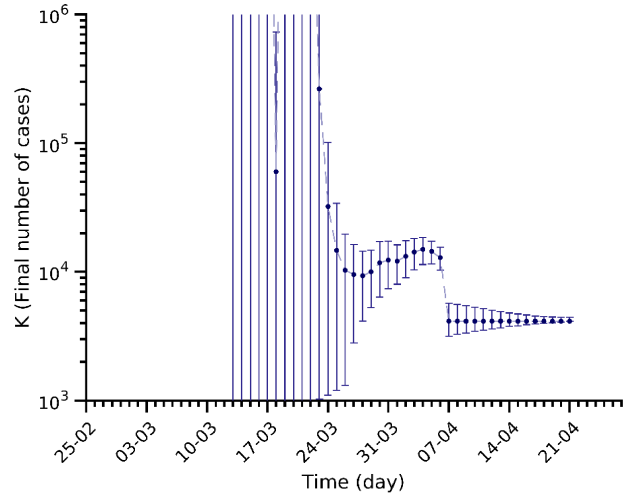
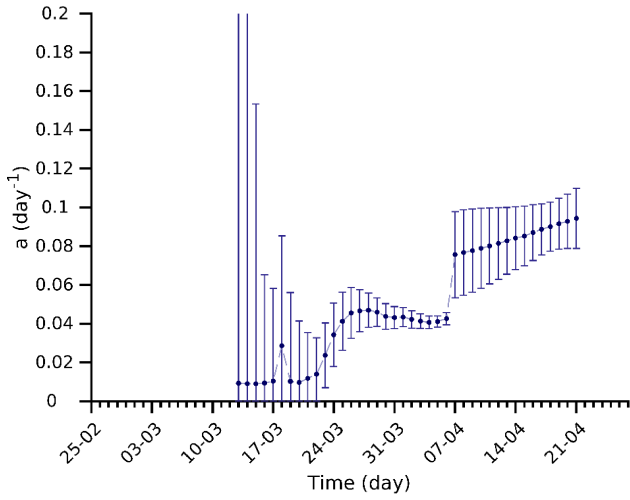
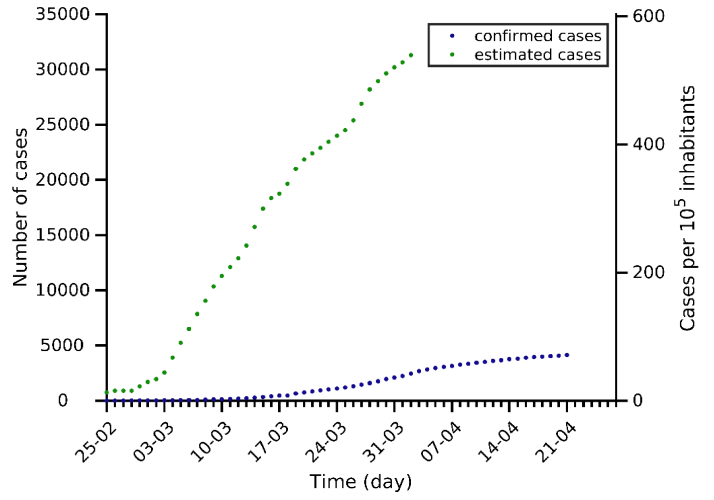
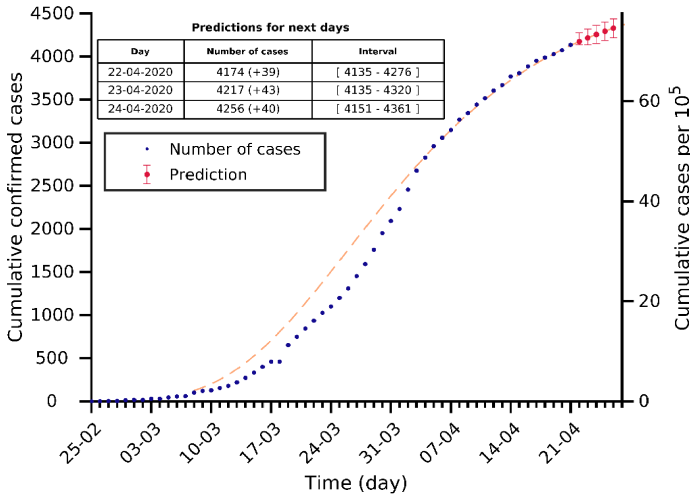
Lazio 21-04-2020. Population: 5.9M. Current cumulated incidence: 100/10⁵



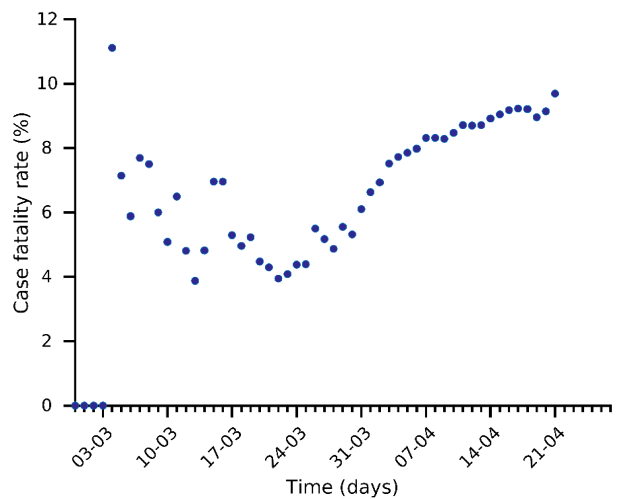
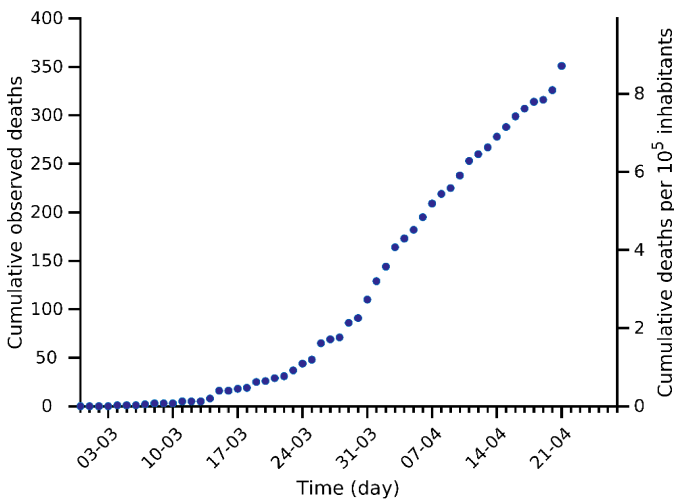
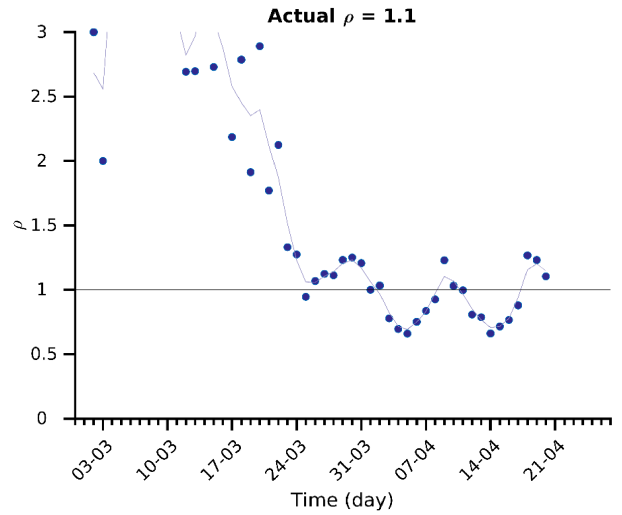
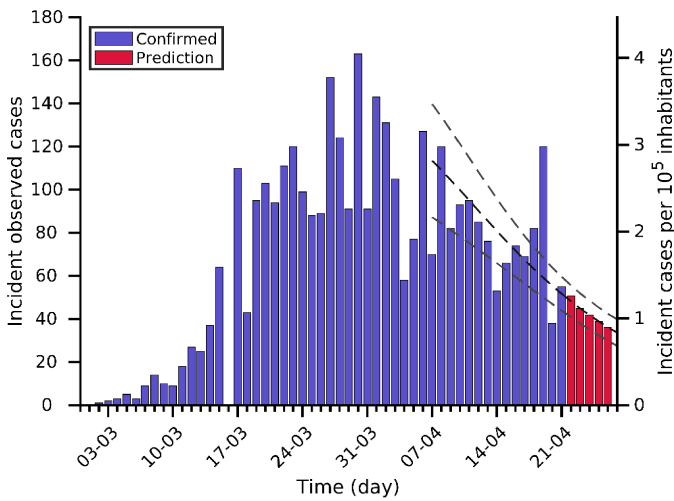
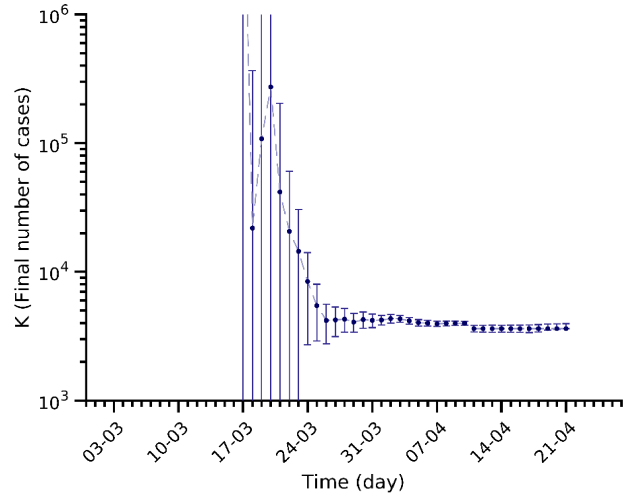
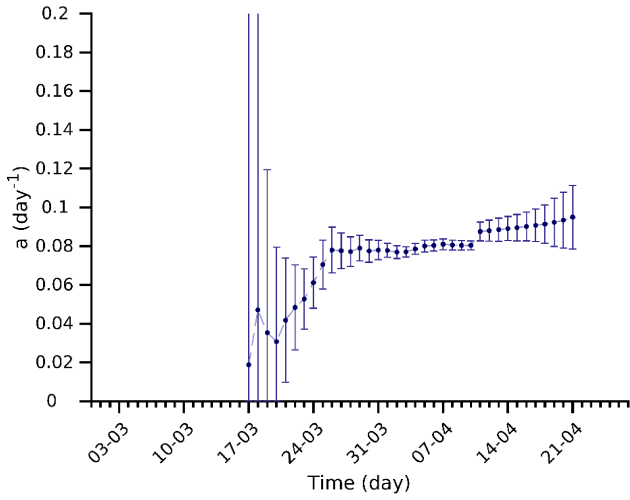
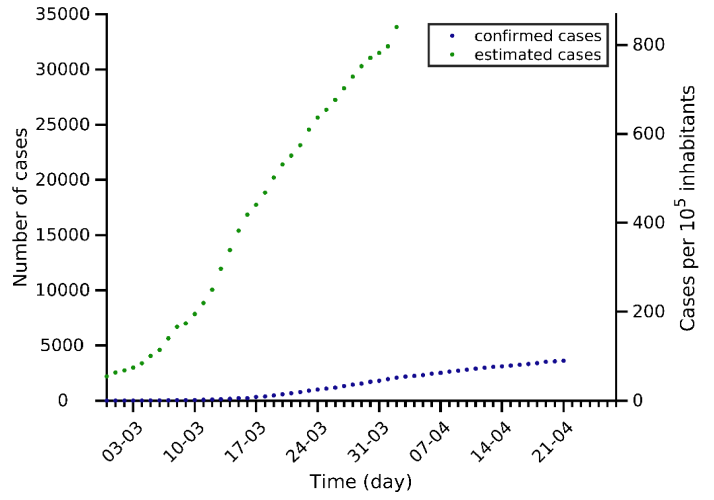
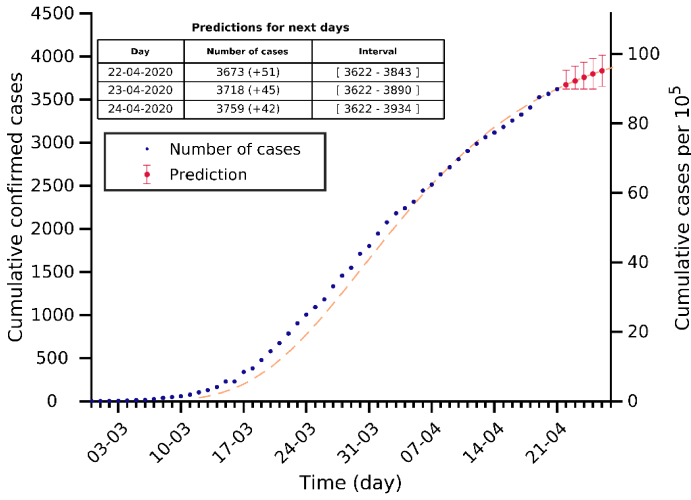
Marche 21-04-2020. Population: 1.5M. Current cumulated incidence: 385/10⁵



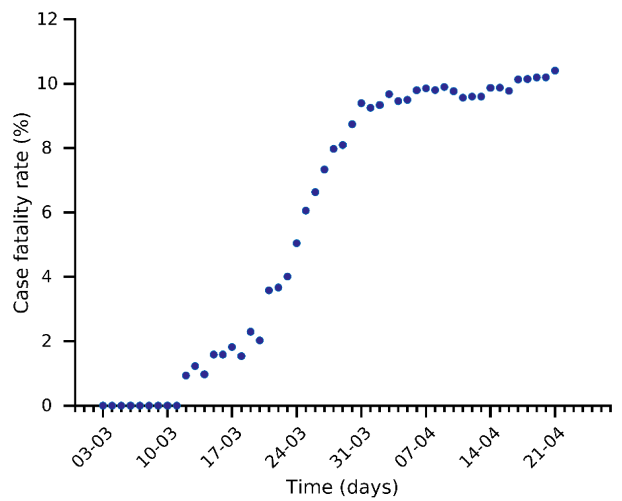
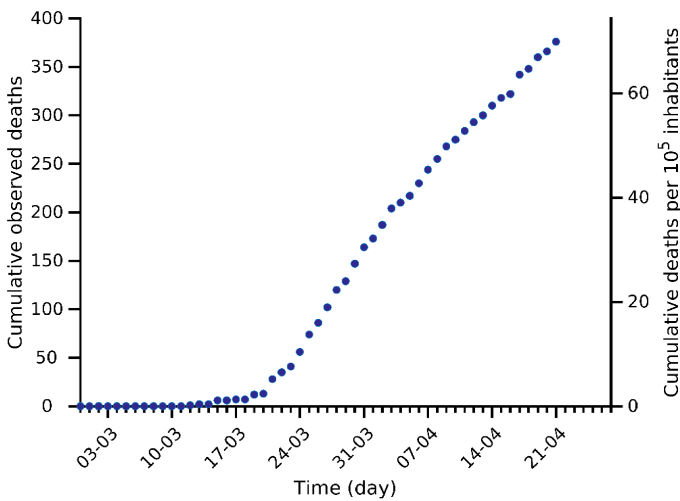
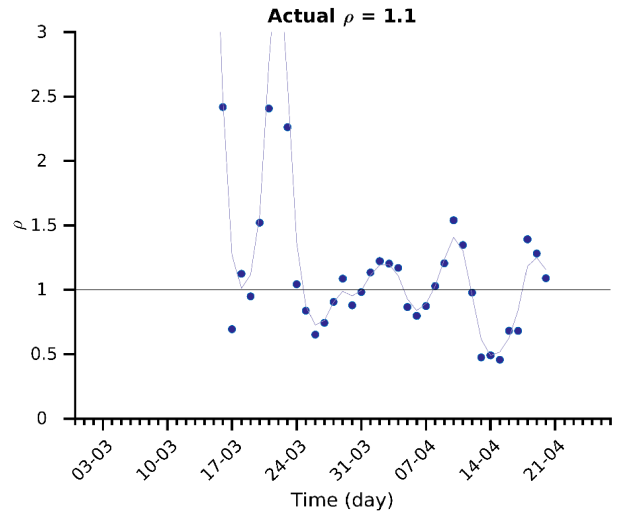
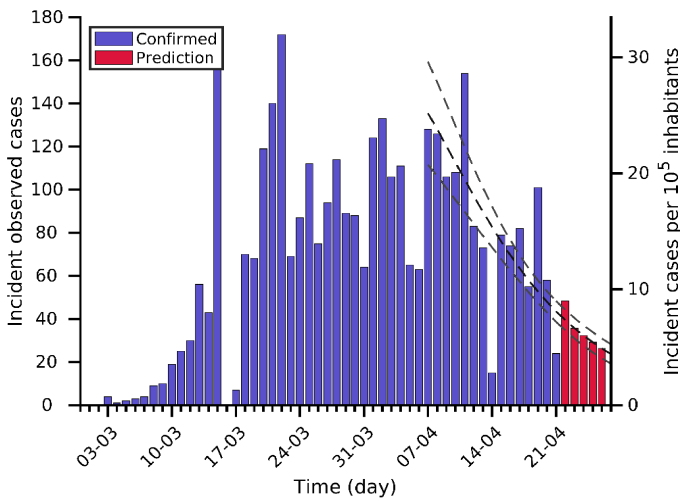
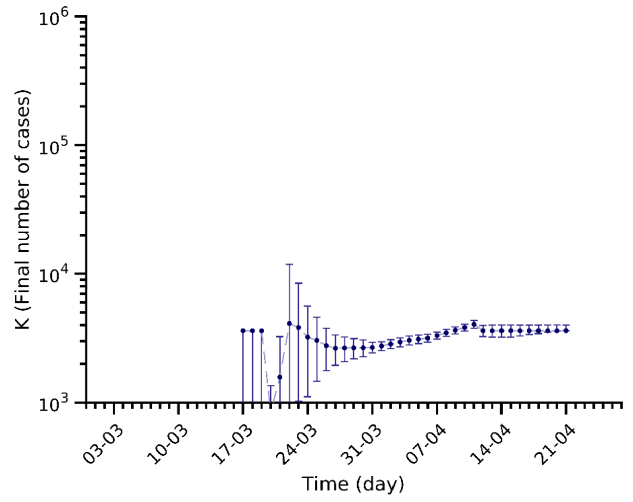
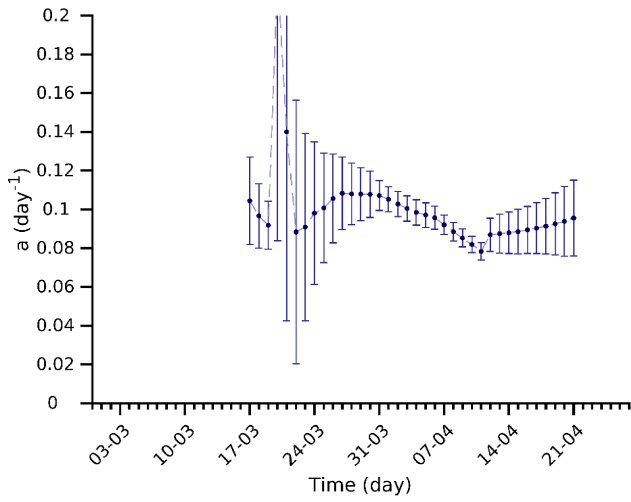
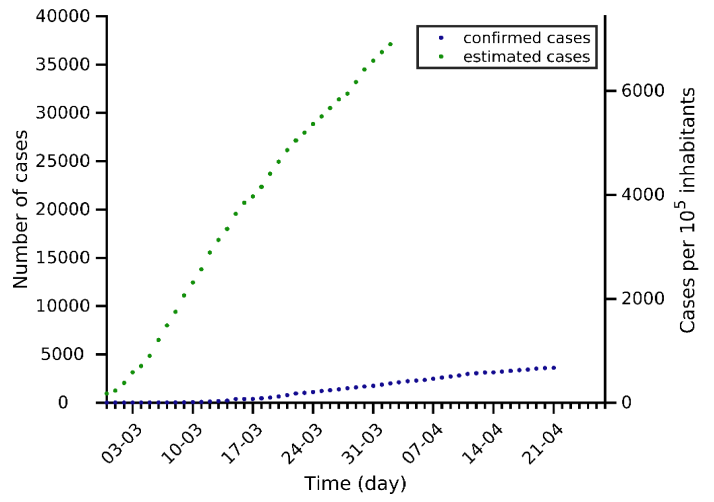
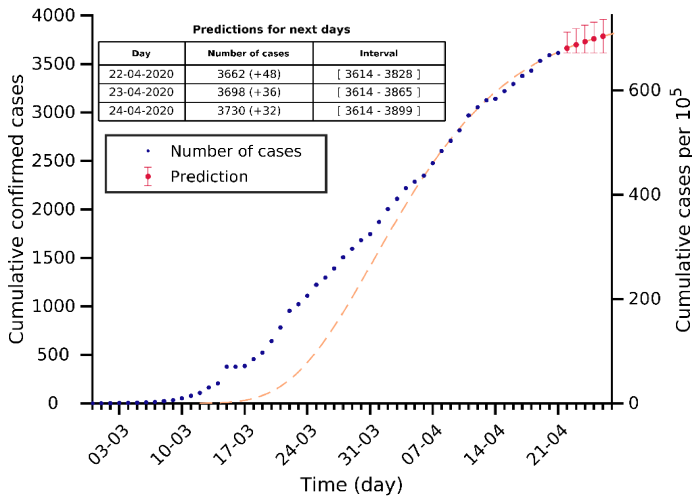
Campania 21-04-2020. Population: 5.8M. Current cumulated incidence: 71/10⁵



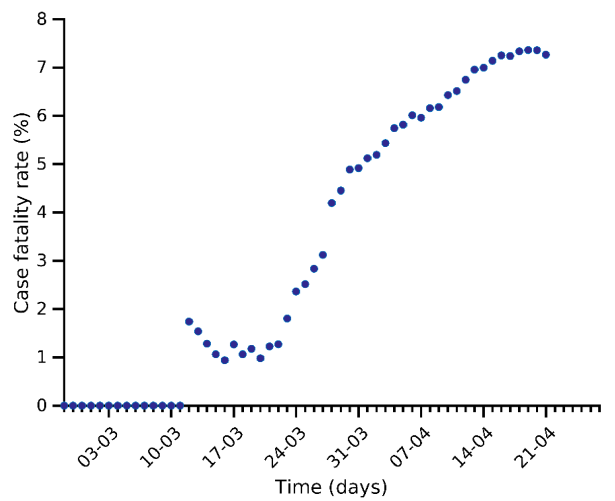
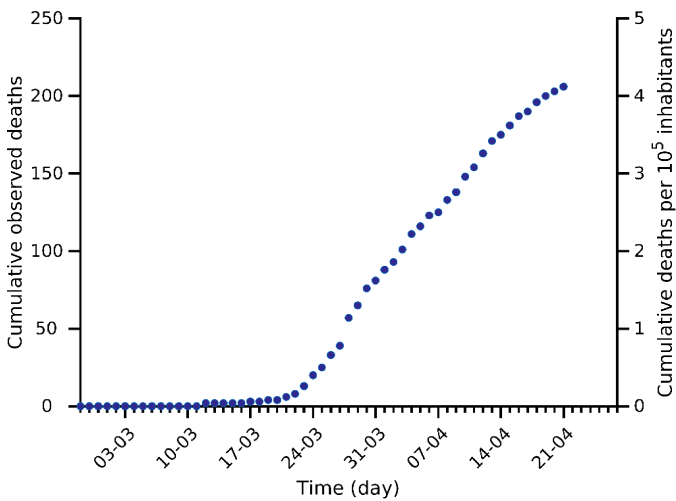
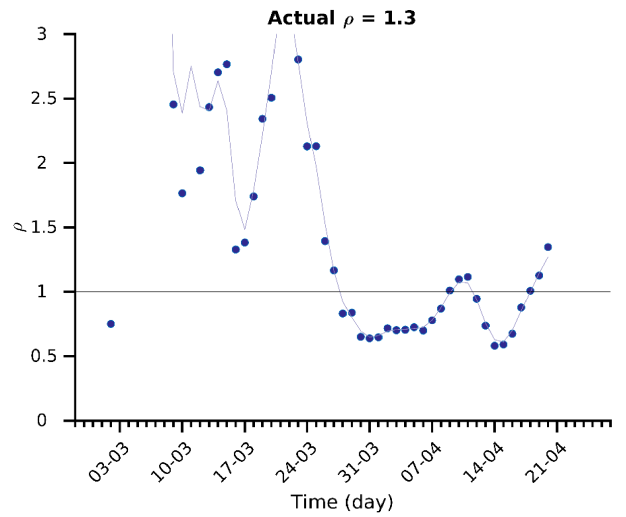
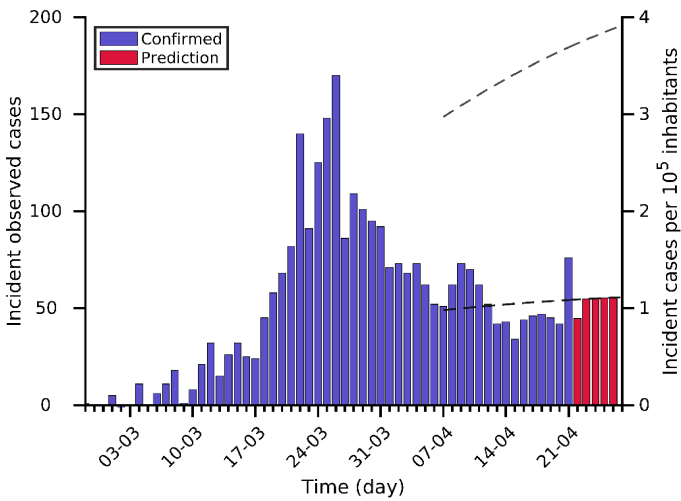
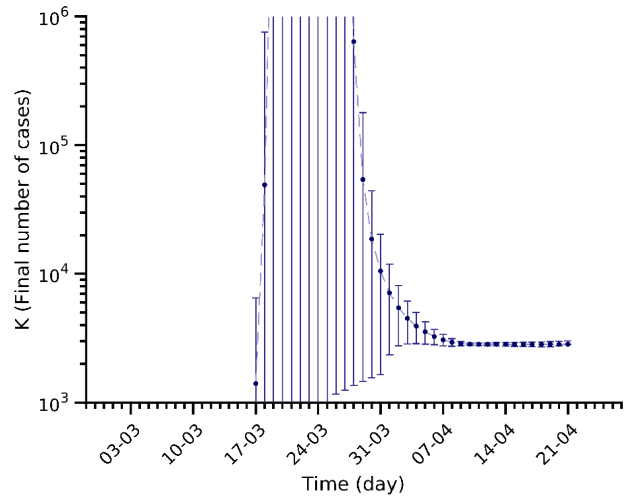
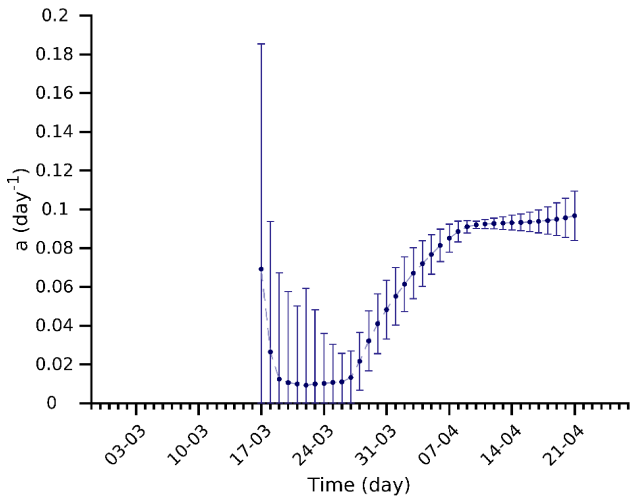
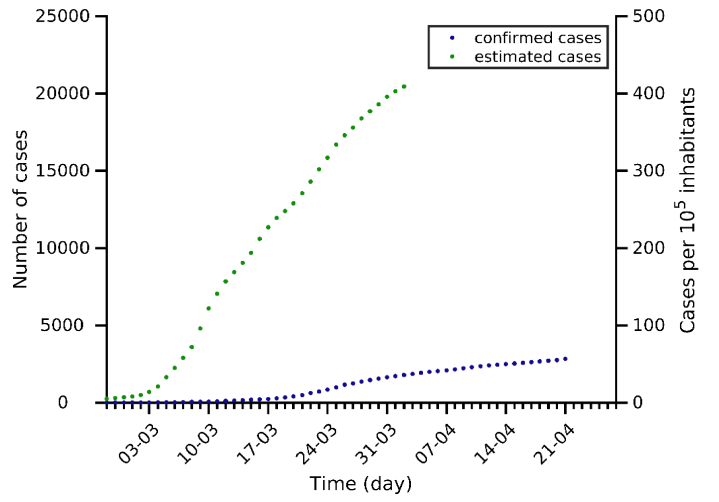
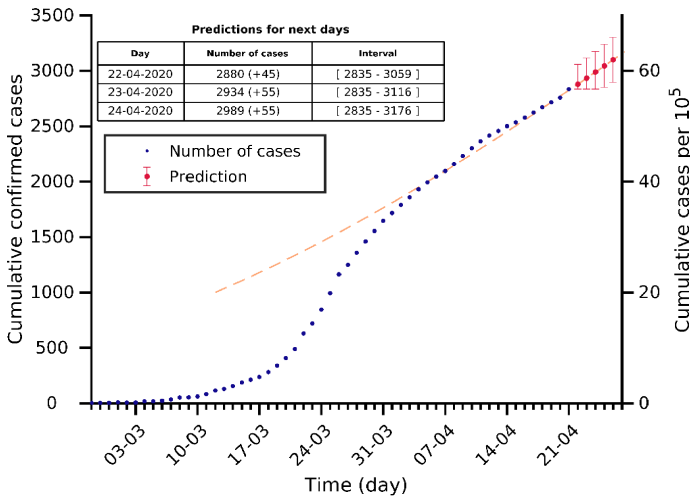
Puglia 21-04-2020. Population: 4.0M. Current cumulated incidence: 90/10⁵



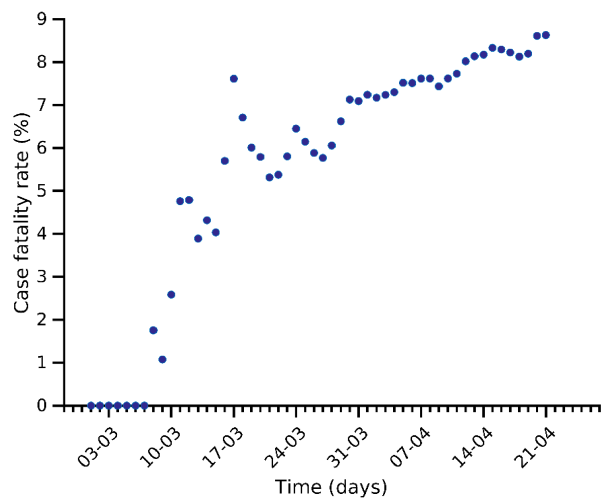
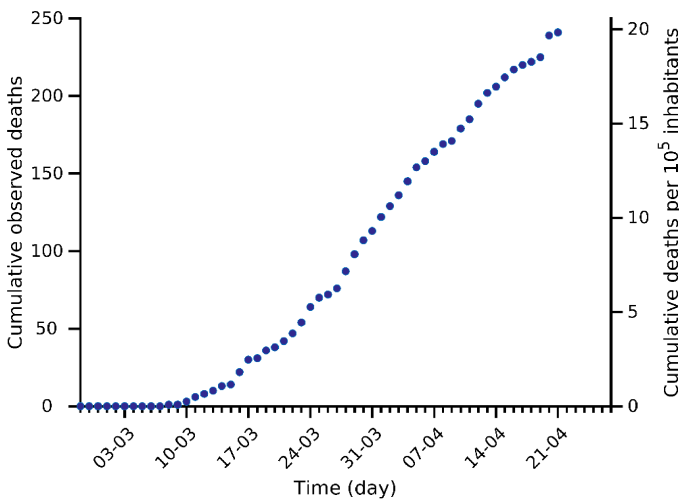
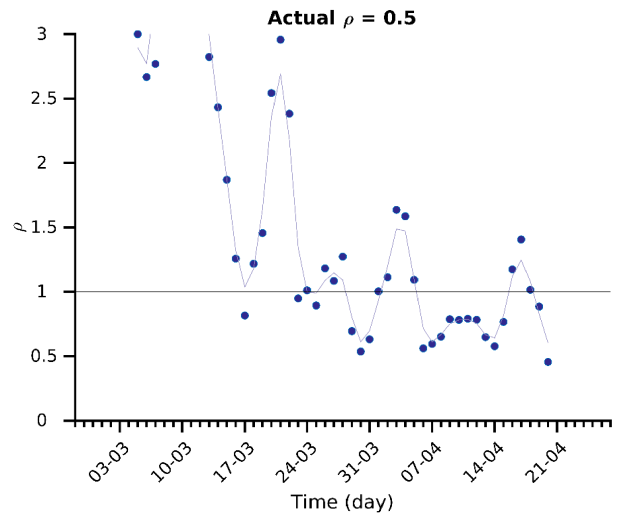
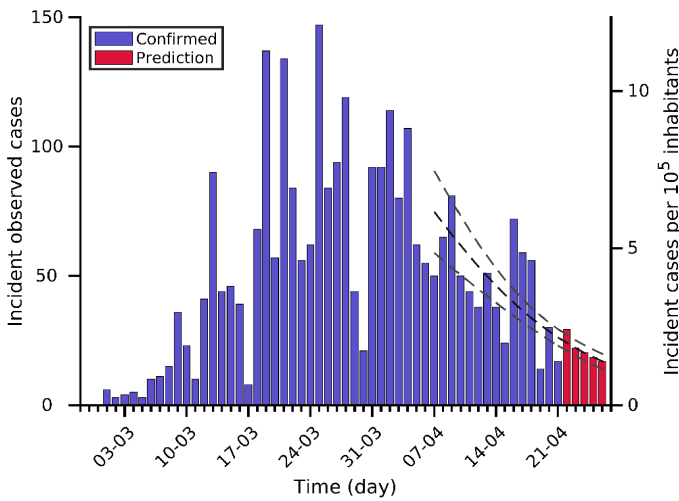
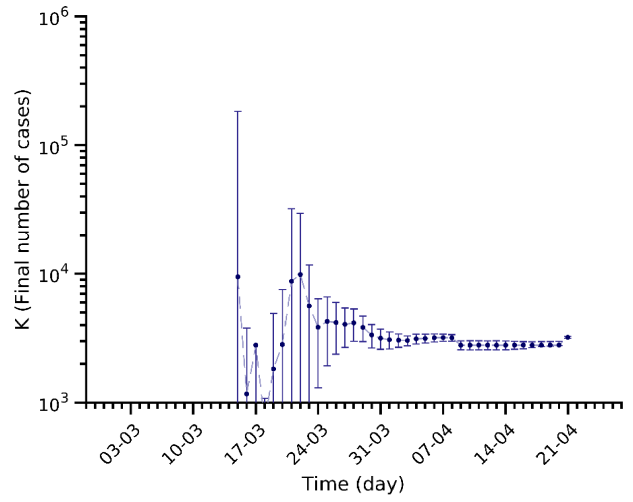
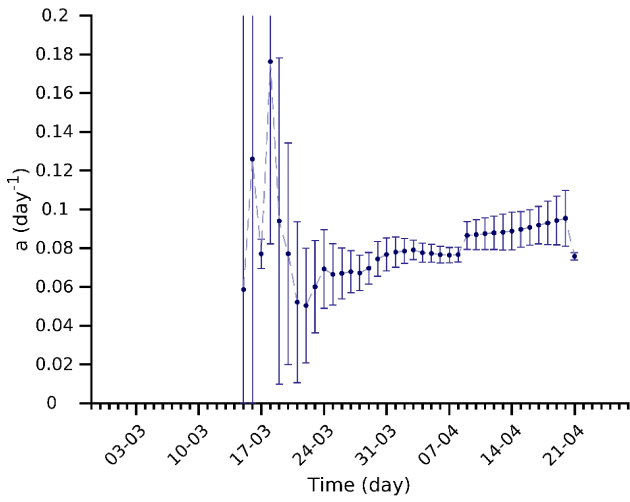
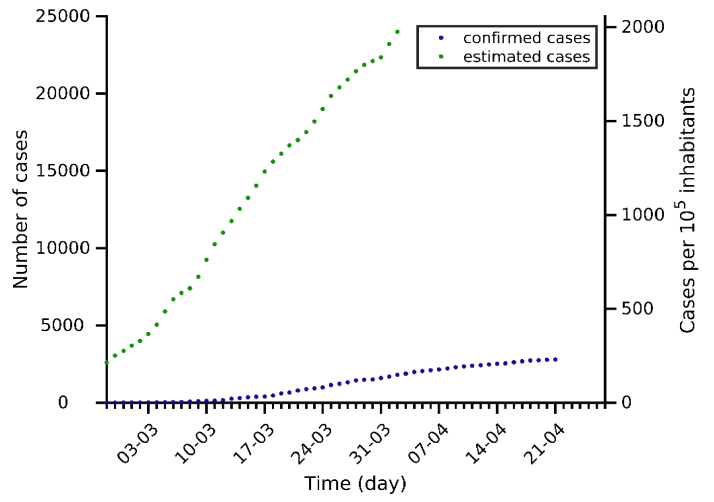
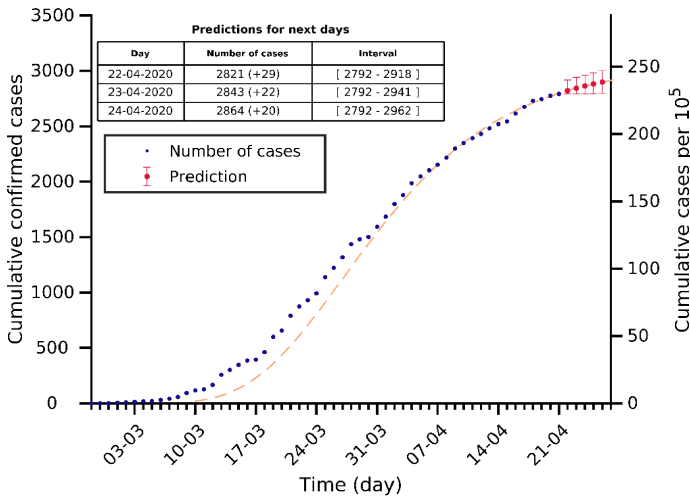
Trento 21-04-2020. Population: 0.5M. Current cumulated incidence: 672/10⁵



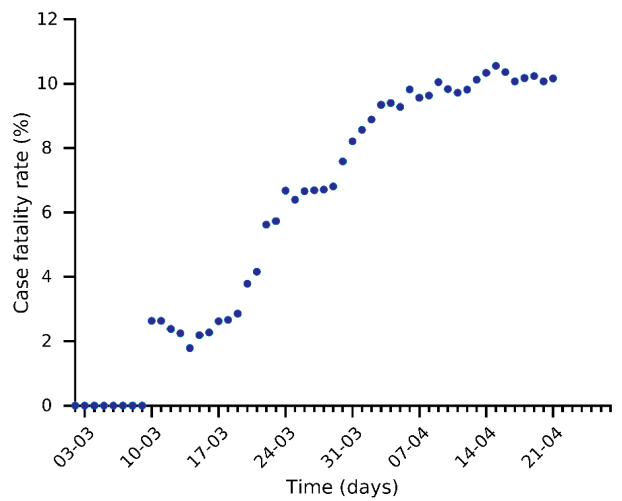
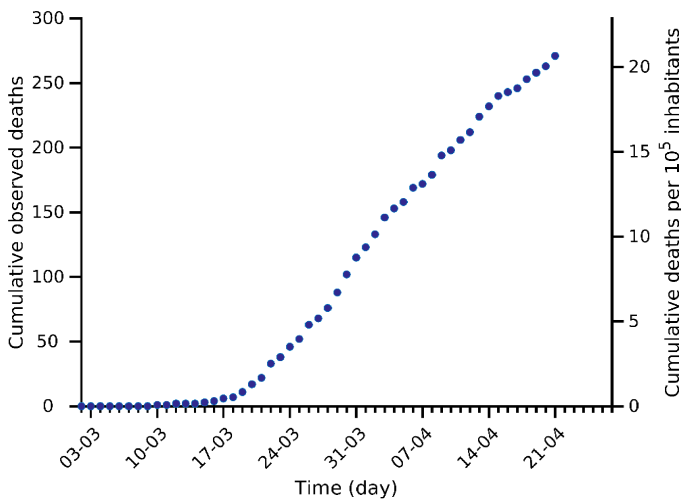
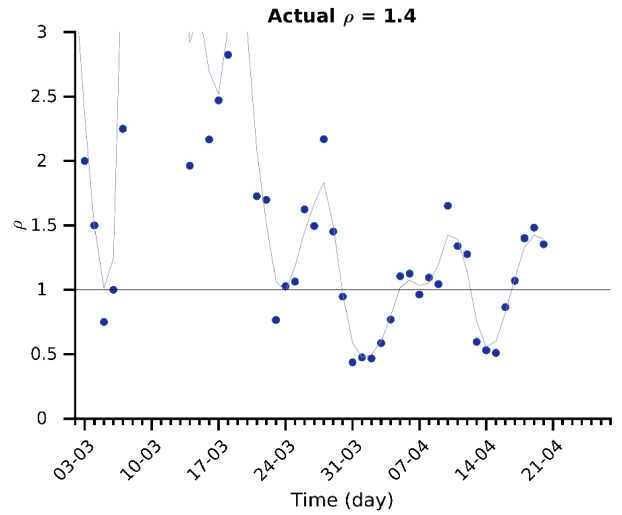
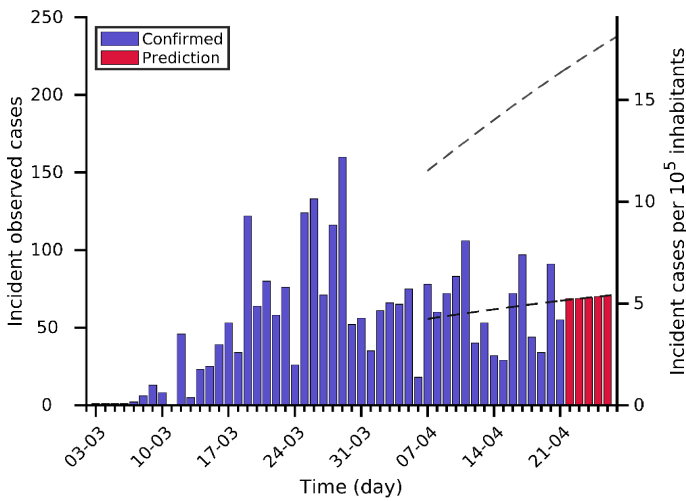
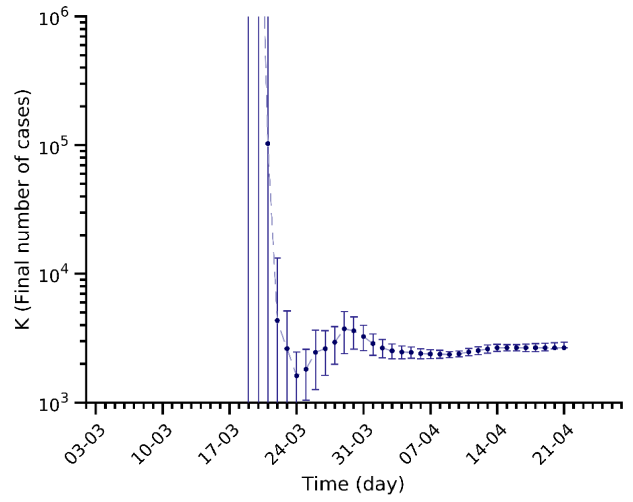
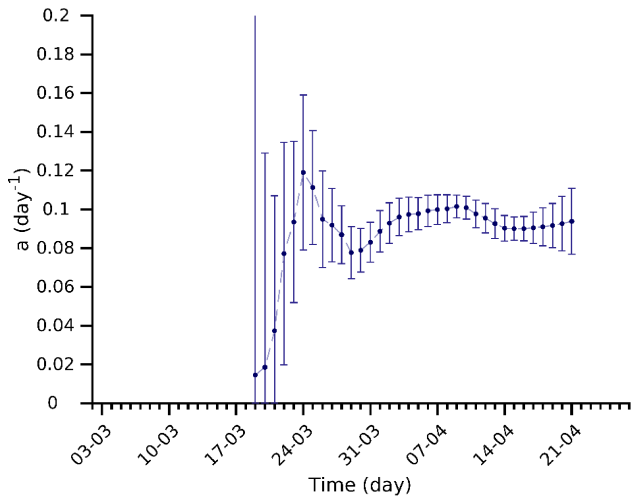
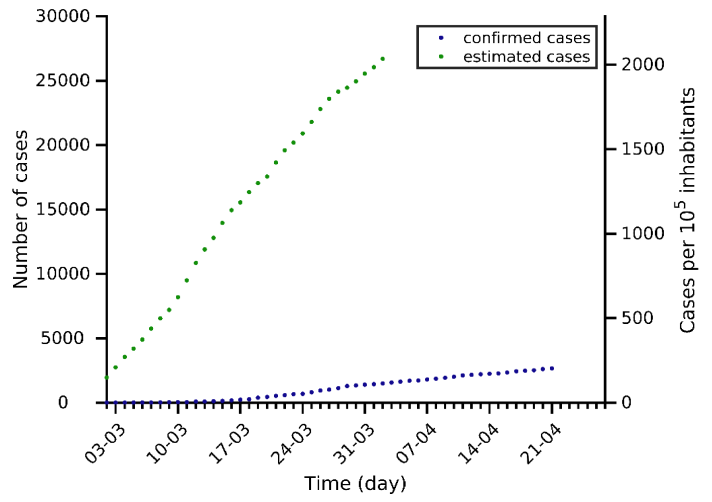
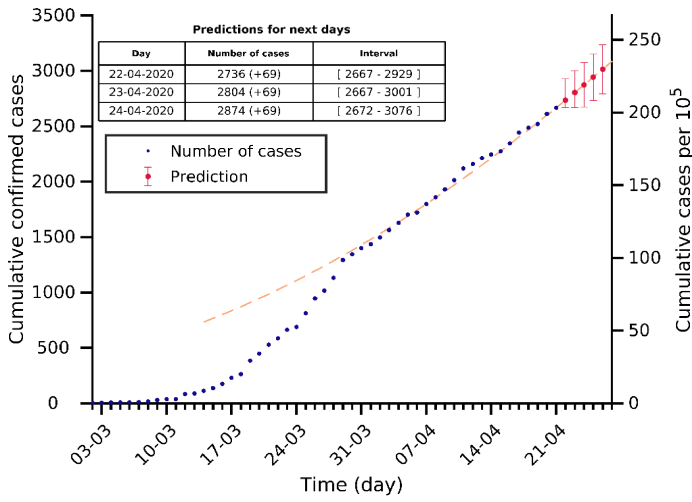
Sicilia 21-04-2020. Population: 5.0M. Current cumulated incidence: 57/10⁵



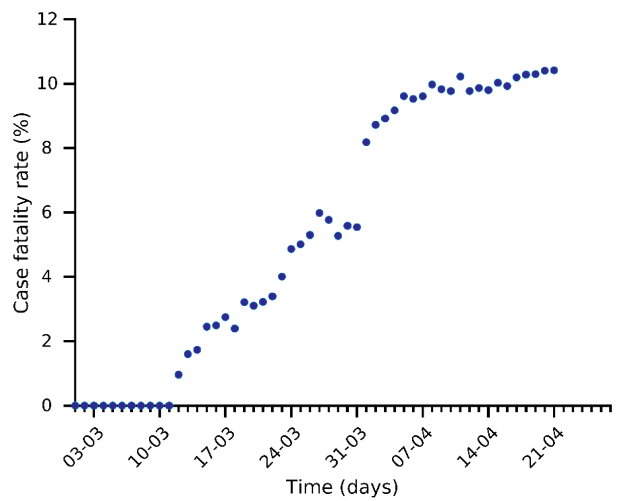
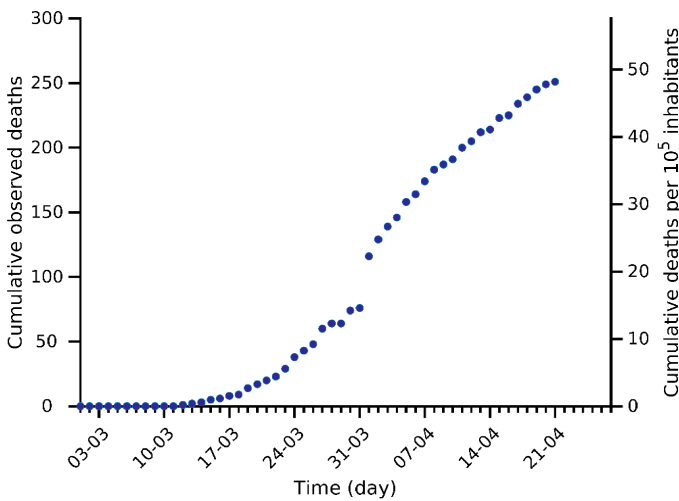
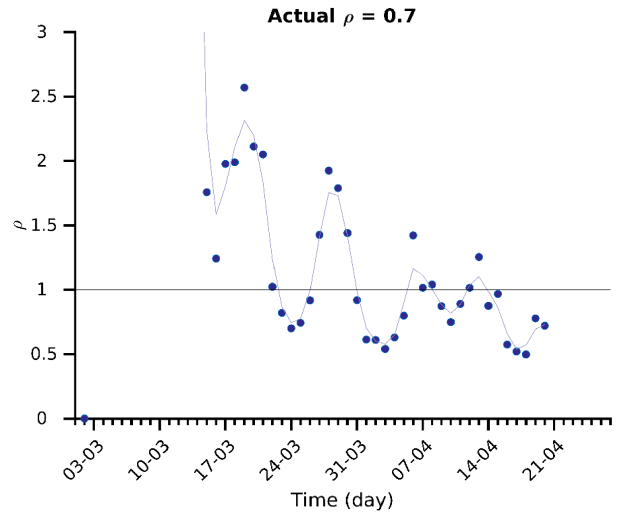
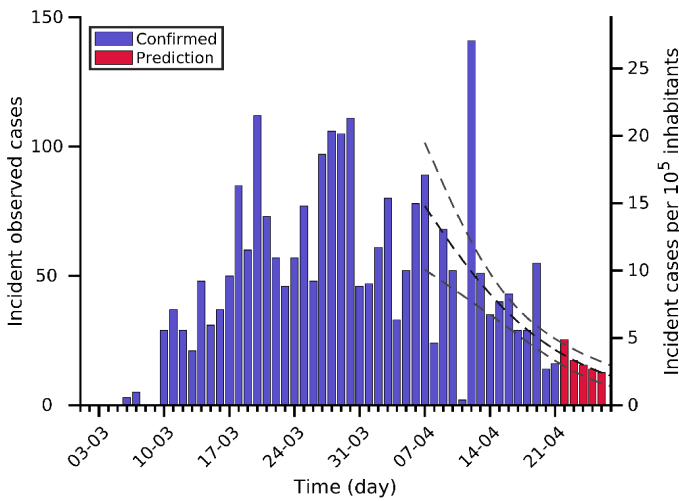
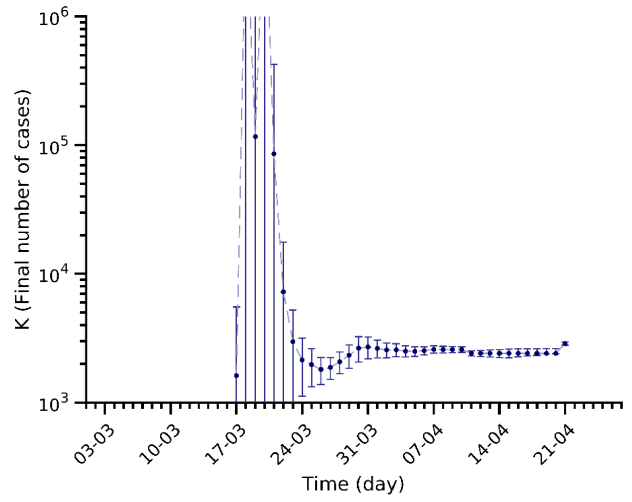
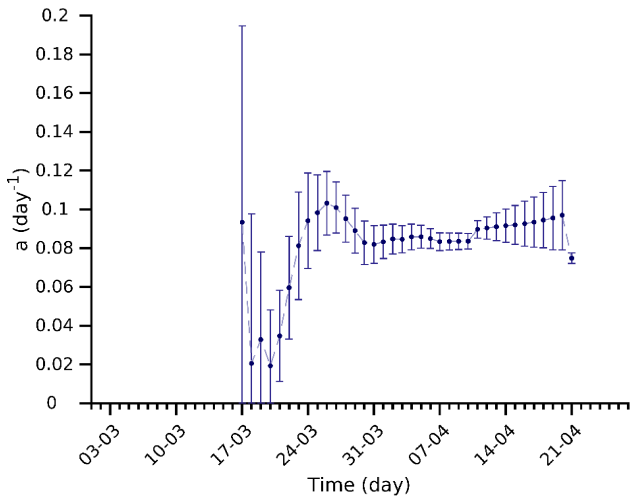
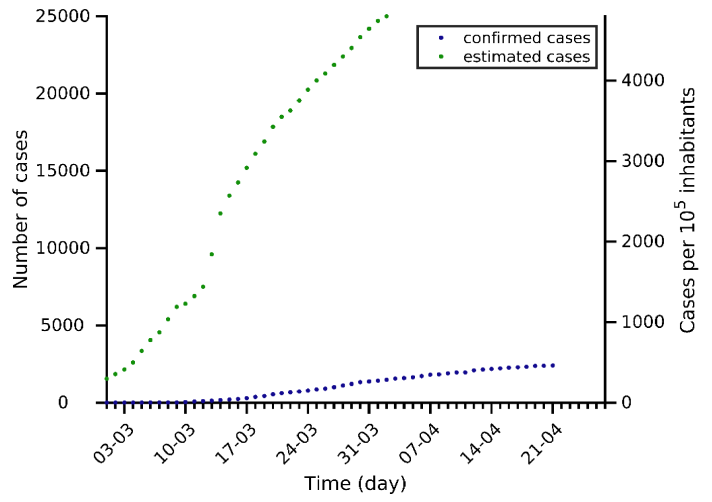
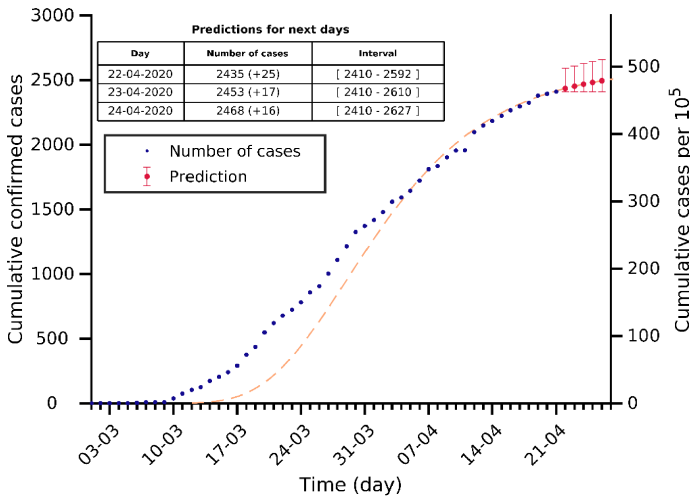
Friuli Venezia Giulia 21-04-2020. Population: 1.2M. Current cumulated incidence: 2



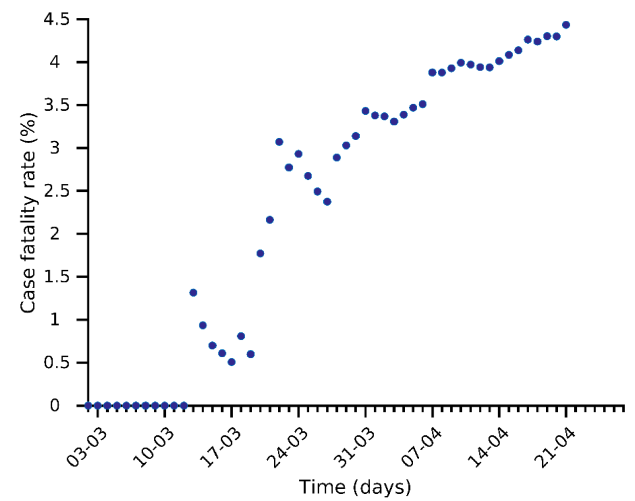
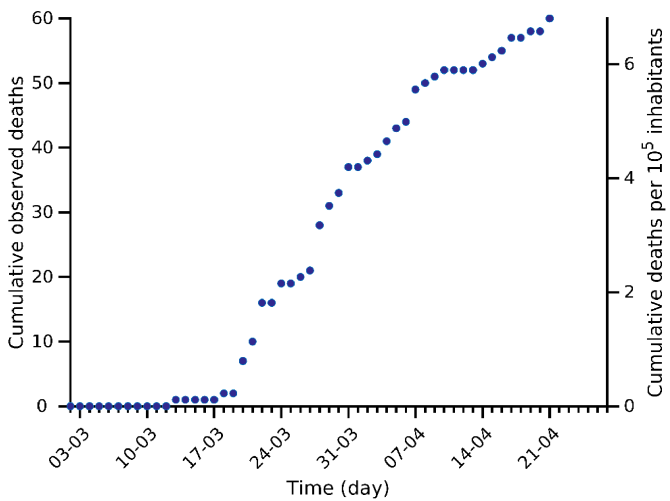
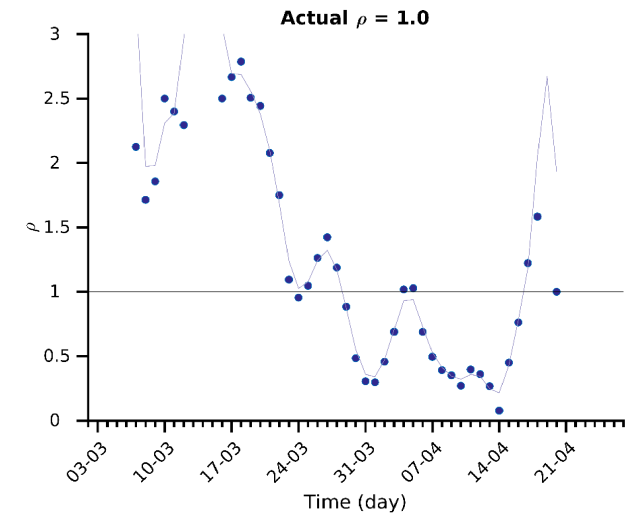
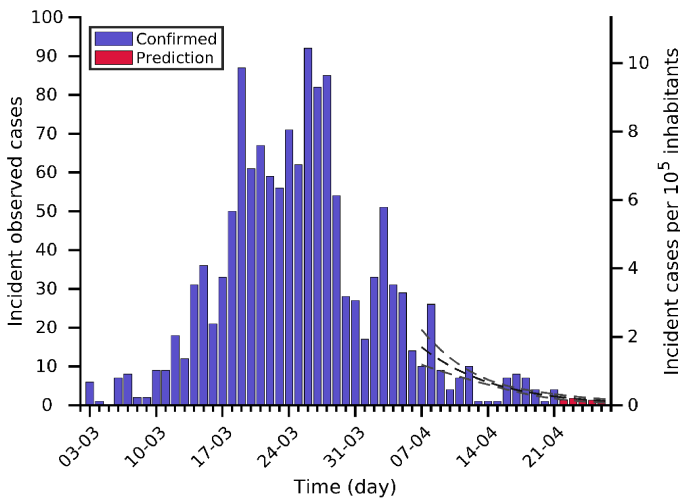
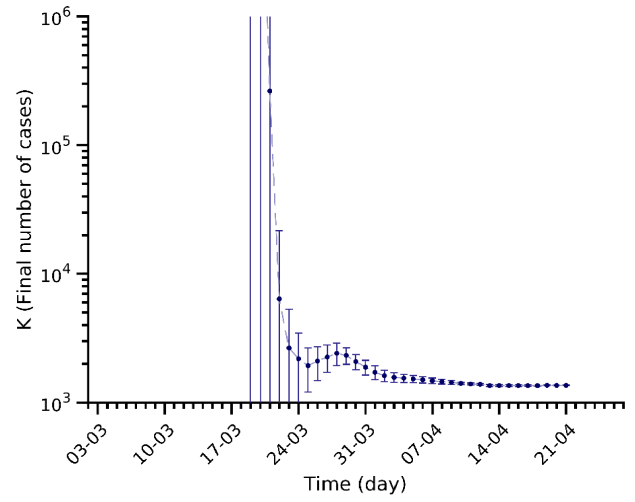
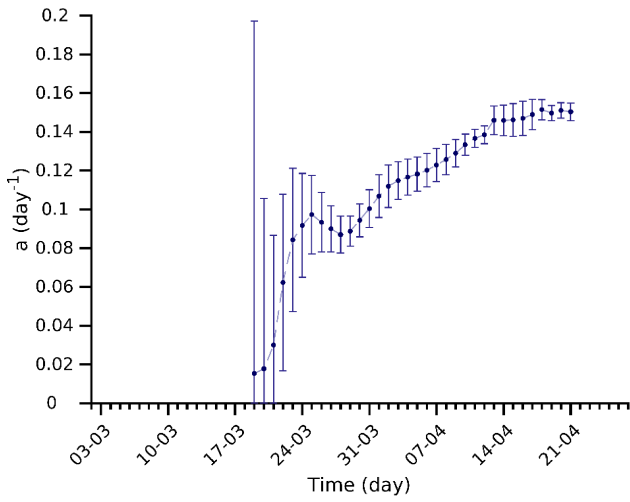
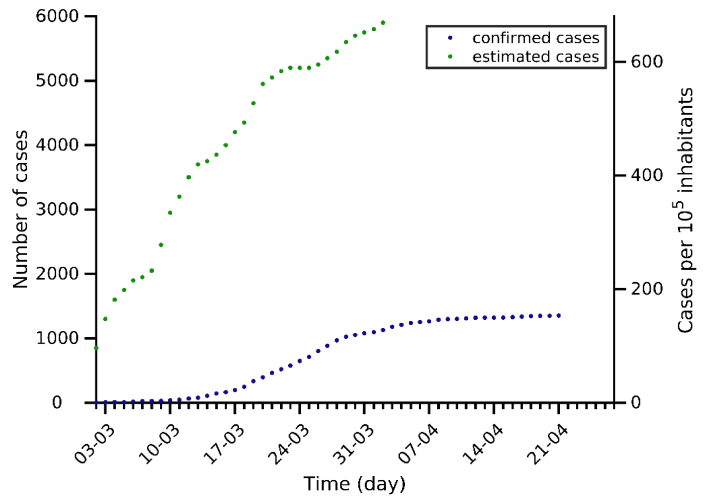
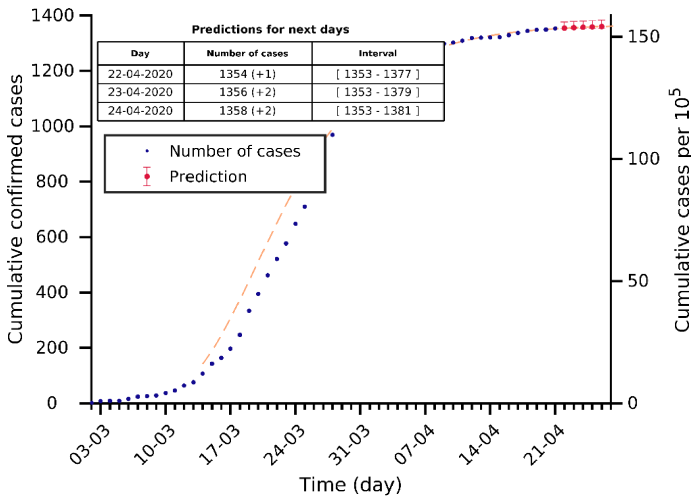
Abruzzo 21-04-2020. Population: 1.3M. Current cumulated incidence: 203/10⁵



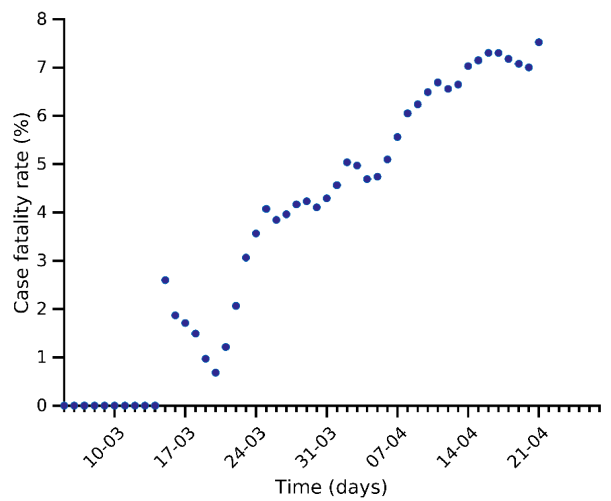
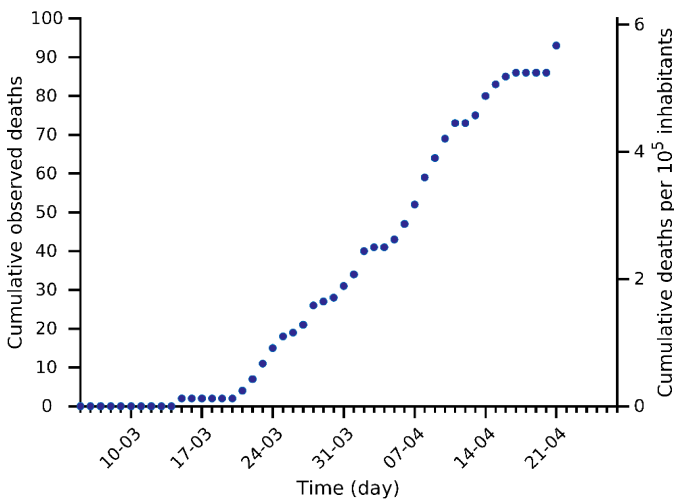
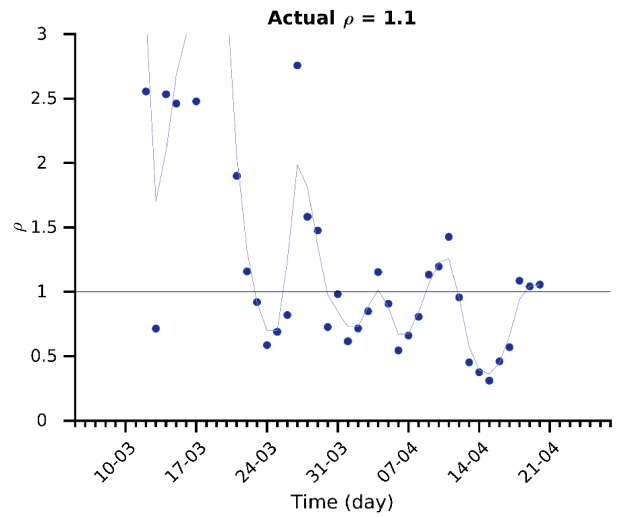
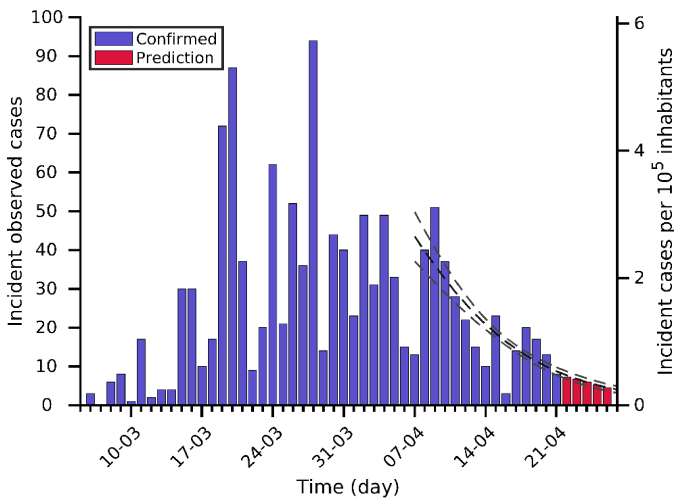
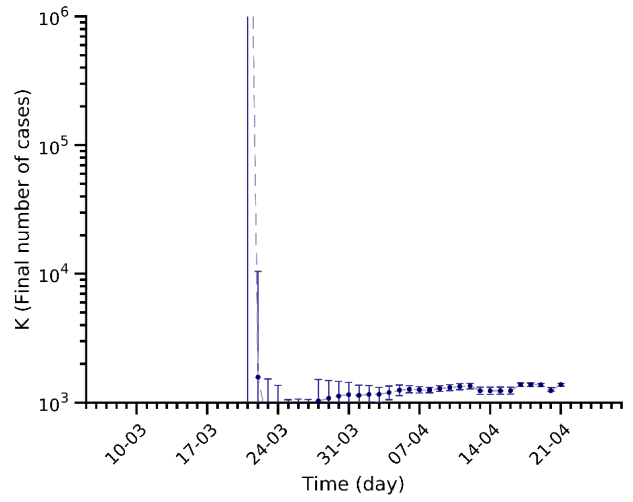
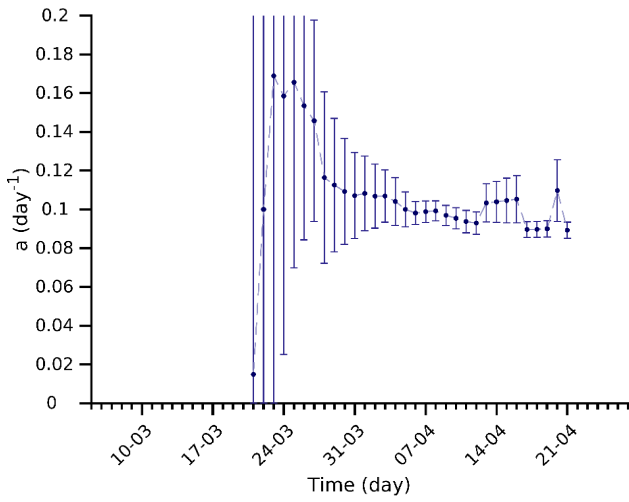
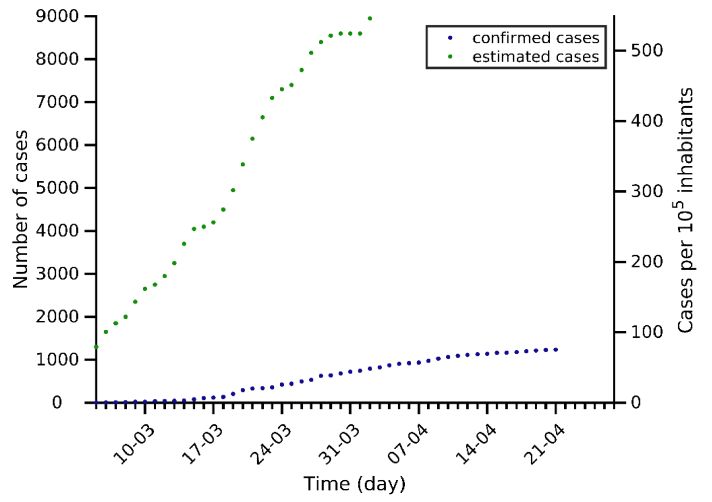
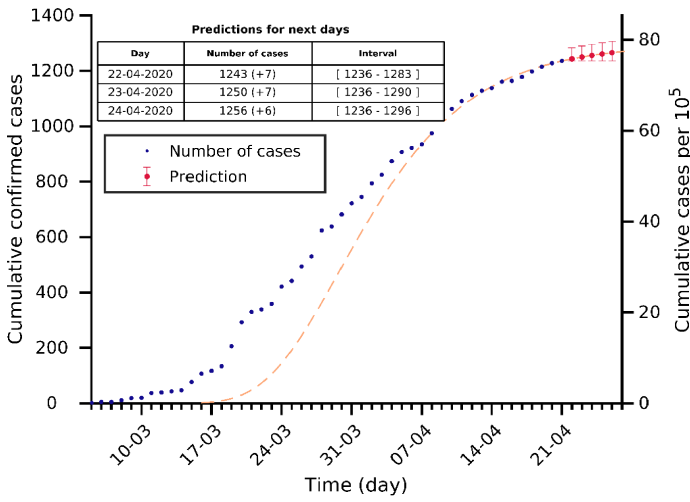
Bolzano 21-04-2020. Population: 0.5M. Current cumulated incidence: 463/10⁵



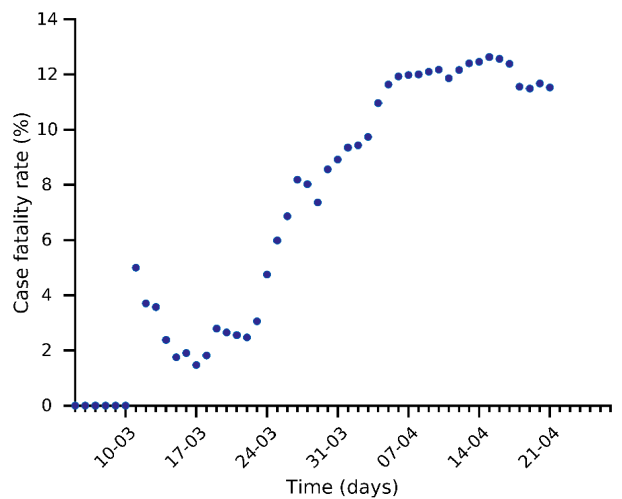
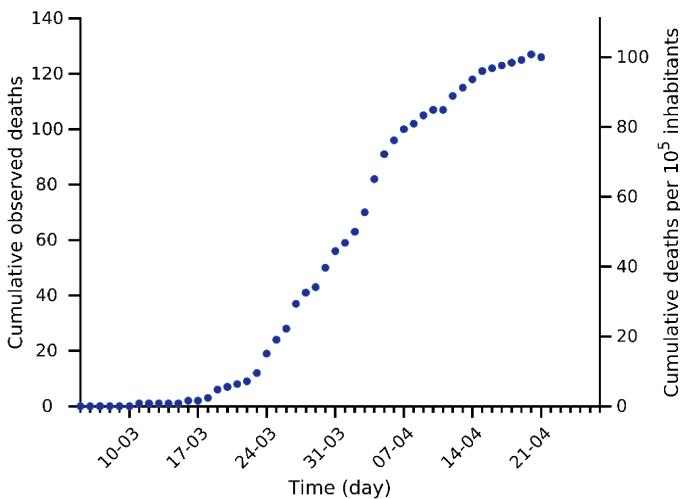
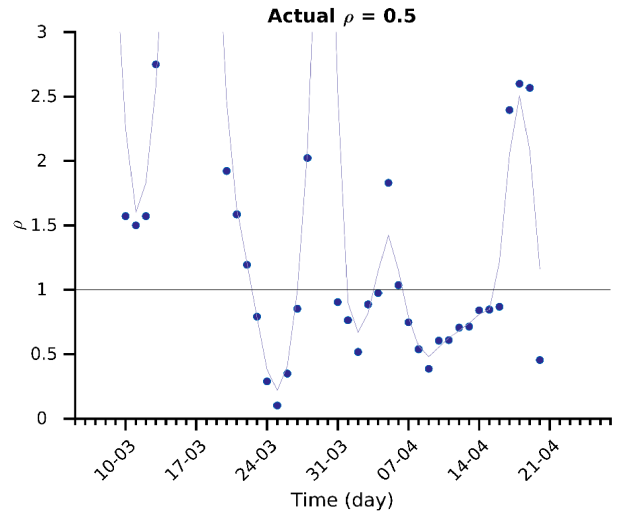
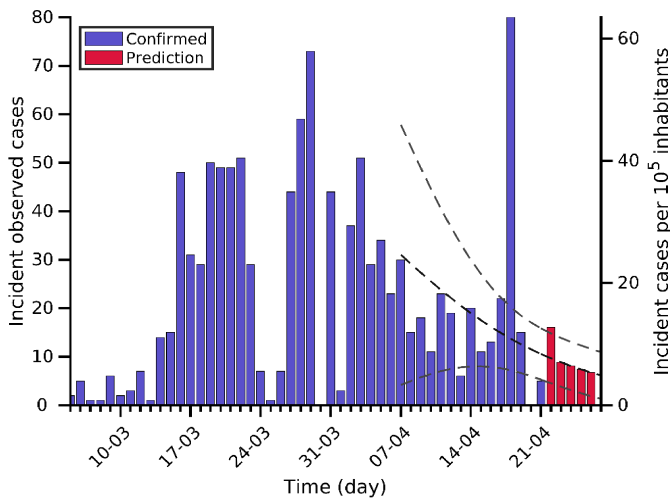
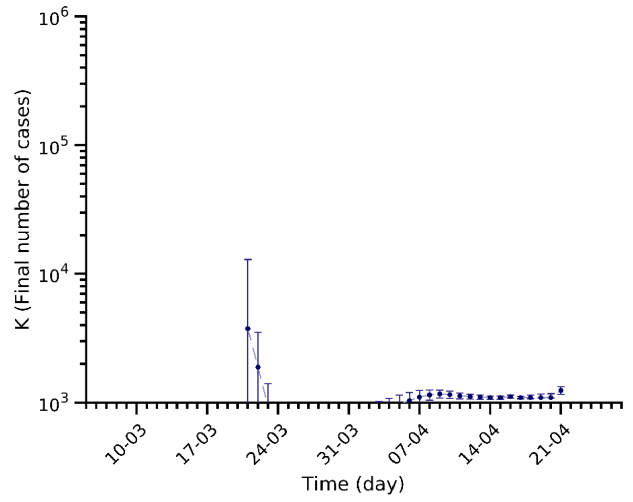
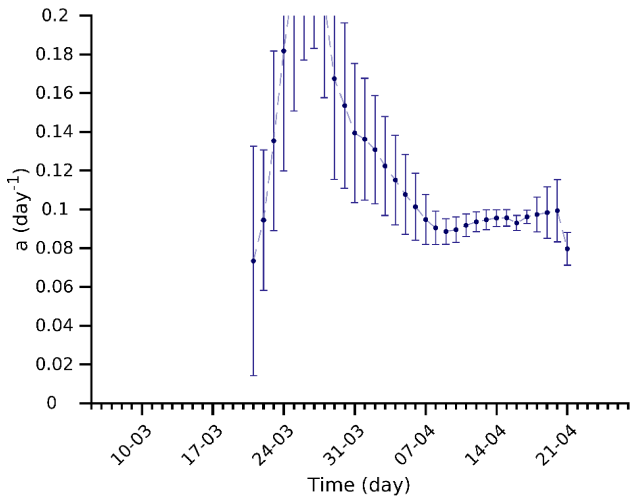
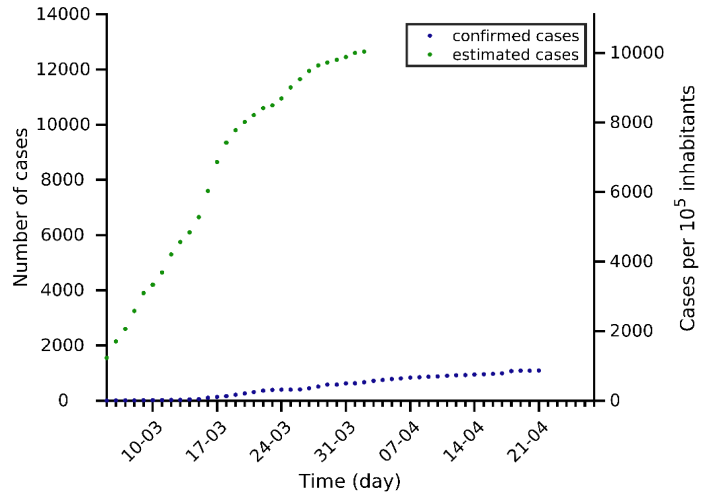
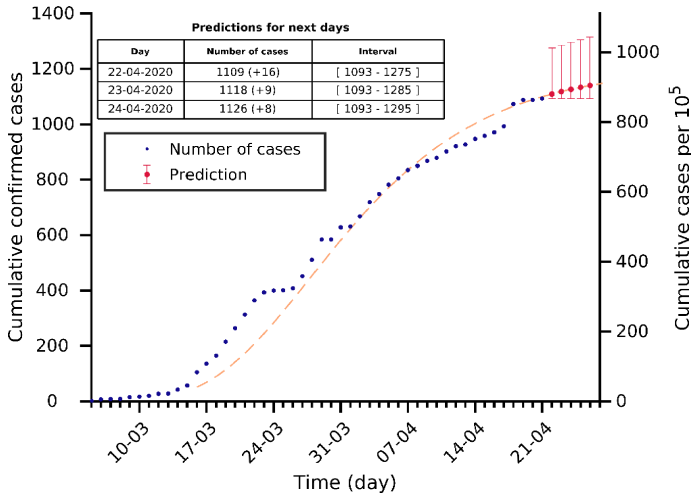
Umbria 21-04-2020. Population: 0.9M. Current cumulated incidence: 153/10⁵



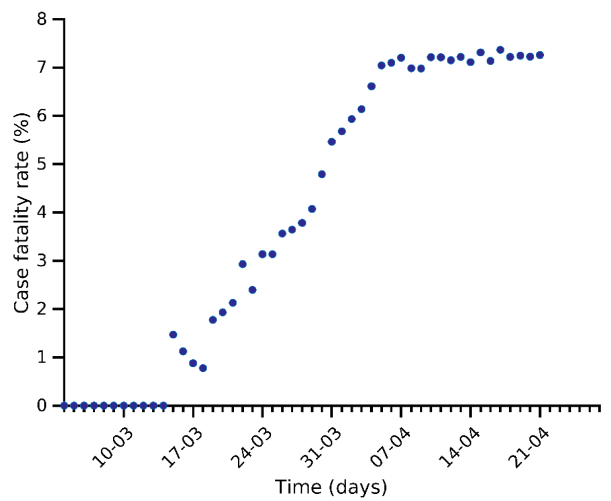
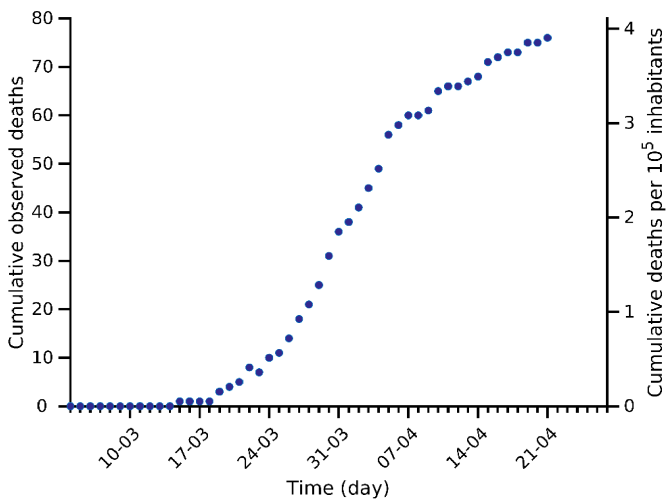
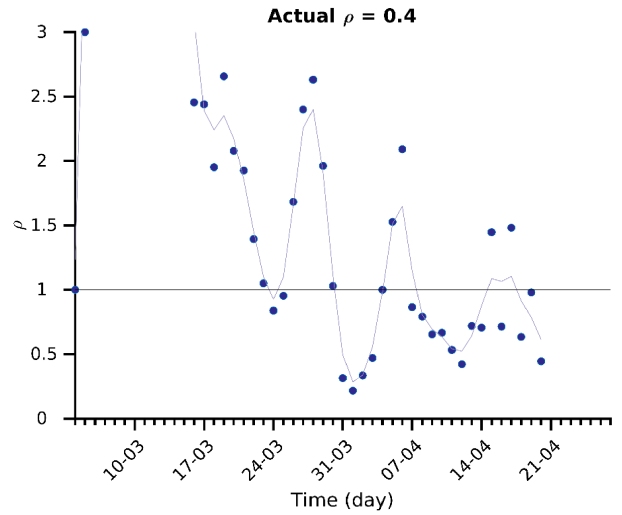
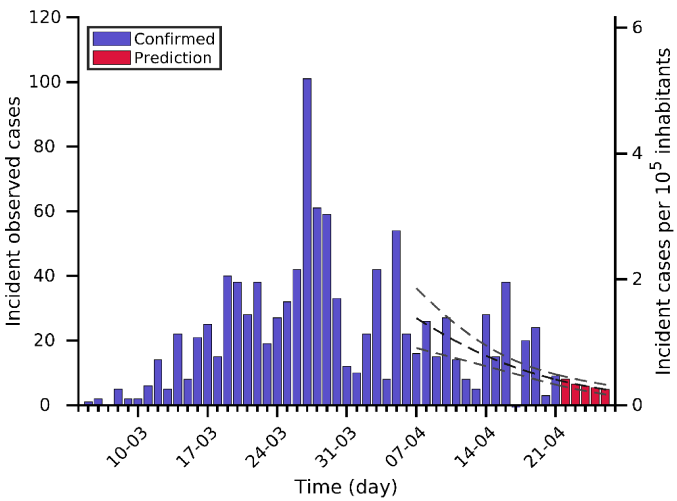
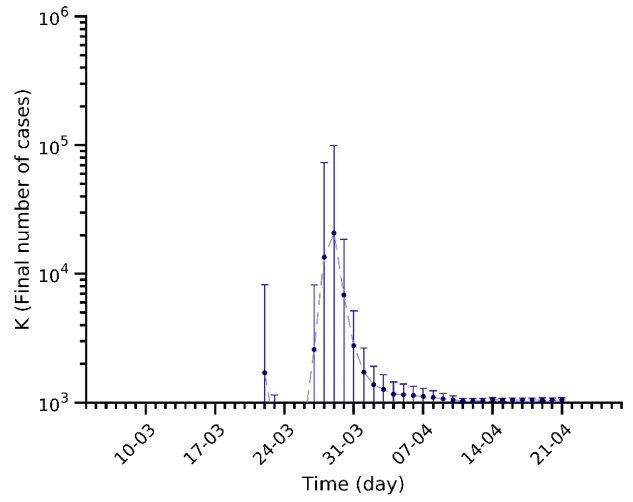
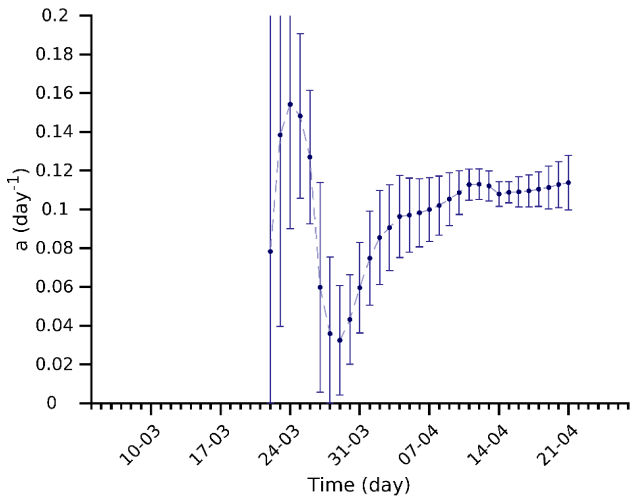
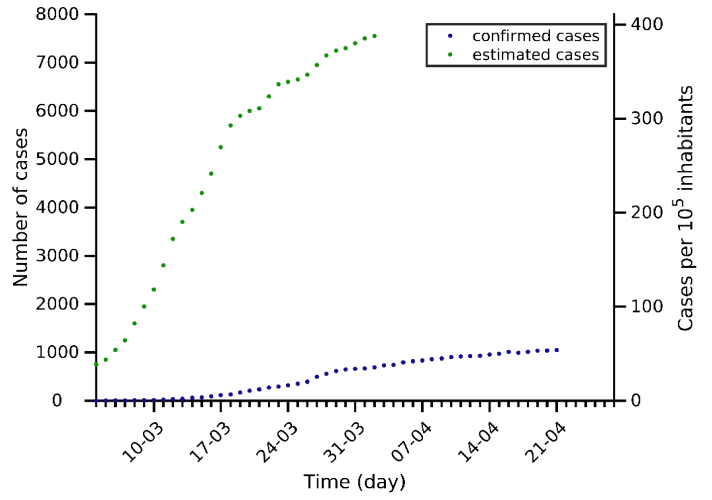
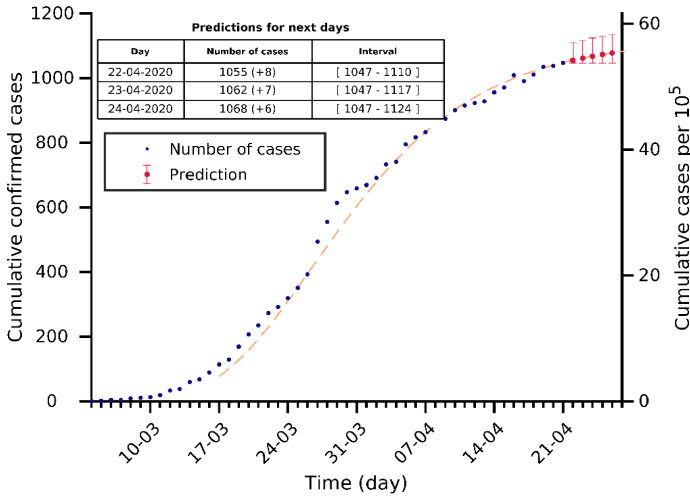
Sardegna 21-04-2020. Population: 1.6M. Current cumulated incidence: 75/10⁵



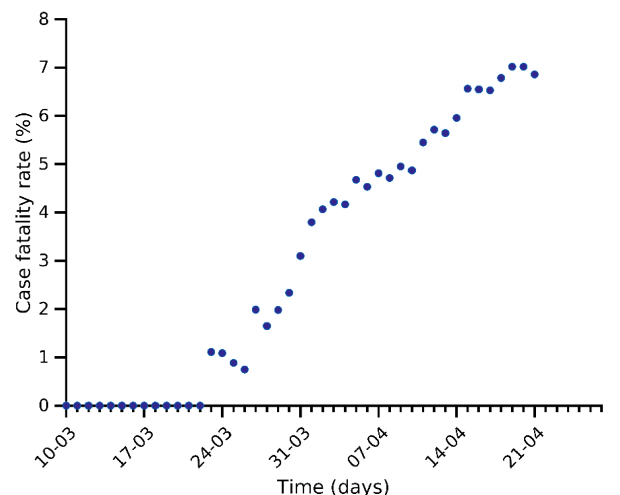
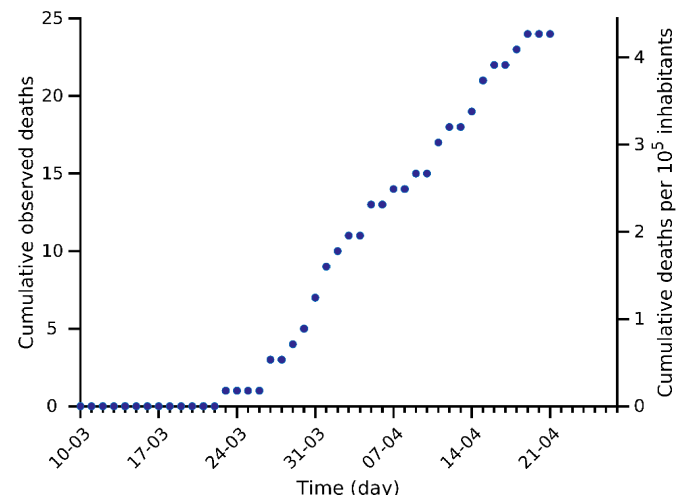
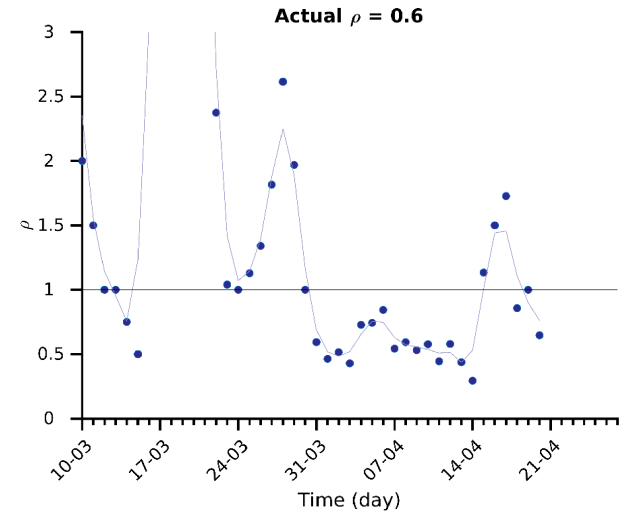
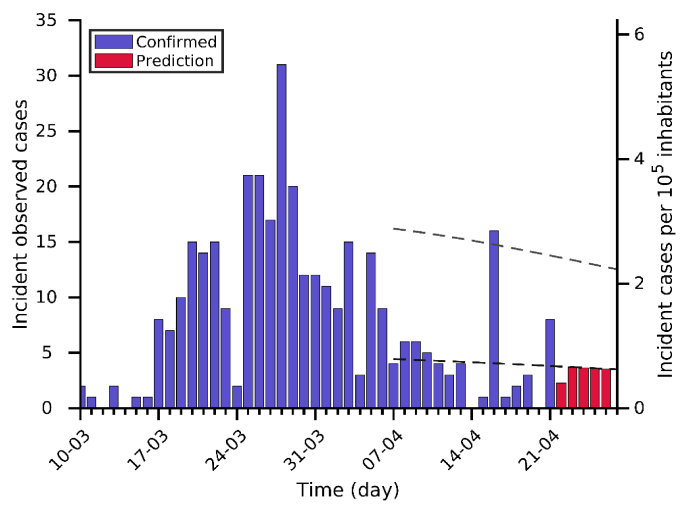
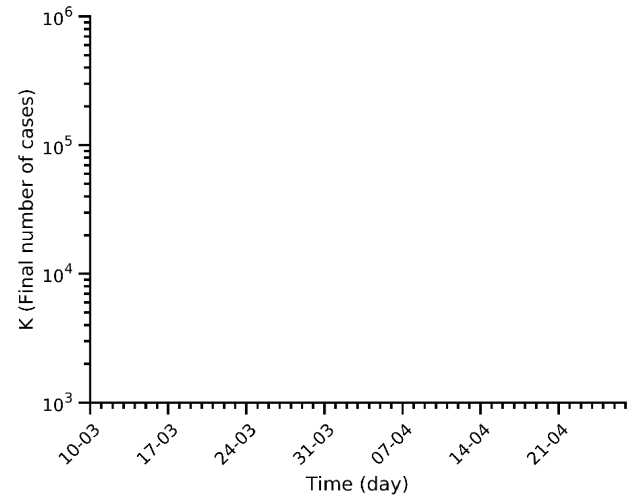
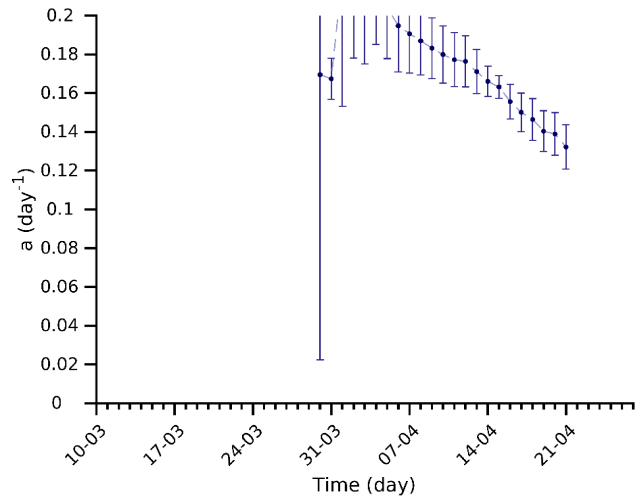
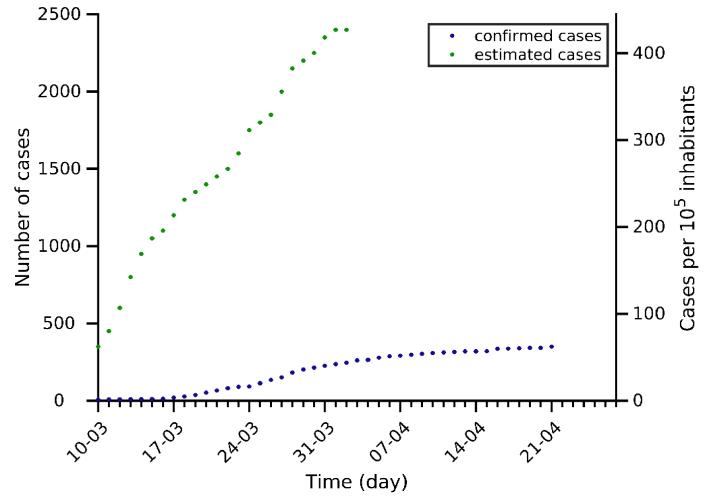
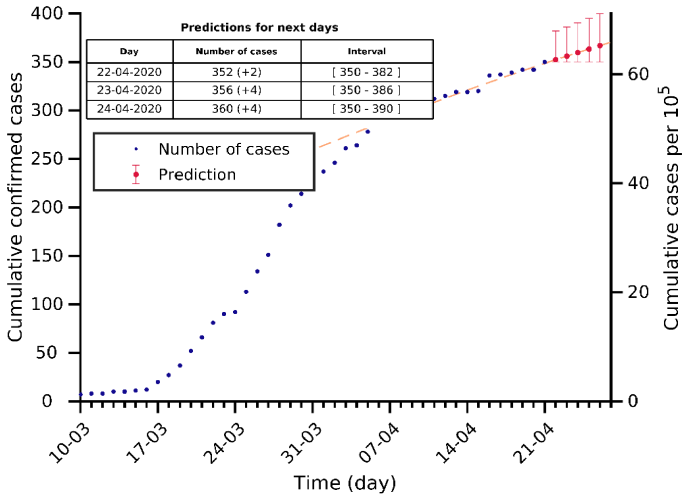
Valle d'Aosta 21-04-2020. Population: 0.1M. Current cumulated incidence: 867/10⁵



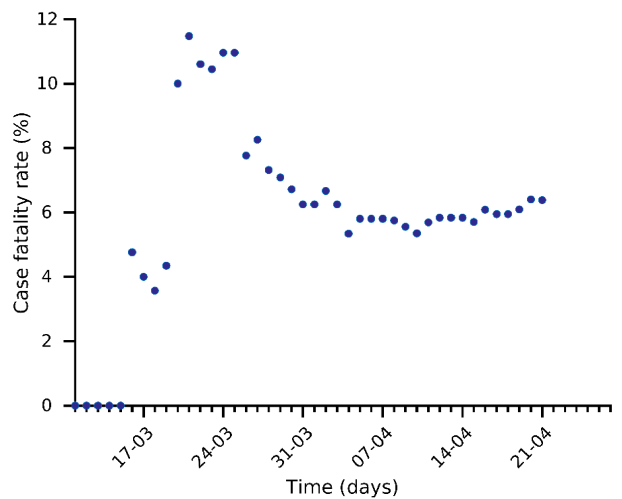
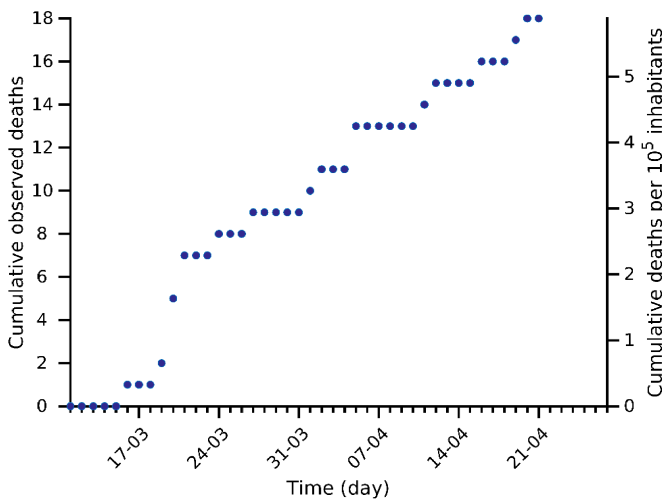
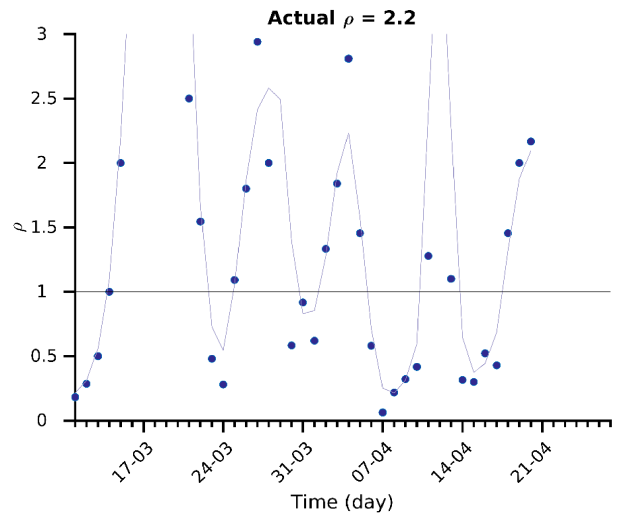
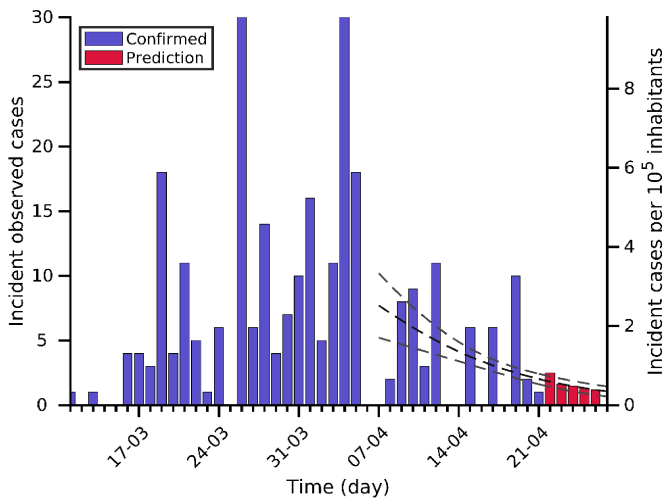
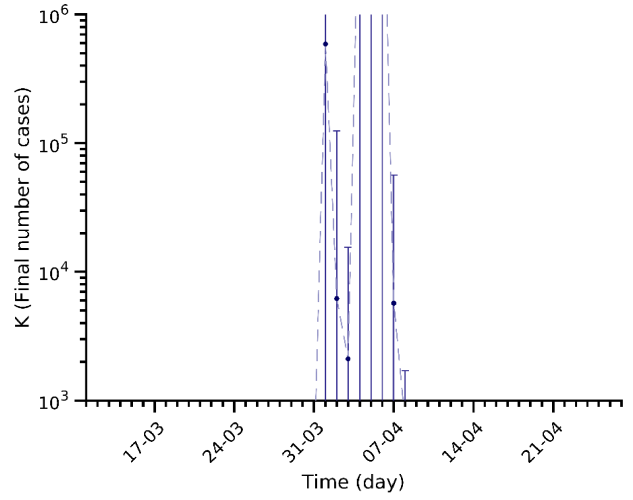
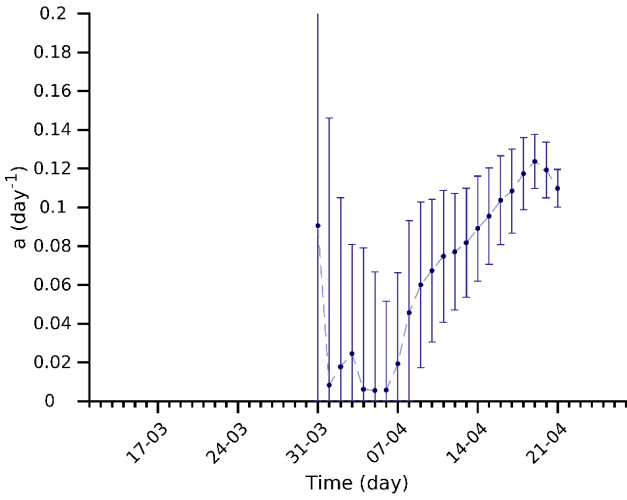
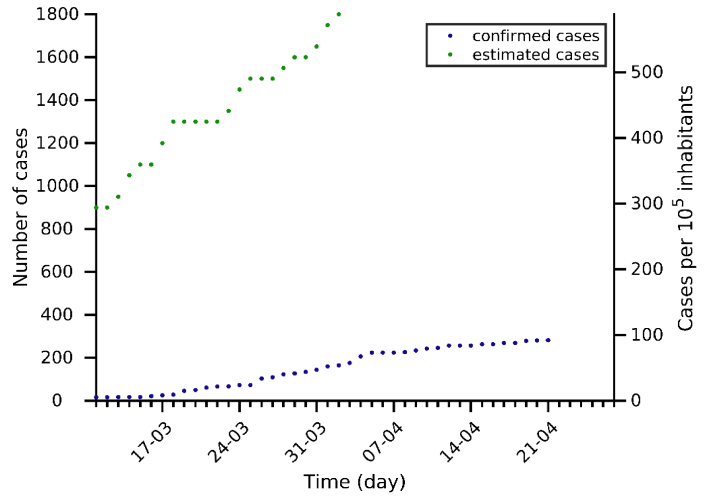
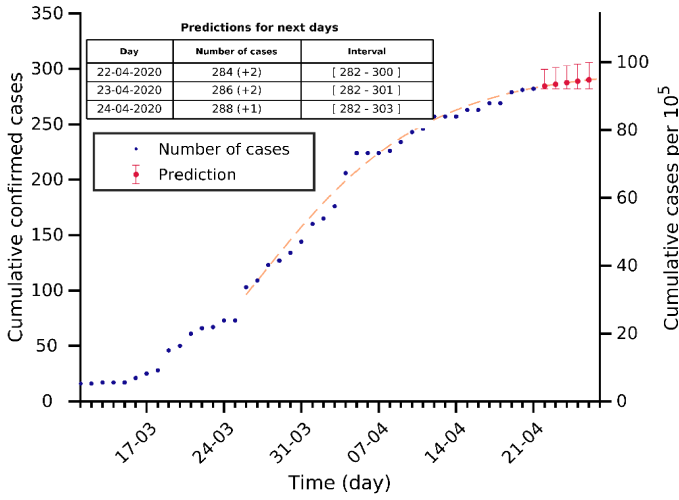
Calabria 21-04-2020. Population: 1.9M. Current cumulated incidence: 54/10⁵



Basilicata 21-04-2020. Population: 0.6M. Current cumulated incidence: 62/10⁵



Molise 21-04-2020. Population: 0.3M. Current cumulated incidence: 92/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports², from European Centre for Disease Prevention and Control (ECDC)³ and from Ministerio de Sanidad⁴. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

² <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

³ <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

⁴ <https://www.msbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁵ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁵ Madden LV. Quantification of disease progression. *Protection Ecology* 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁶;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁷ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁶ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁷ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet*; March 9, doi: 10.1016/S0140-6736(20)30566-3