

Daily report

28-04-2020

**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.

Martí Català  
Pere-Joan Cardona, PhD  
*Comparative Medicine and Bioimage Centre of  
Catalonia; Institute for Health Science Research  
Germans Trias i Pujol*

Clara Prats, PhD  
Sergio Alonso, PhD  
Enric Álvarez, PhD  
Miquel Marchena  
Daniel López, PhD  
*Computational Biology and Complex Systems;  
Universitat Politècnica de Catalunya - BarcelonaTech*

**With the collaboration of:** Guillem Álvarez, Oriol Bertomeu, Laura Dot, Lavínia Hriscu, Helena Kirchner, Daniel Molinuevo, Pablo Palacios, Sergi Pradas, David Rovira, Xavier Simó, Tomás Urdiales

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## **(0) Executive summary – Dashboard**

## Global EU+EFTA+UK trends and needs

EU+EFTA+UK countries keep following the decrease in new cases, and consolidate the level of 15,000 cases. **Spreading rate also maintains its  $\rho < 1$  level for third consecutive week.**

Problems with Spain data reporting, that have communicated no new cases today, have been temporally overcome by using the historical series provided by Spanish government. This series has been corrected last days in order to homogenize the information that it gathers.

Today we include the appendix with **updated risk diagrams**. These diagrams have been improved so that they are easier to understand: a **background colour scale has been added indicating zones with low (green), intermediate (yellow) and high risk (red)**.

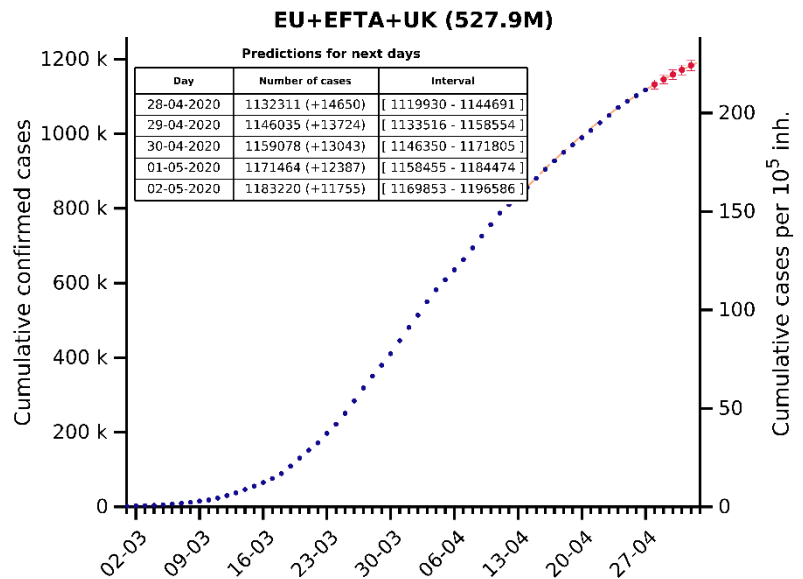
Two diagrams are provided for each country: (1) spreading rate vs reported 14-day attack rate (i.e., last 14 days attack rate reported by countries); (2) spreading rate vs estimated 14-day attack rate (i.e., estimated real incidence of last 14 days). Two different colour scales have been fixed according to  $EPG_{REP}$  and  $EPG_{EST}$  values. Note that there are countries that change their risk assessment depending on the use of reported or estimated data.

The analysis section is focused on analysing the distribution of new cases among countries.

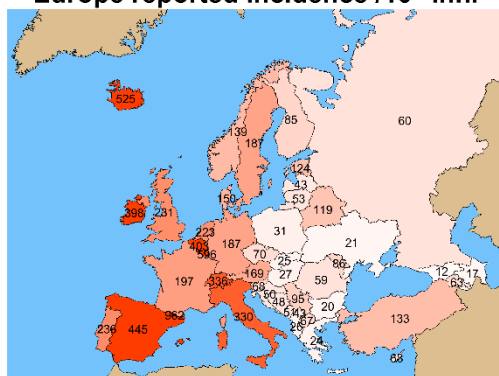
### Trends for specific countries

**UK** is the country with highest 14-day cumulative cases (68,528), while **Ireland** is the one with highest 14-day attack rate (190.5 per  $10^5$  inhabitants). Therefore, both are at risk of uncontrolled growth if  $\rho_7$  does not remain below 1. Another country at intermediate to high risk is **Sweden**, with an intermediate 14-day attack rate but a  $\rho_7 > 1$ . **Belgium** is also among countries at highest risk, although  $\rho_7$  is consolidating its dynamic  $< 1$ . If this is maintained, trend to control should be confirmed the next days. **Denmark**, which had entered an apparently control phase, has experimented a gradual increase in  $\rho_7$ . Given that this country started relaxing measures 10 days ago, it should be closely watched out the next days. Regarding **Greece**, its high  $\rho_7$  (4.08) is related with some inconsistencies in data reporting.

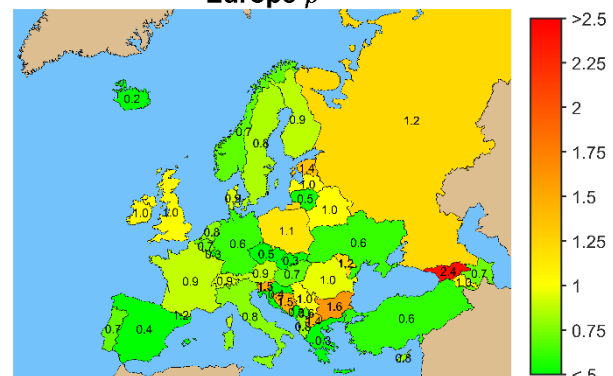
The map in the right shows the current  $\rho$ , therefore, without the smoothing provided by the 7-day moving average.



Europe reported incidence / $10^5$  inh.



Europe  $\rho$



## Situation and trends per country

Table of current situation in EU countries. 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. **New!** Last column (EPG<sub>EST</sub>) indicates EPG assessed with **estimated real 14-day attack rate** (see report 39 for details). EPG<sub>REP</sub> is calculated with **data reported by countries**. EPG<sub>REP</sub> and EPG<sub>EST</sub> **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 <sup>5</sup> inh.	Cumulative deaths	Mortality /10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate /10 <sup>5</sup> inh.	$\rho_7^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Spain	210,773	454.8	23,190	50.0	38,809	83.7	0.84	70	785
Italy	199,414	335.5	26,977	45.4	39,898	67.1	0.86	58	813
United Kingdom	157,149	236.5	21,092	31.7	68,528	103.1	0.94	97	1,440
Germany	156,337	190.9	5,913	7.2	31,239	38.1	0.77	29	129
France	128,339	198.3	23,293	36.0	30,263	46.8	0.95	44	881
Belgium	46,687	411.0	7,207	63.5	16,098	141.7	0.82	116	2,134
Netherlands	38,245	225.1	4,518	26.6	11,694	68.8	0.78	54	677
Switzerland	29,081	339.3	1,352	15.8	3,582	41.8	0.68	28	138
Portugal	24,027	231.7	928	8.9	7,093	68.4	0.91	62	265
Ireland	19,648	415.7	1,102	23.3	9,001	190.5	0.93	176	1,270
Sweden	18,926	192.4	2,274	23.1	7,978	81.1	1.09	88	1,625
Austria	15,256	175.1	549	6.3	1,213	13.9	0.83	12	42
Poland	11,902	31.1	562	1.5	4,968	13.0	0.93	12	74
Romania	11,339	57.3	631	3.2	4,706	23.8	0.98	23	151
Denmark	8,698	152.3	427	7.5	2,380	41.7	1.00	42	221
Norway	7,533	140.3	193	3.6	1,045	19.5	0.75	15	40
Czech Republic	7,449	70.2	223	2.1	1,390	13.1	0.71	9	31
Finland	4,695	85.3	193	3.5	1,631	29.6	0.95	28	148
Luxembourg	3,729	647.4	88	15.3	437	75.9	0.61	46	ND
Hungary	2,649	27.2	291	3.0	1,137	11.7	0.97	11	173
Greece	2,534	22.7	136	1.2	389	3.5	4.08	14	88
Croatia	2,039	48.4	59	1.4	389	9.2	0.80	7	ND
Iceland	1,792	492.0	10	2.7	81	22.2	0.36	8	ND
Estonia	1,647	125.5	50	3.8	315	24.0	0.78	19	ND
Lithuania	1,449	49.8	41	1.4	379	13.0	0.47	6	ND
Slovenia	1,407	67.7	83	4.0	195	9.4	0.87	8	ND
Slovakia	1,381	25.4	18	0.3	612	11.2	0.61	7	ND
Bulgaria	1,363	19.1	58	0.8	678	9.5	1.60	15	ND
Cyprus	822	70.3	20	1.7	160	13.7	0.61	8	ND
Latvia	818	41.5	13	0.7	163	8.3	1.06	9	ND
Malta	450	104.9	4	0.9	66	15.4	ND	ND	ND
Liechtenstein	83	215.3	1	2.6	2	5.2	ND	ND	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500	2500
Best	Best	Best	Best	Best	Best	Best	0.0	0	0.0

- (1) Disclaimer: parameter  $\rho$  is very sensitive and experiments daily variations.  $\rho_3$  is the average of 3 consecutive  $\rho$ , but can still fluctuate. (2) EPG stands for Effective Growth Potential. EPG<sub>REP</sub> is obtained by multiplying attack rate of last 14 days per 10<sup>5</sup> inhabitants (i.e. density of cases) by  $\rho_3$  (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG<sub>EST</sub> is obtained by multiplying estimated real attack rate of last 14 days per 10<sup>5</sup> inhabitants by  $\rho_3$ .

## Highlights for countries with highest number of reported cases

- ✓ UK remains at the level of 4,000 expected daily new cases. France has shown a sudden increase in data that causes an increase in forecasted new cases (>1,000). Spain could reach Italy in the next days, both of them being at the level of 1,500-2,000. Germany is the country with lowest expected number of new cases, among these five.
- ✓ New  $\rho_7$  is still close to 1 for UK, and <1 for Spain, France, Italy and Germany.

## Time indicators by country

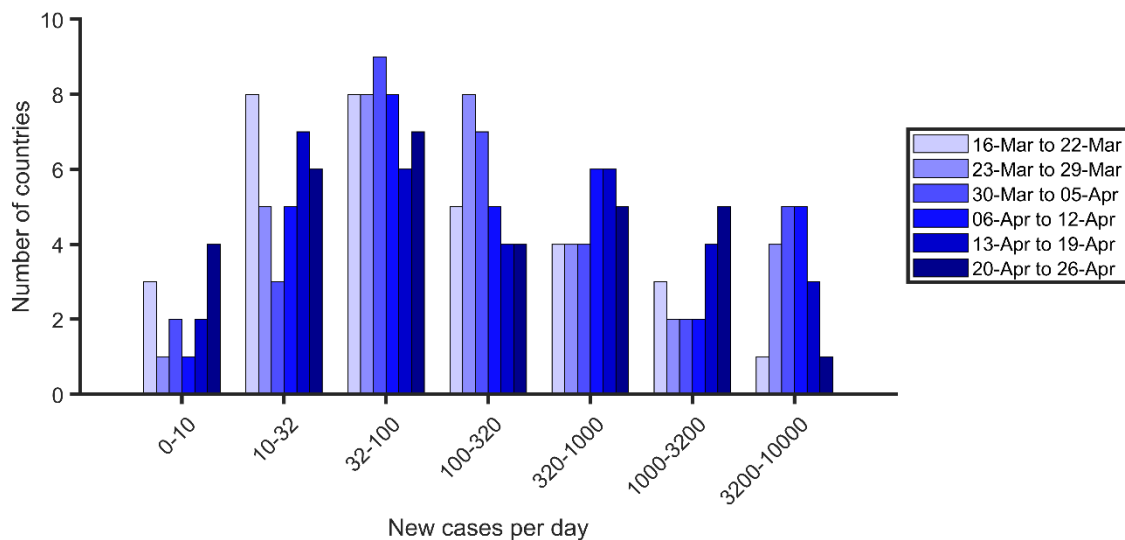
This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of  $1/10^5$  inhabitants and an attack rate of  $10/10^5$  inhabitants, and time interval between attack rates of 10 to 100 per  $10^5$  inhabitants (only for countries 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	66	11	16
France	60	10	20
Germany	60	12	17
Spain	59	7	12
United Kingdom	56	11	19
Norway	55	9	24
Switzerland	55	9	12
Netherlands	54	11	20
Sweden	54	10	28
Austria	53	10	14
Belgium	53	11	14
Greece	52	18	ND
Iceland	52	5	15
Denmark	50	4	30
Czech Republic	49	11	ND
Finland	48	12	ND
Portugal	48	9	15
Slovenia	48	6	ND
Ireland	47	8	18
Romania	47	15	ND
Estonia	46	5	30
Poland	46	15	ND
Bulgaria	44	18	ND
Luxembourg	44	6	7
Slovakia	44	20	ND
Croatia	43	12	ND
Latvia	42	12	ND
Cyprus	41	12	ND
Hungary	41	15	ND
Malta	40	8	34
Lithuania	39	9	ND
Liechtenstein	34	9	11

## Analysis: Distribution of new cases among countries.

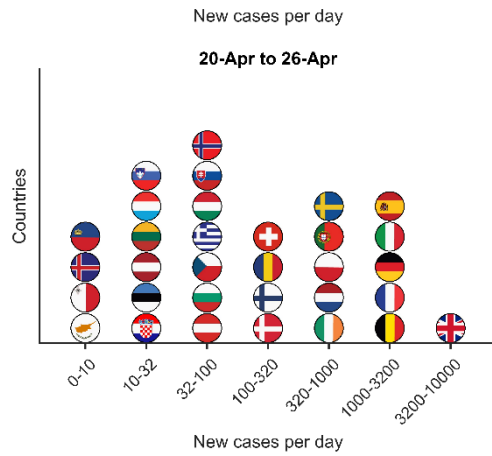
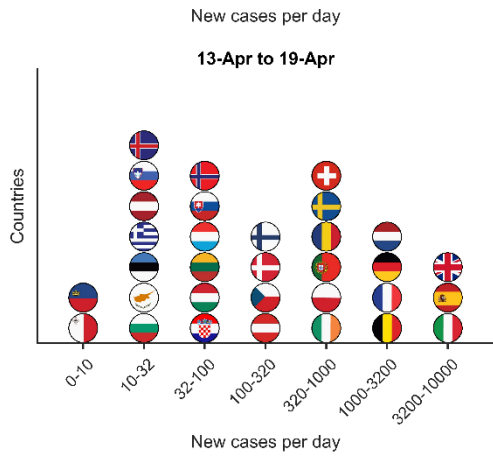
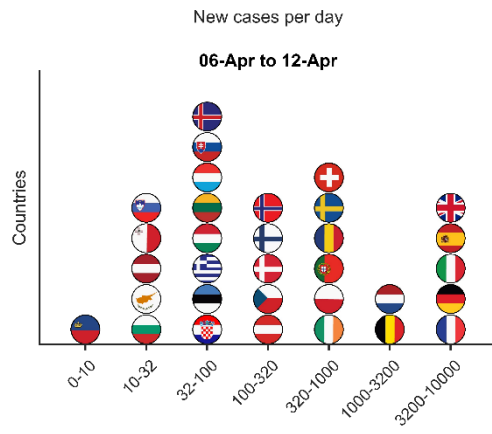
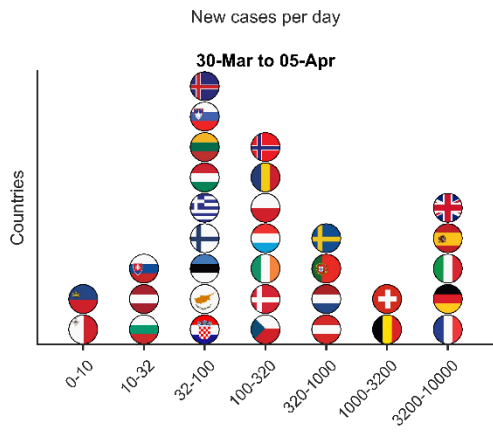
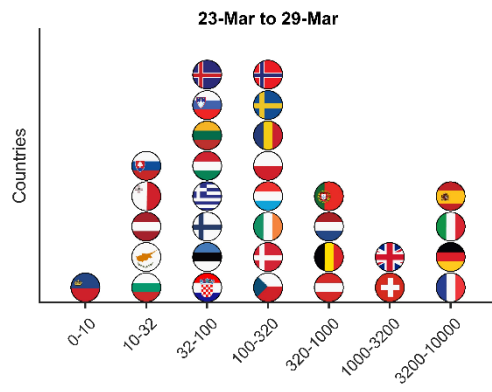
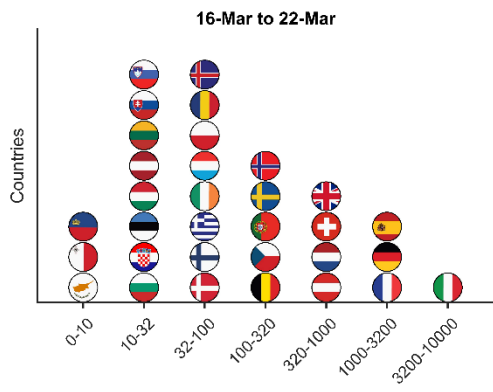
COVID19 has affected differently each country. Many factors are involved in such differences, and it is still difficult to provide the whole picture of causes behind each particular dynamics. It is clear that confinement measures have marked a milestone on spreading rate, but other factors like health system structure and facilities, kind of social interactions between people, cultural behaviour, baseline mobility, relative importance of public transport, temperature, pollution and other factors have also had a role on each particular COVID19 evolution.

Today, we focus on the resulting **distribution of new cases among countries**. The next figure summarizes how **daily new cases have evolved for the last 6 weeks**. X-axis is divided in different bins, each one accounting for a certain range of new cases per day. Note that X-axis is not linear, but that the scale is logarithmic-like. Then, light to dark blue bars show the number of countries in that bin along the 6 represented weeks.



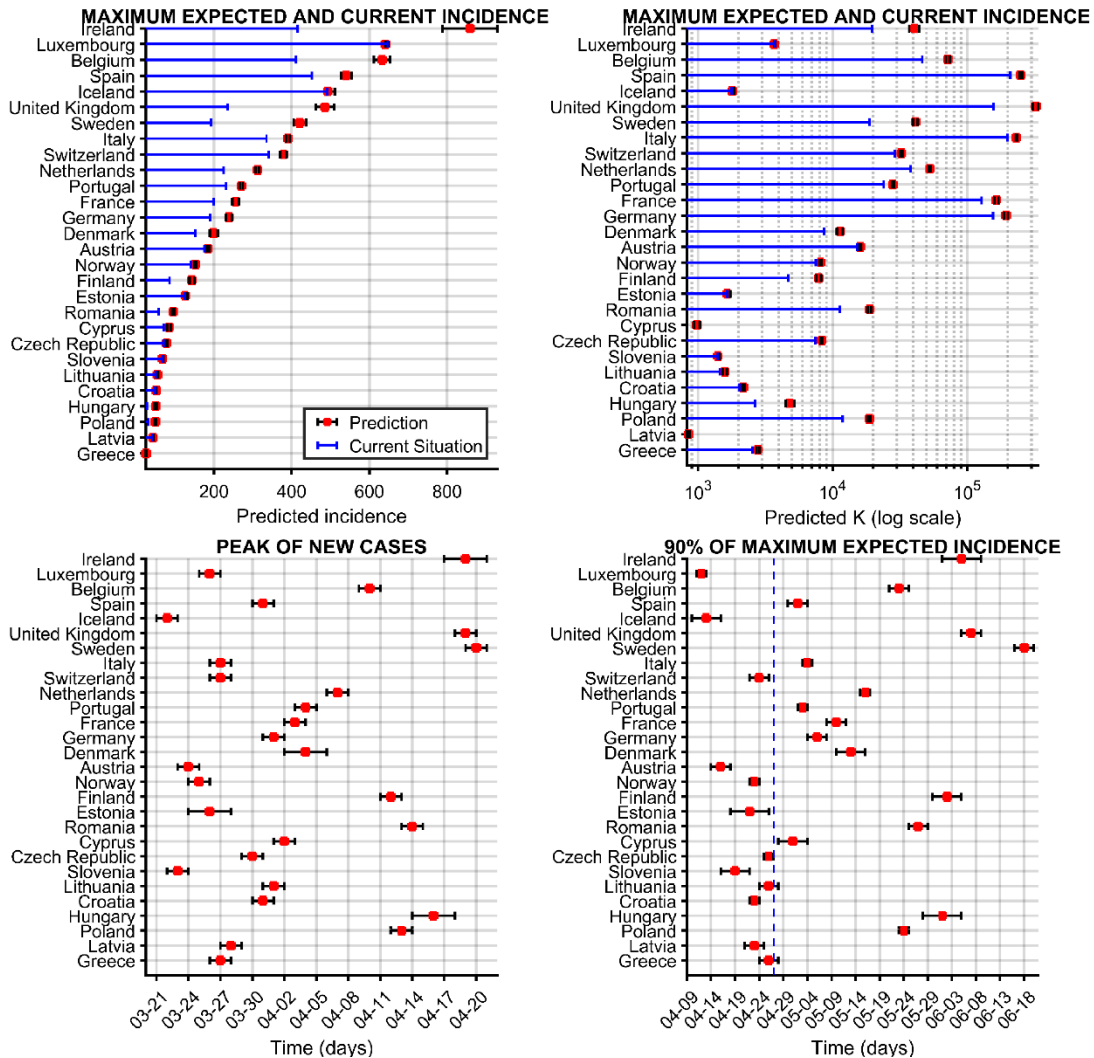
If we look at lower and intermediate bins, we corroborate that **the number of countries with intermediate values for daily case reporting (32-100 and 100-320) has decreased**, while lower intervals (0-10 and 10--32) show an increase. This would be a symptom of control. On the right part of the plot, which corresponds to countries to high incidence, we observe a **decrease with time in the last bin (3,200-10,000)** with the corresponding increase in the previous one (1,000-3,200). This would be also a positive symptom as well, although there is still a long way to walk before full control.

It is also of interest to observe **how particular countries have moved between these intervals**. Next, we show an individual figure for each week where we specify the countries in each bin. We can see, for instance, that Spain was at the penultimate bin 6 weeks ago, and then spent 4 weeks in the highest interval, where Italy was also ubicated for 5 weeks. Last week, Spain and Italy moved one bin backwards. United Kingdom has followed a similar dynamic one week after Spain. On the other side, Iceland started in the third bin and last two weeks has moved backwards until the first interval.

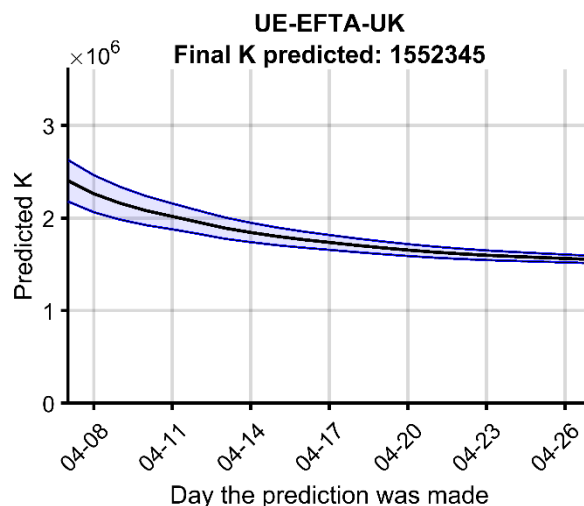


## Long-term predictions

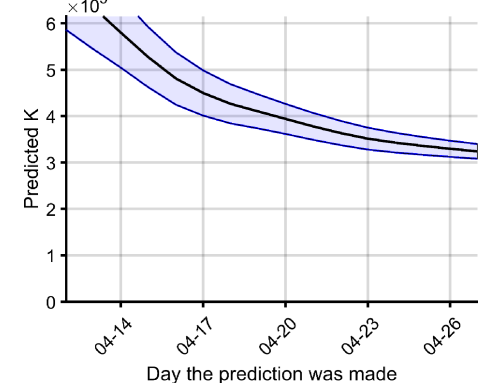
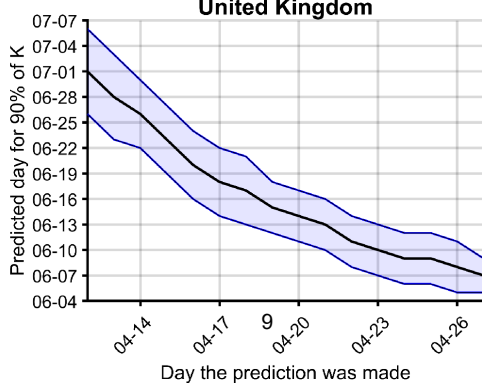
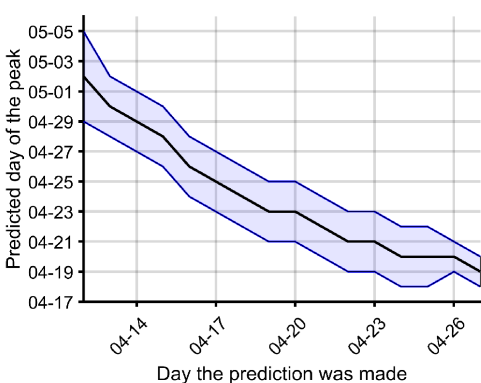
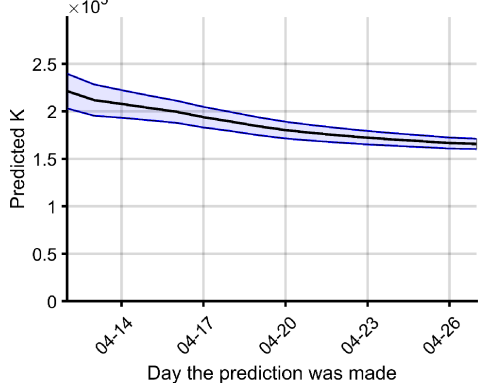
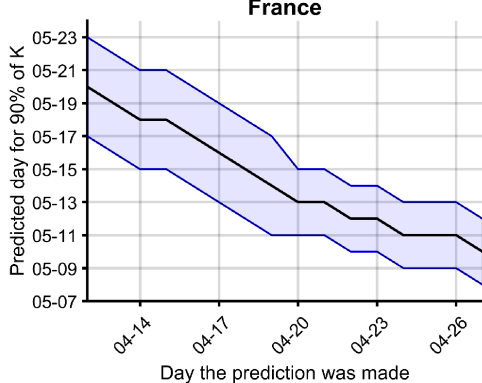
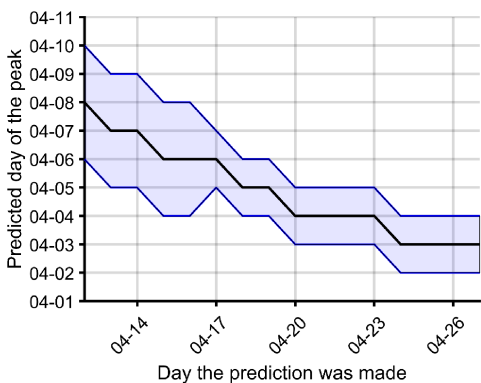
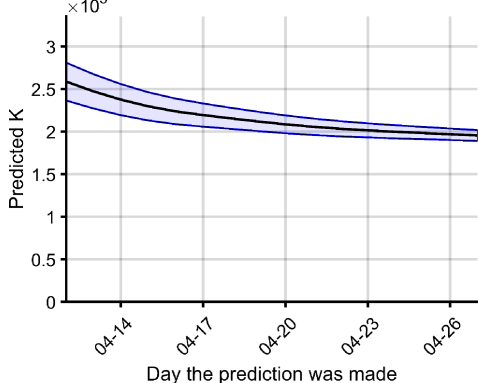
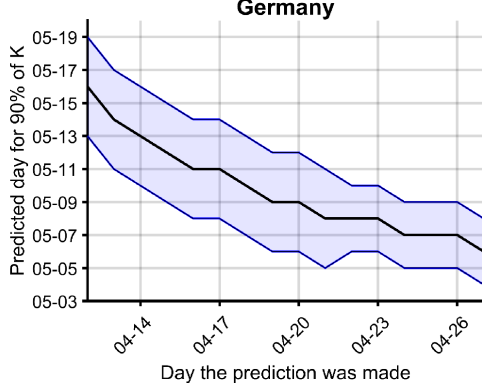
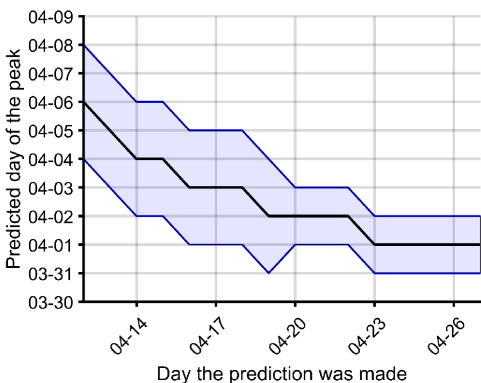
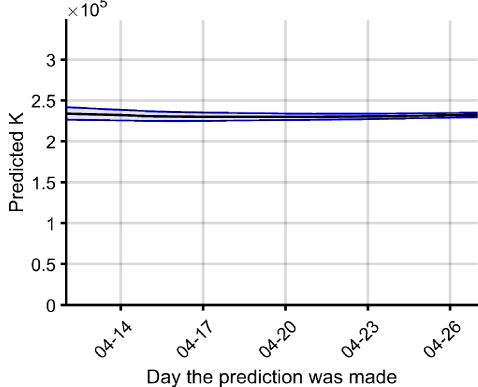
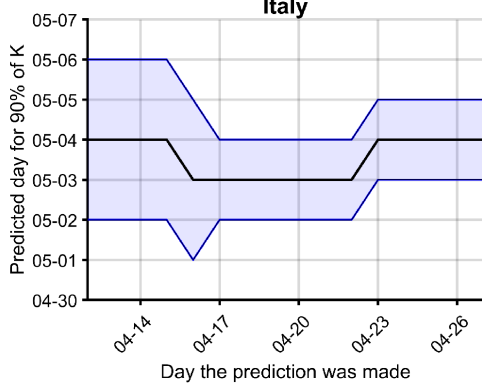
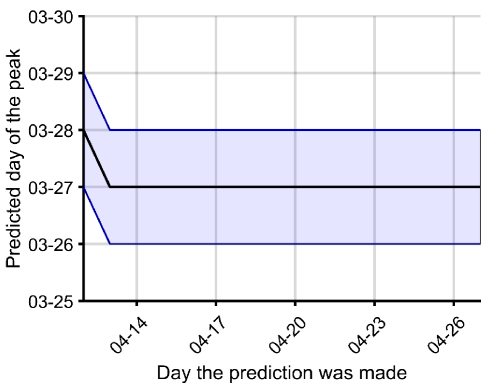
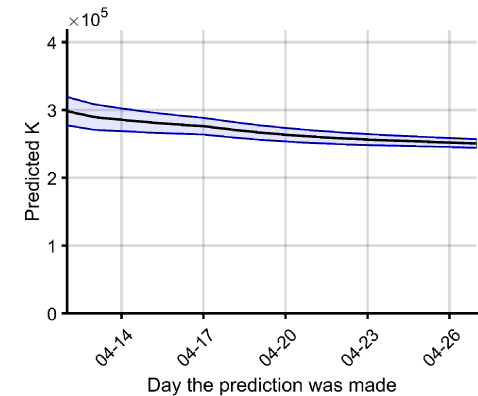
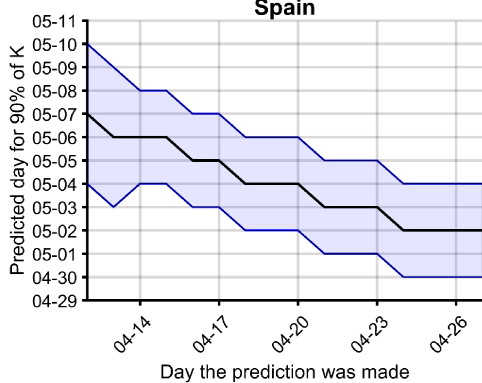
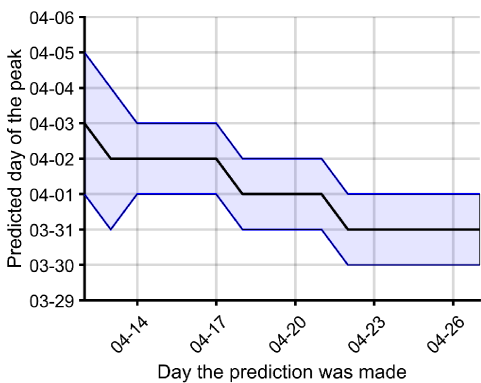
**Long-term predictions**, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per  $10^5$  inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log 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.



**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.

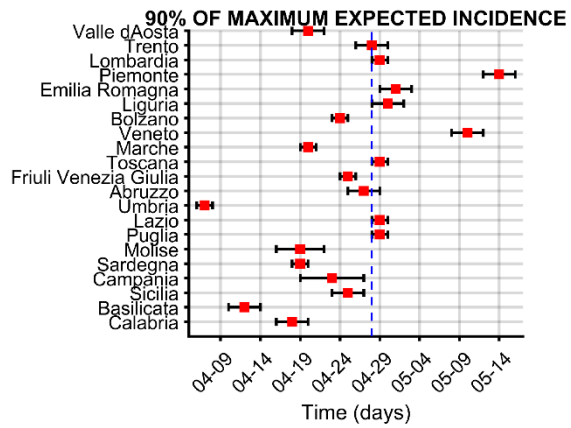
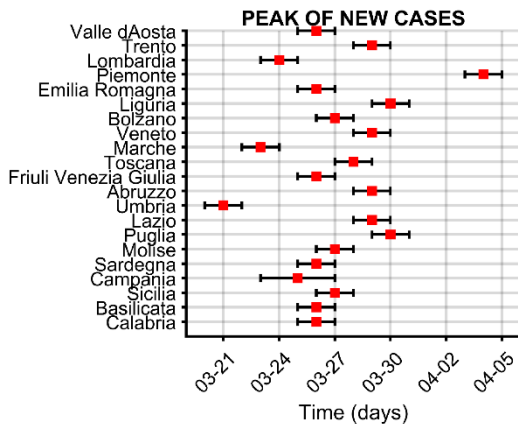
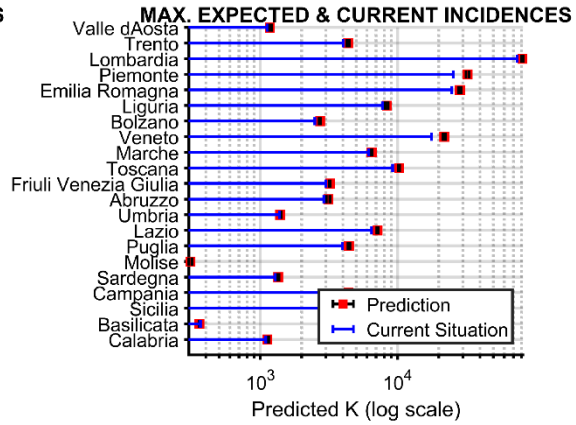
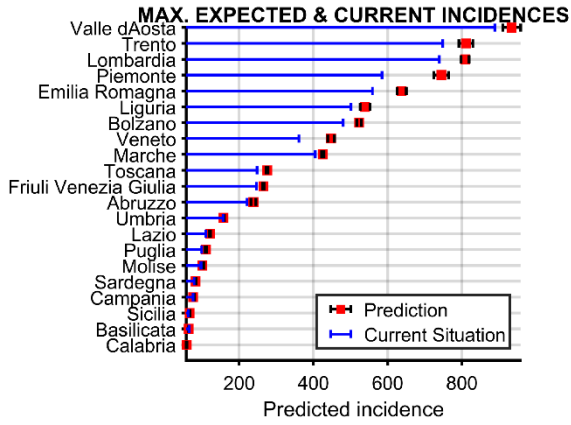


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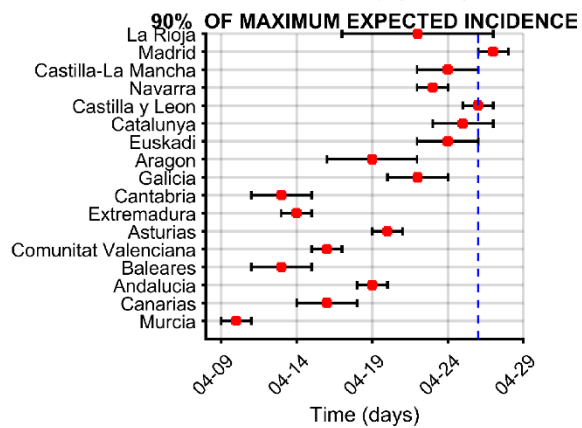
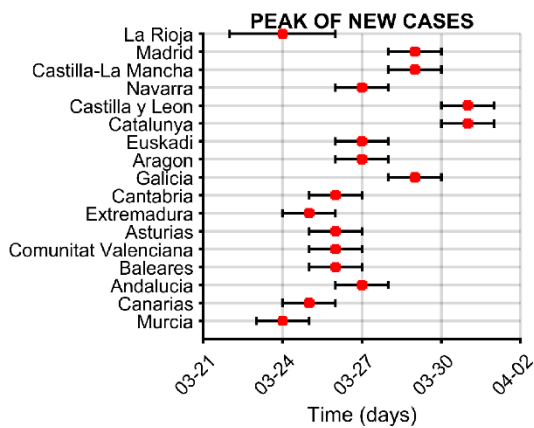
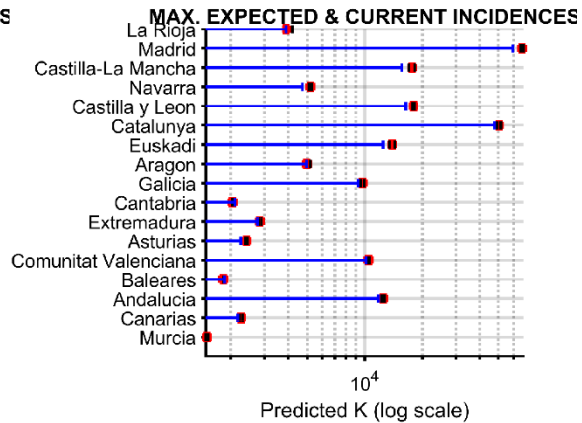
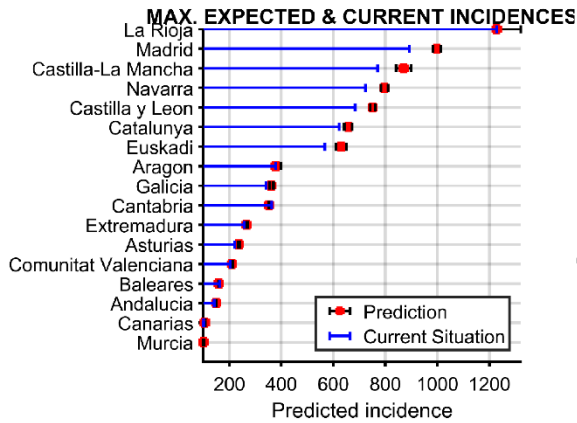




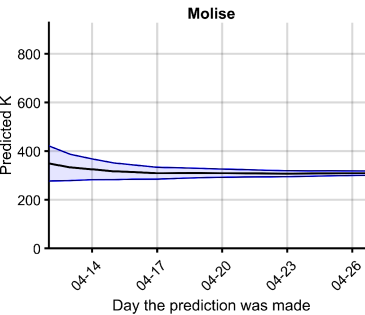
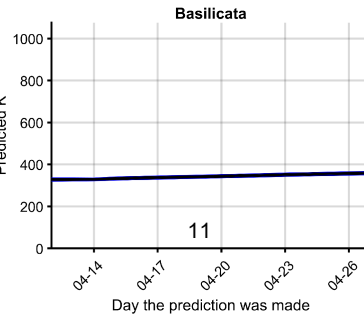
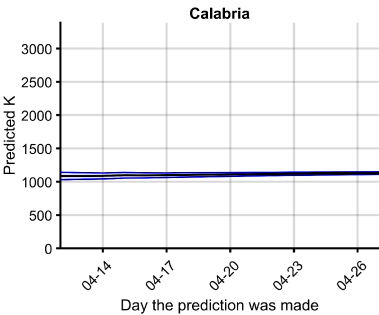
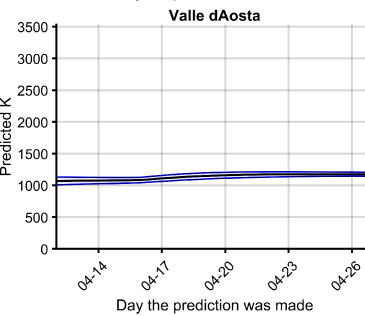
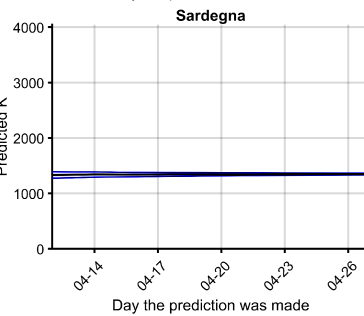
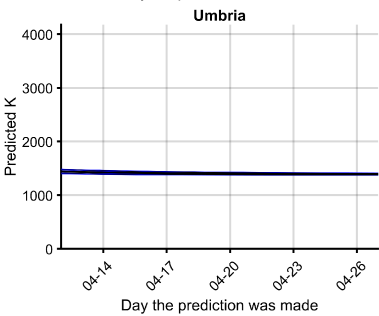
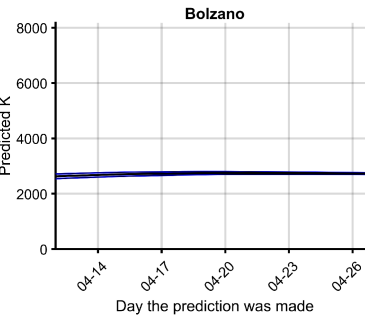
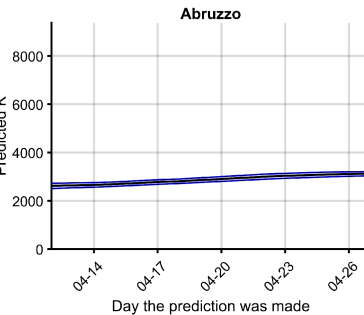
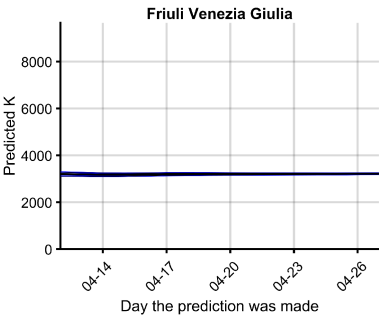
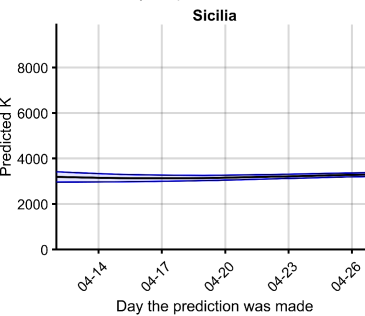
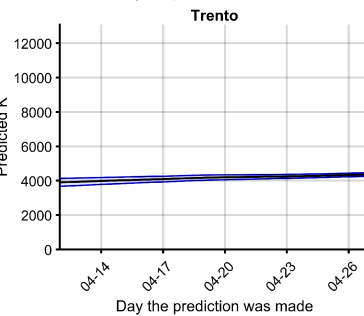
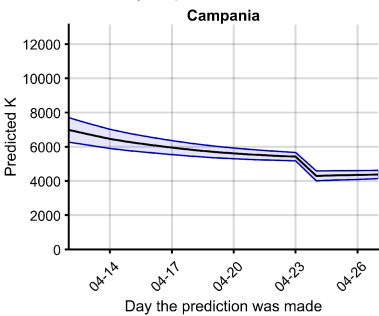
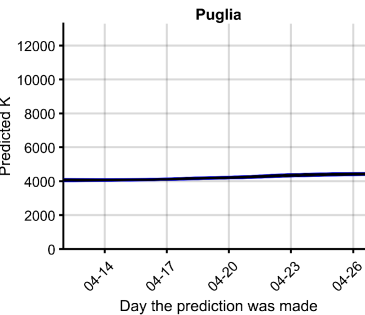
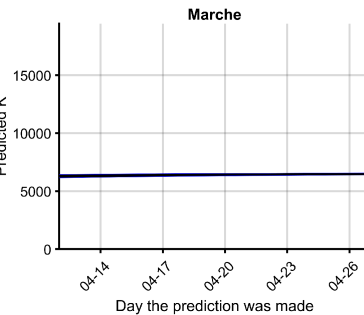
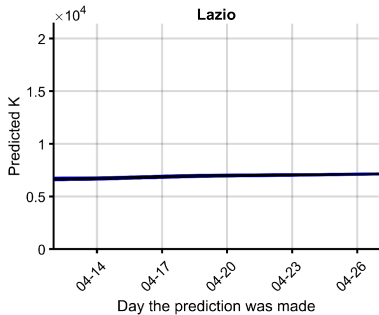
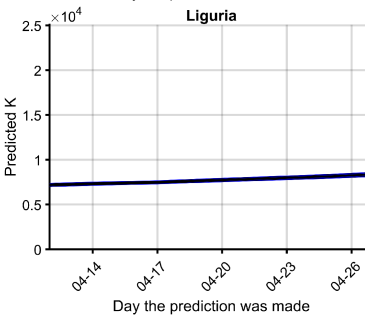
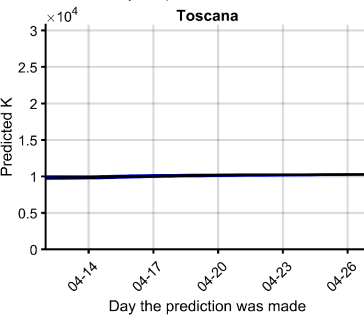
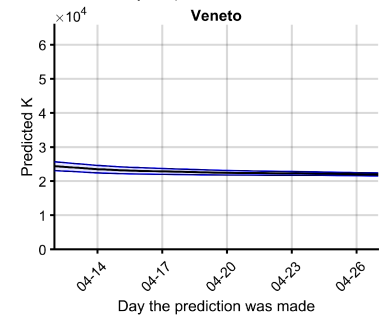
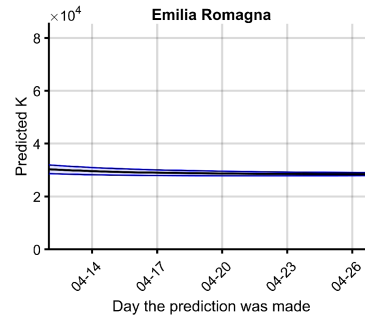
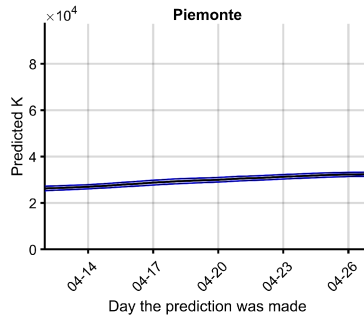
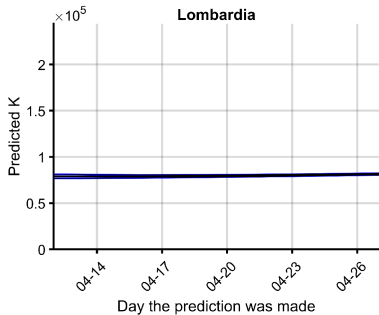
## Italian regions



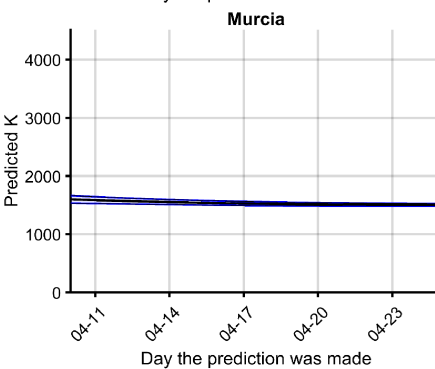
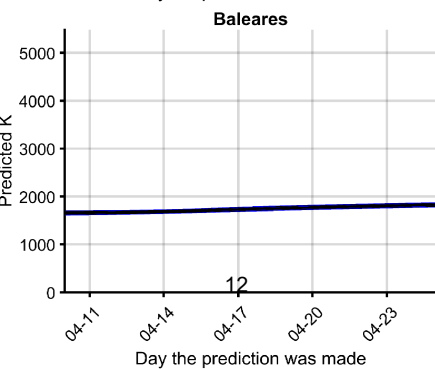
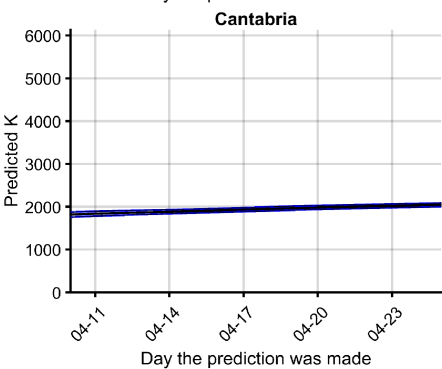
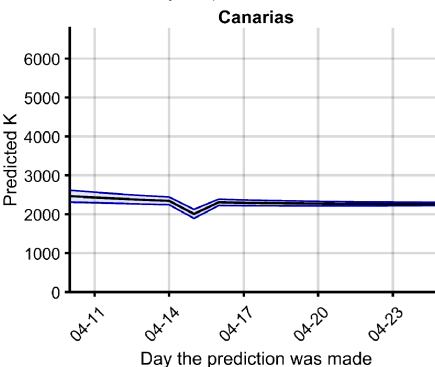
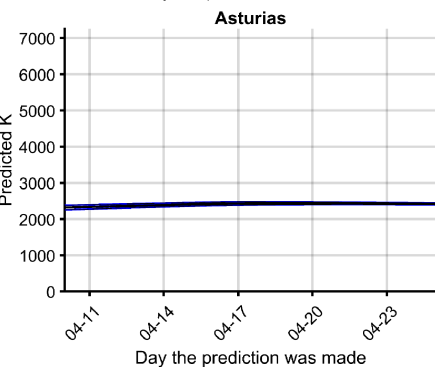
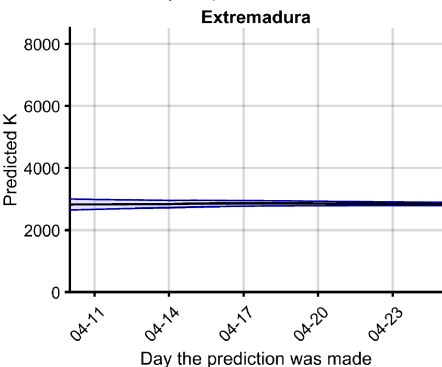
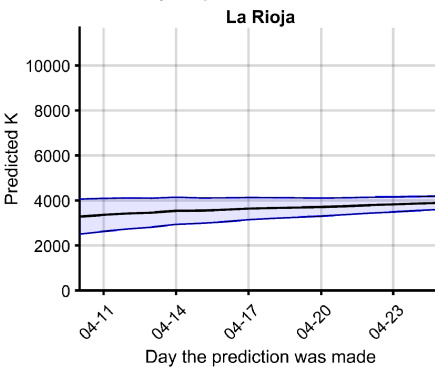
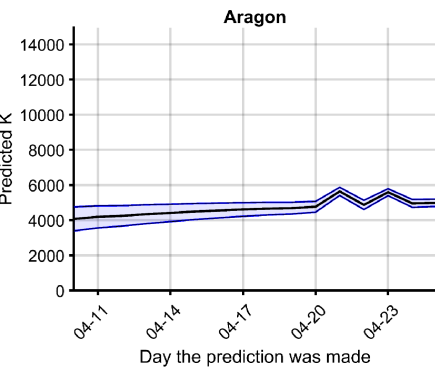
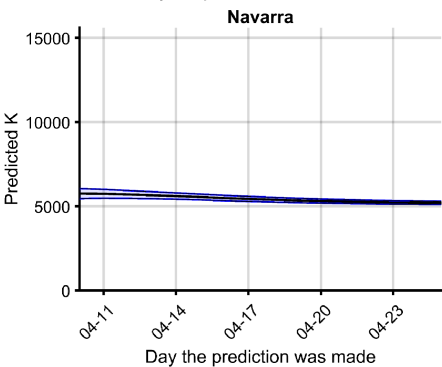
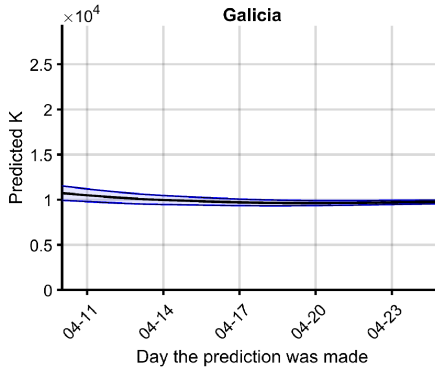
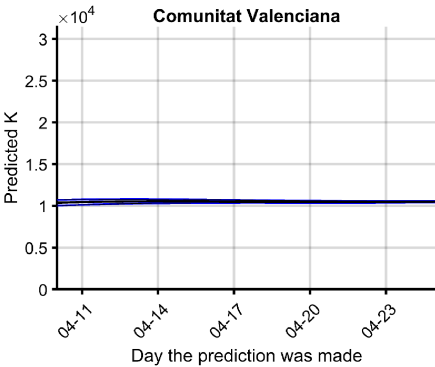
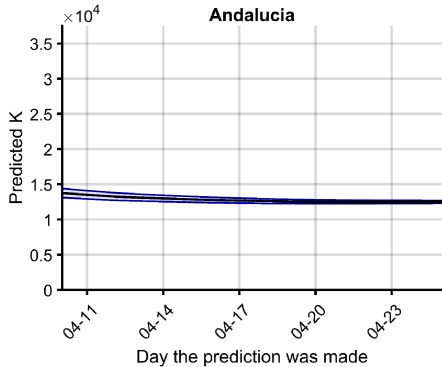
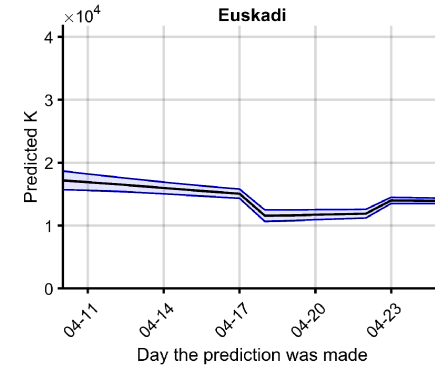
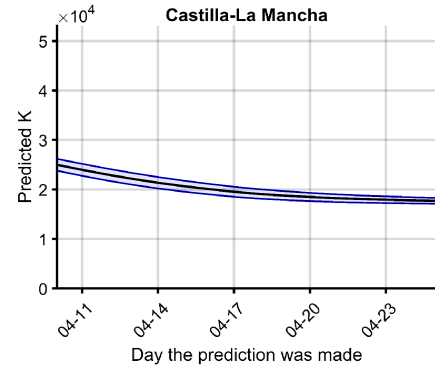
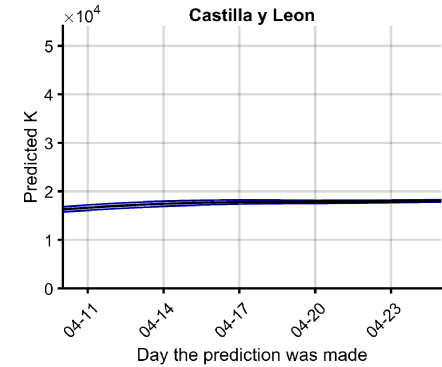
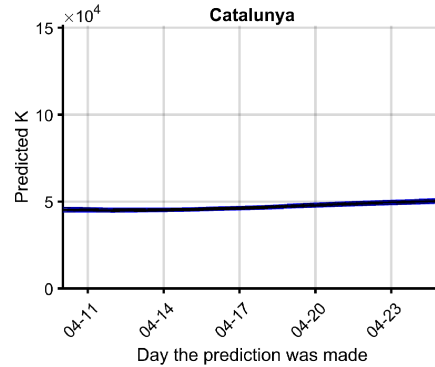
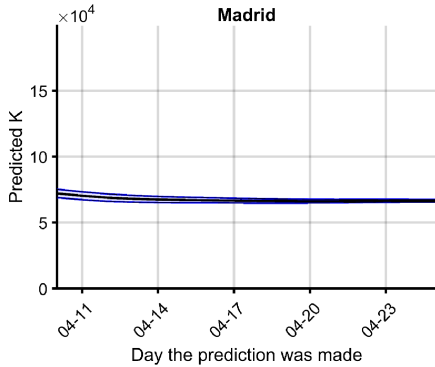
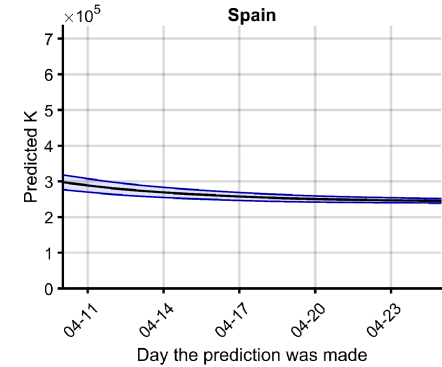
## Spanish regions



# 2020-04-28



# 2020-04-26



## Situation and trends in Italian and Spanish regions

### Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 <sup>5</sup> inh.	Cumulative deaths	Mortality / 10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate / 10 <sup>5</sup> inh	$\rho_7^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Lombardia	74,348	740.4	13,575	135.2	13,022	129.7	0.95	124	2,368
Piemonte	25,450	584.2	2,936	67.4	7,760	178.1	0.87	155	1,958
Emilia Romagna	24,914	558.7	3,472	77.9	4,162	93.3	0.79	74	1,069
Veneto	17,708	361.0	1,408	28.7	3,276	66.8	0.71	48	412
Toscana	9,231	247.5	811	21.7	1,704	45.7	0.74	34	321
Liguria	7,772	501.2	1,141	73.6	1,964	126.7	1.01	128	2,062
Lazio	6,467	110.0	414	7.0	1,356	23.1	0.84	19	131
Marche	6,175	404.8	893	58.5	749	49.1	0.78	38	571
Campania	4,380	75.5	358	6.2	611	10.5	0.75	8	68
Trento	4,025	375.4	412	38.4	884	82.4	0.99	81	1,734
Puglia	3,980	98.8	407	10.1	862	21.4	0.72	15	171
Sicilia	3,120	62.4	232	4.6	619	12.4	0.95	12	95
Friuli Venezia Giulia	2,995	246.5	278	22.9	475	39.1	0.84	33	320
Abruzzo	2,899	221.0	310	23.6	654	49.9	0.63	31	344
Bolzano	2,498	2,325.1	272	253.2	314	292.3	0.56	164	380
Umbria	1,379	156.3	65	7.4	58	6.6	0.70	5	ND
Sardegna	1,285	78.4	109	6.6	147	9.0	0.63	6	50
Valle d'Aosta	1,119	890.9	135	107.5	172	136.9	0.68	94	1,160
Calabria	1,097	56.3	85	4.4	141	7.2	0.69	5	ND
Basilicata	366	65.0	25	4.4	47	8.4	0.89	7	ND
Molise	297	97.2	21	6.9	40	13.1	0.90	12	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500	2500
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

### Spain

Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate /10 <sup>5</sup> inh.	Cumulated deaths	Mortality rate /10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate /10 <sup>5</sup> inh.	$\rho_7^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Madrid	59,784	900.3	8,048	121.2	11,736	176.7	0.75	132	1,791
Catalunya	48,158	636.6	4,808	63.6	12,961	171.3	0.8	132	1,369
Castilla y Leon	16,589	688.9	1,710	71.0	3,539	147.0	0.97	143	1,570
Castilla-La Mancha	15,706	771.6	2,396	117.7	1,554	76.3	1.45	111	1,757
Euskadi	12,564	576.8	1,255	57.6	1,338	61.4	3.80	233	2,570
Andalucia	11,913	141.4	1,168	13.9	1,710	20.3	0.95	19	201
Comunitat Valenciana	10,204	205.1	1,200	24.1	991	19.9	1.03	21	255
Galicia	9,328	345.4	412	15.3	1,731	64.1	1.09	70	335
Aragon	5,004	378.9	735	55.6	759	57.5	0.79	45	704
Navarra	4,759	732.2	432	66.5	609	93.7	0.95	89	866
La Rioja	3,897	1,242.7	326	104.0	477	152.1	0.99	150	1,333
Extremadura	2,751	258.2	433	40.6	225	21.1	0.74	16	254
Asturias	2,255	220.6	261	25.5	255	24.9	0.42	10	132
Canarias	2,187	99.1	133	6.0	229	10.4	0.89	9	59
Cantabria	2,115	363.6	188	32.3	319	54.8	0.69	38	361
Baleares	1,870	157.4	181	15.2	299	25.2	0.65	16	172
Murcia	1,475	99.1	130	8.7	60	4.0	1.17	5	43
Melilla	114	134.6	2	2.4	13	15.3	ND	ND	ND
Ceuta	100	117.9	4	4.7	4	4.7	ND	ND	ND

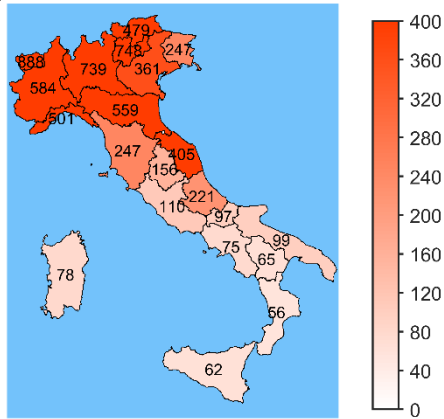
Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500	2500
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

<sup>(1)</sup> Disclaimer: parameter  $\rho$  is very sensitive and experiments daily variations.  $\rho_3$  is the average of 3 consecutive  $\rho$ , but can still fluctuate. <sup>(2)</sup> EPG stands for Effective Growth Potential. EPG<sub>REP</sub> is obtained by multiplying attack rate of last 14 days per 10<sup>5</sup> inhabitants (i.e. density of cases) by  $\rho_3$  (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG<sub>EST</sub> is obtained by multiplying estimated real attack rate of last 14 days per 10<sup>5</sup> inhabitants by  $\rho_3$ .

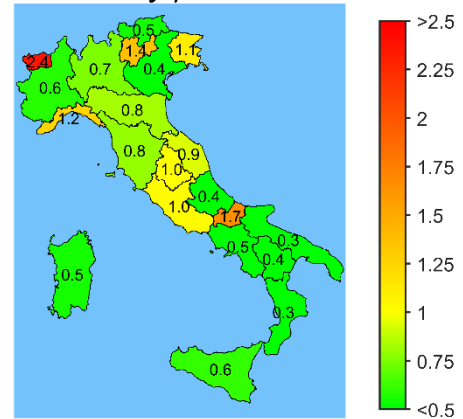
## Maps of Italian and Spanish regions

Cumulative incidence and spreading rate ( $\rho$ ) in Italian regions.

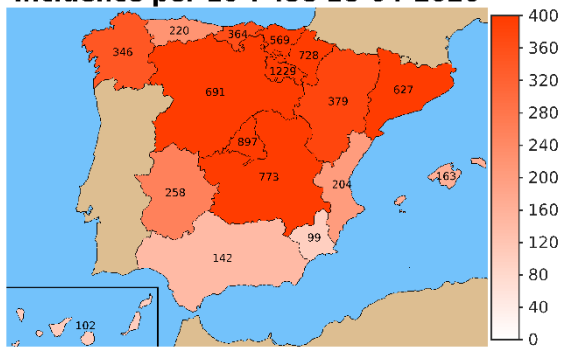
Italy Measured incidence =  $333/10^5$  inh.



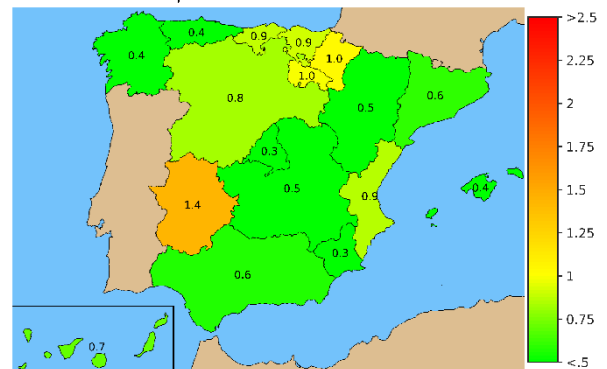
Italy  $\rho = 0.7$



Incidence per 10<sup>5</sup>: 458 28-04-2020



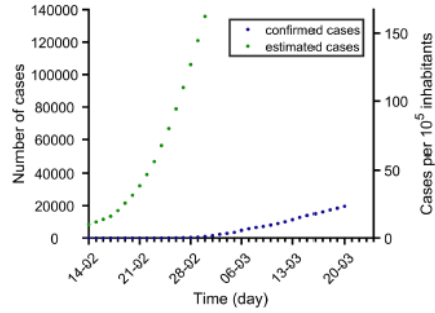
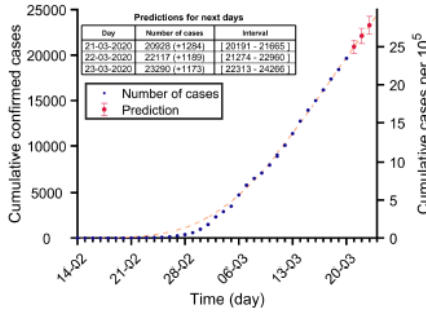
$\rho = 0.5$  27-04-2020



# Legend: Countries' reports details

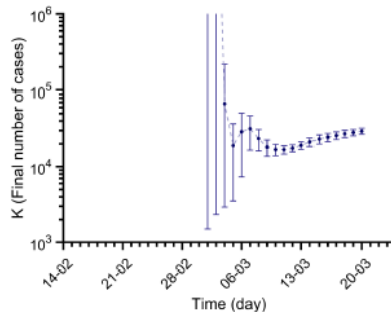
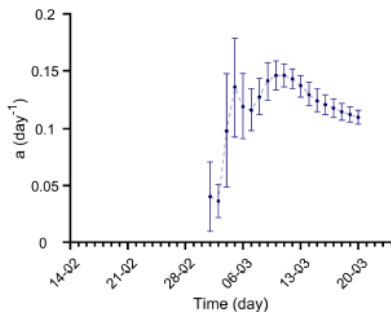
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: 23/10<sup>5</sup>

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



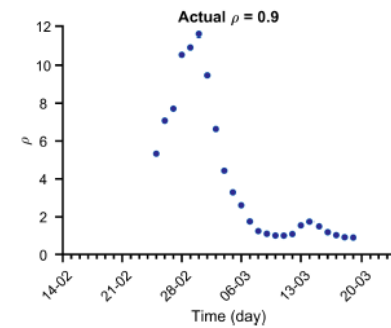
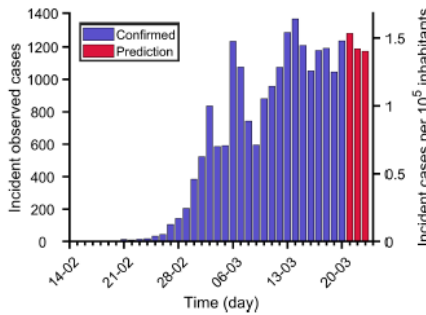
Estimated cases using death rate (see Methods)

Fitted  $a$  value using points prior to each date



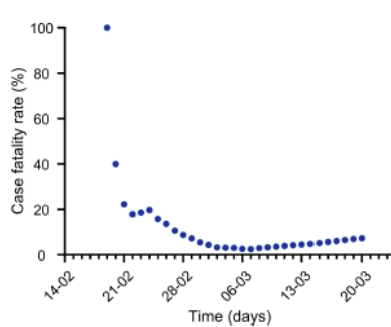
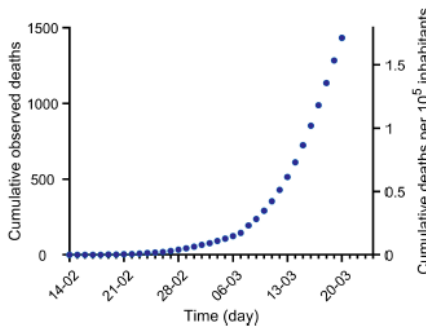
Fitted  $K$  value using points prior to each date

Reported and predicted new cases



Evolution of  $\rho$ , a parameter related with Reproduction number (see Methods)

Reported deaths

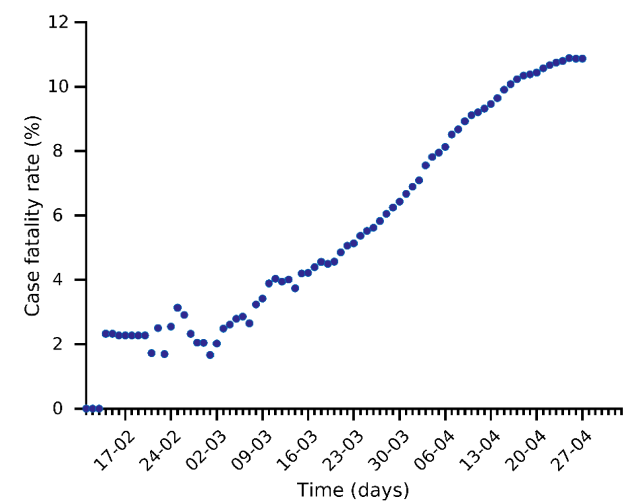
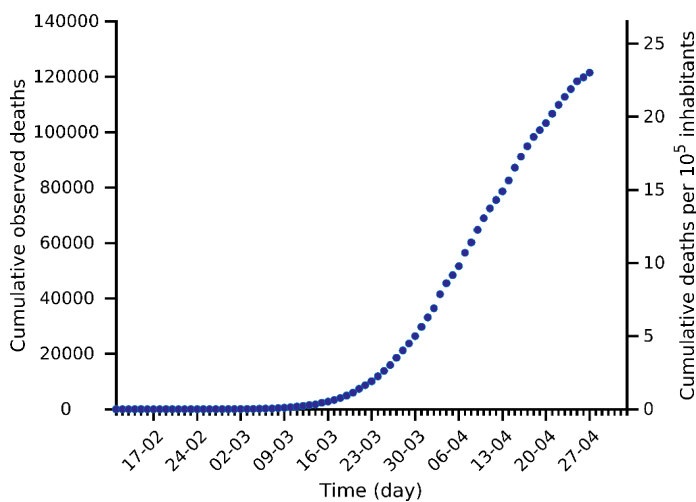
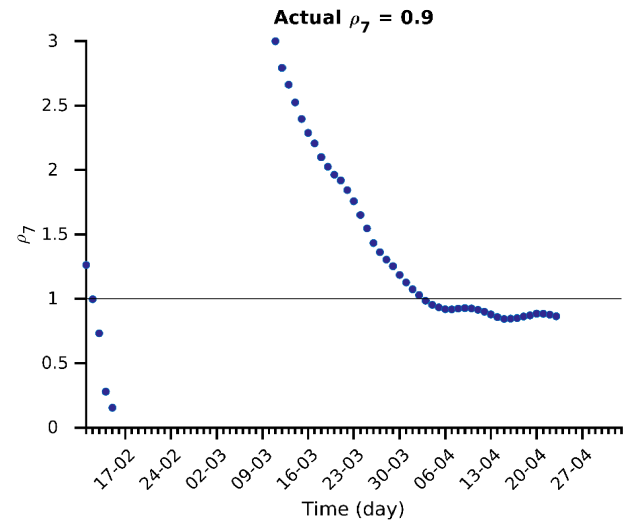
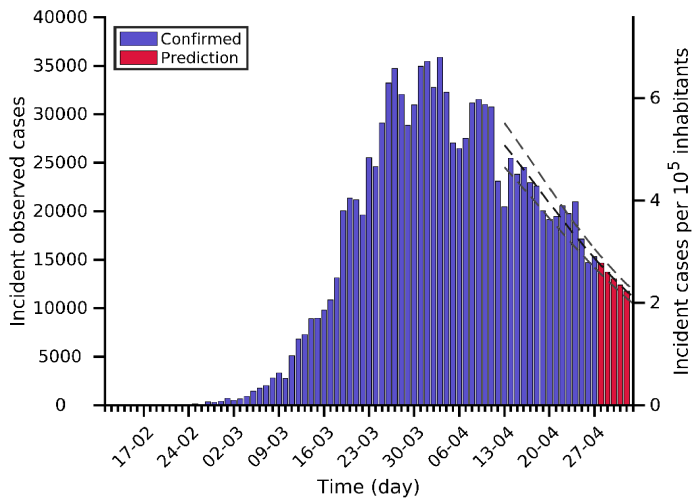
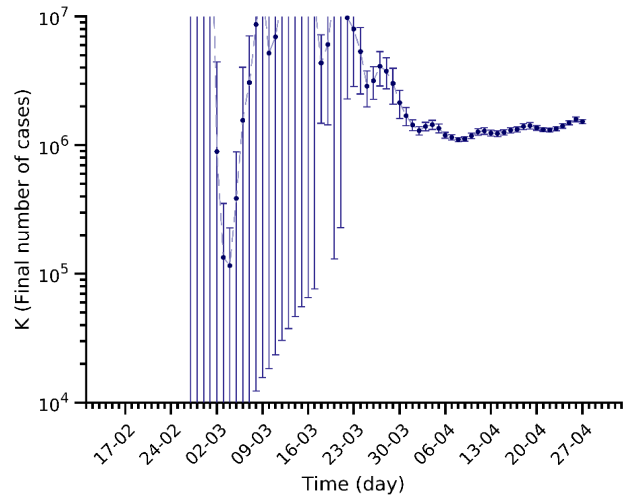
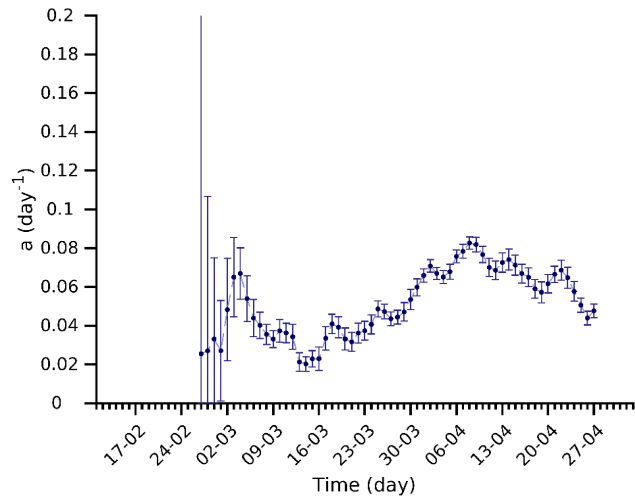
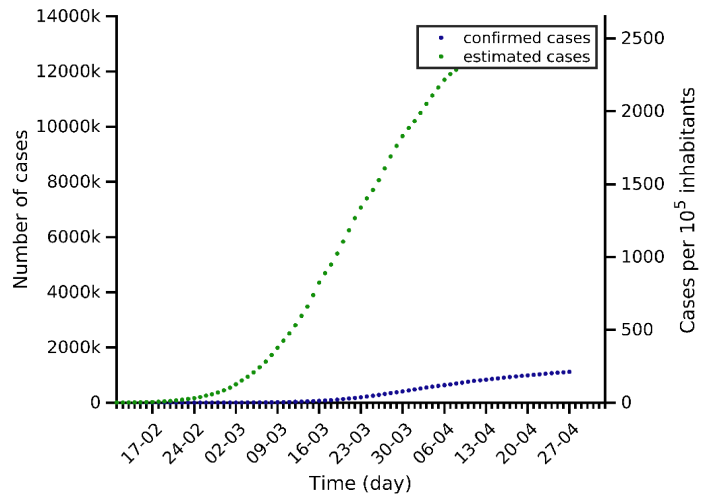
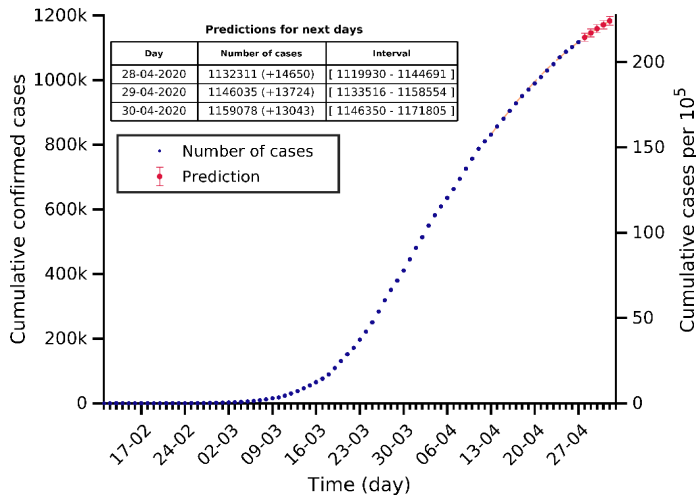


Deaths / cumulated reported cases

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

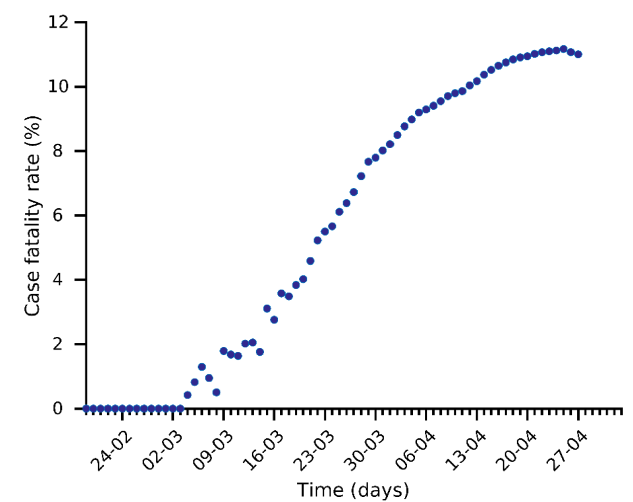
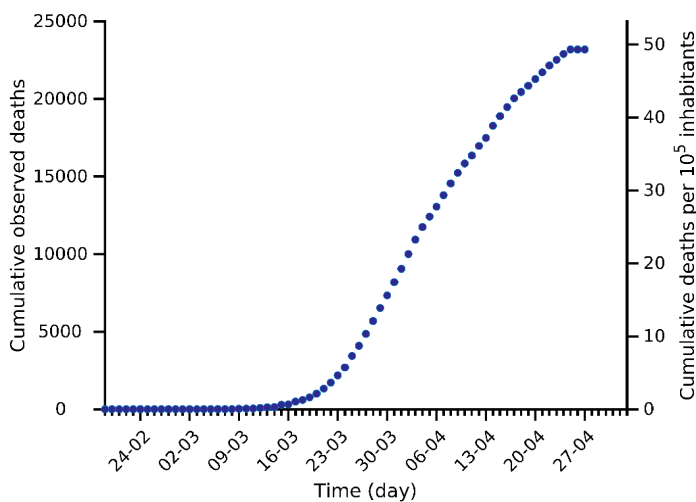
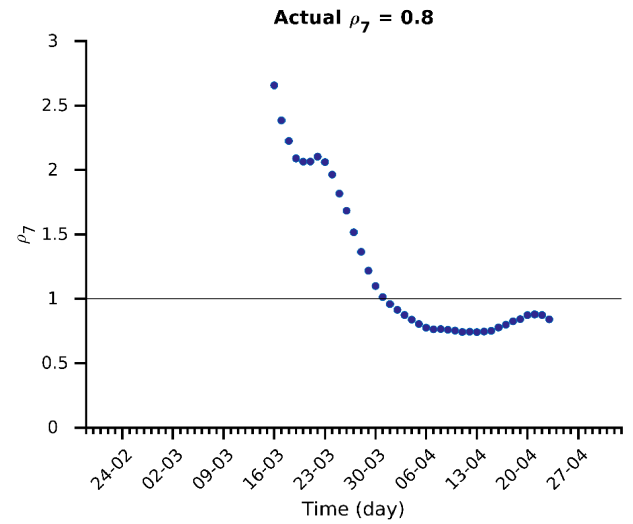
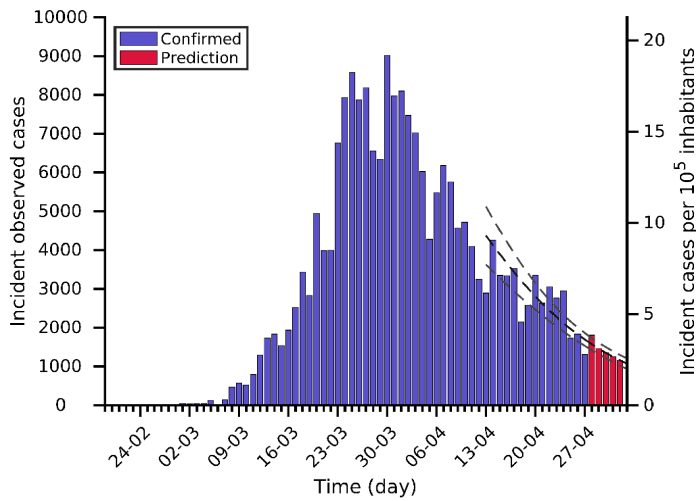
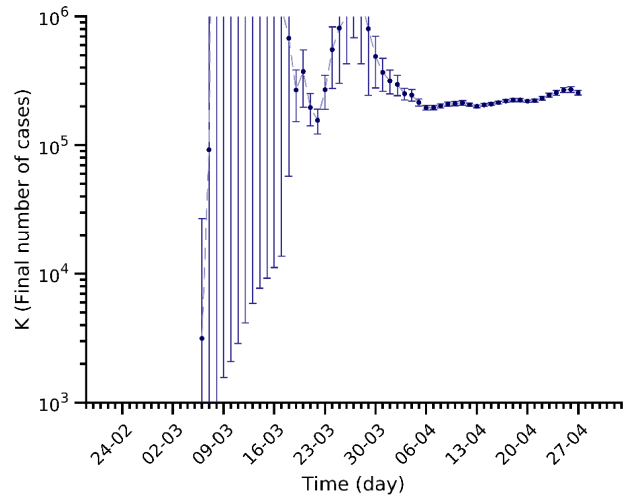
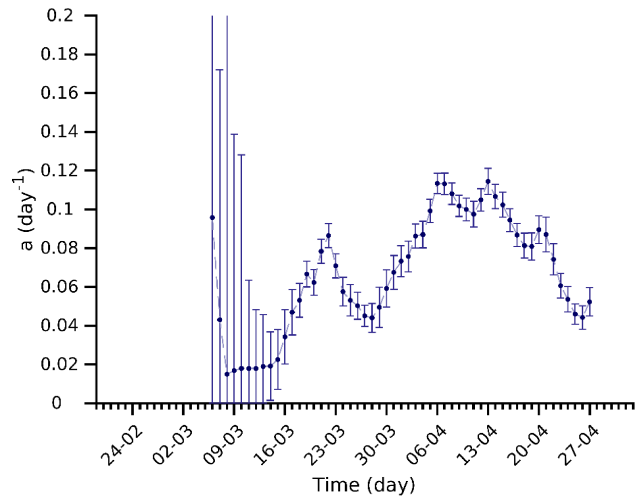
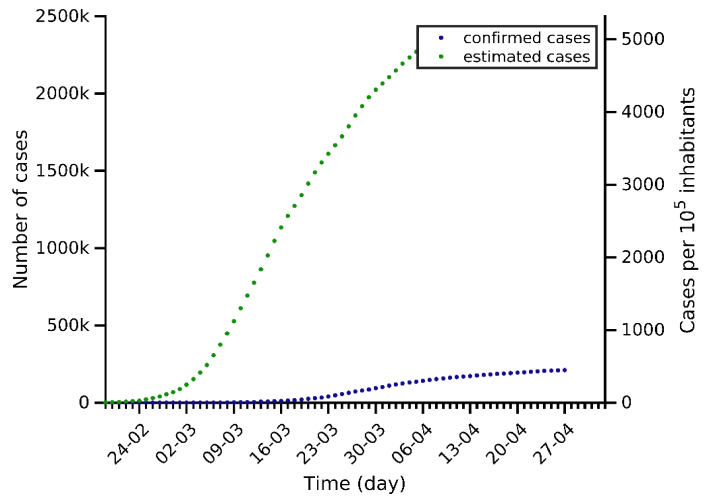
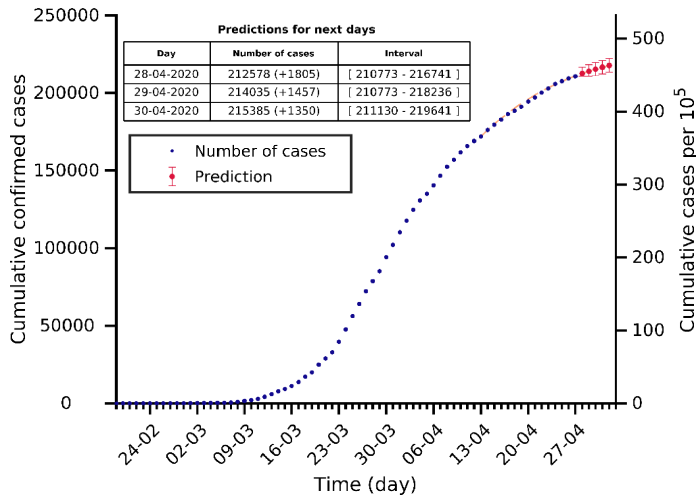
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

**EU+EFTA+UK 27-04-2020. Population: 527.9M. Current cumulated incidence: 212/10<sup>5</sup>**

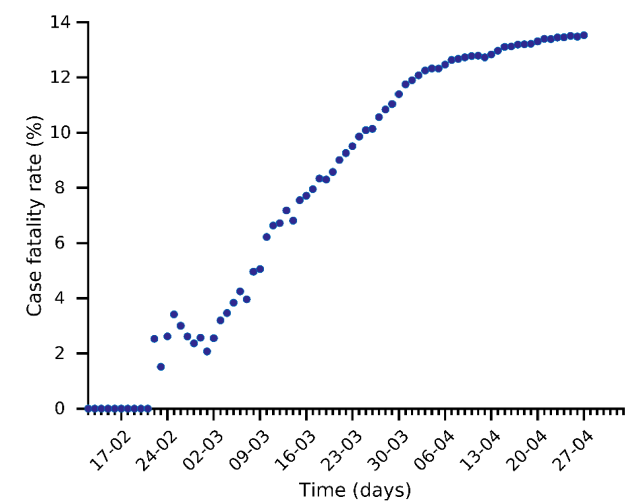
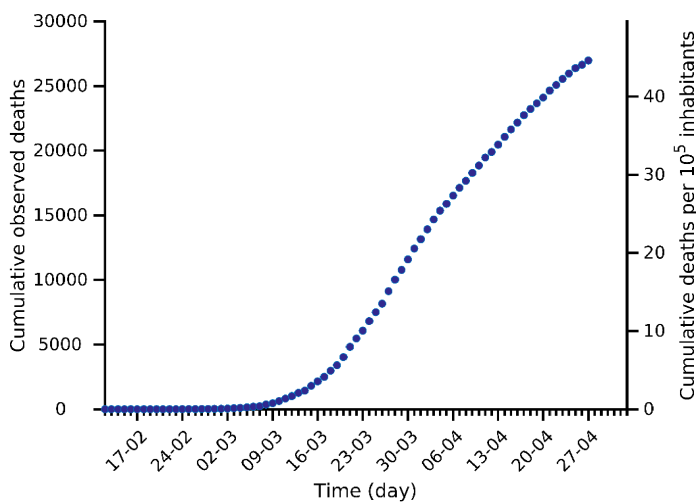
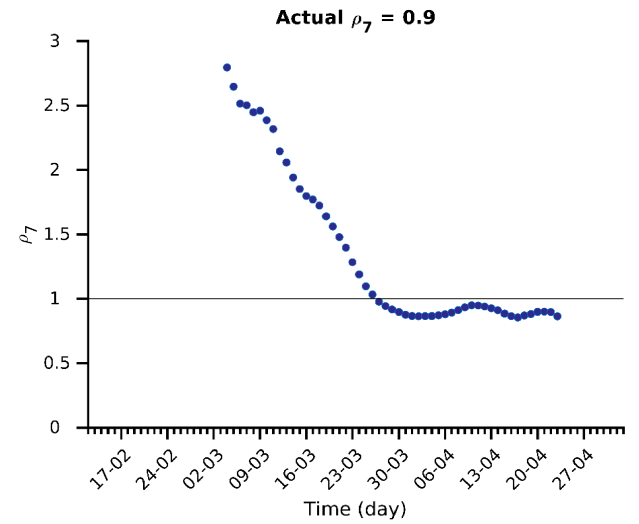
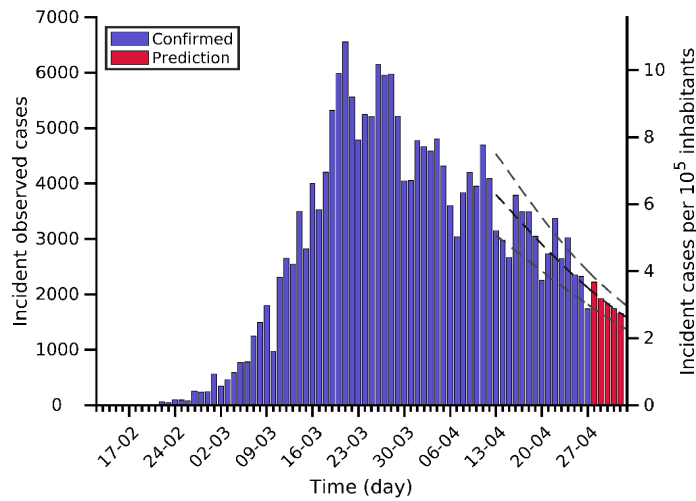
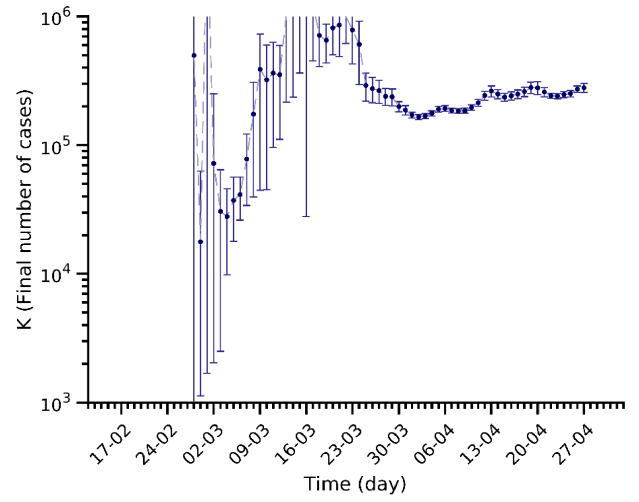
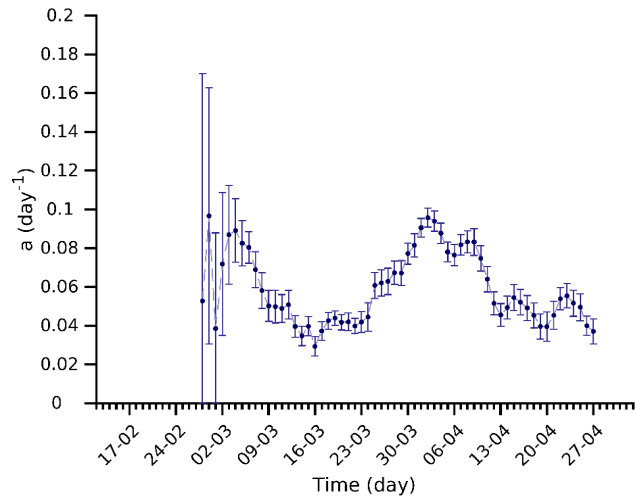
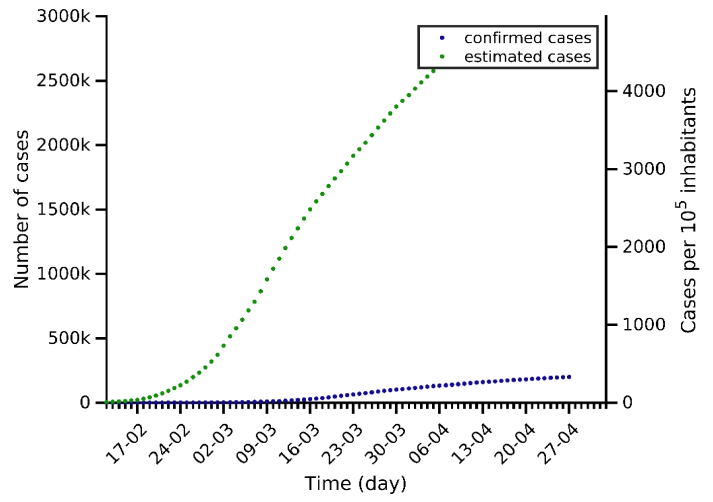
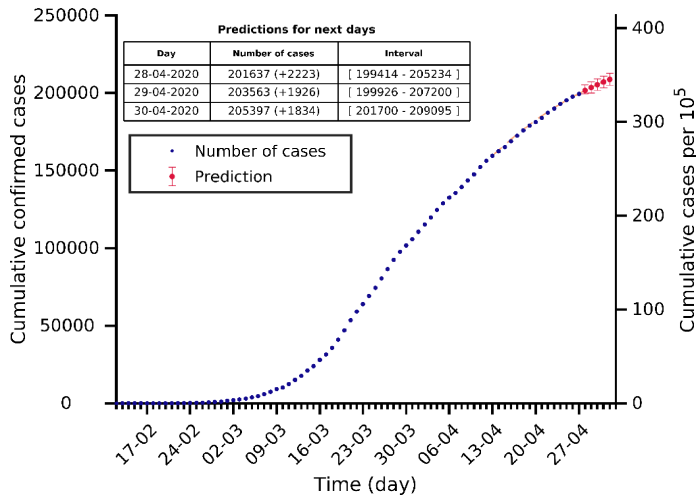




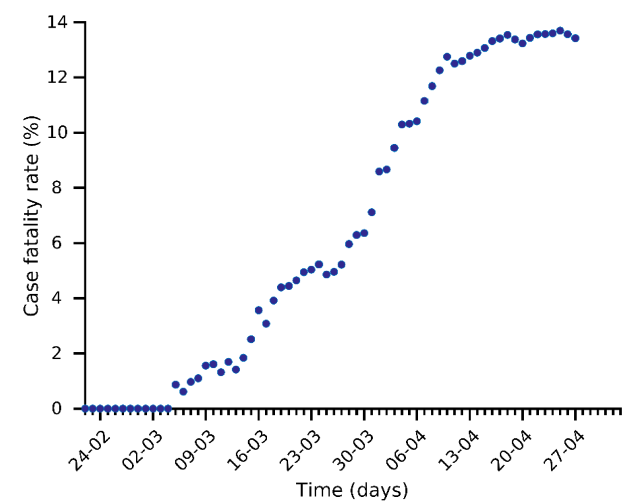
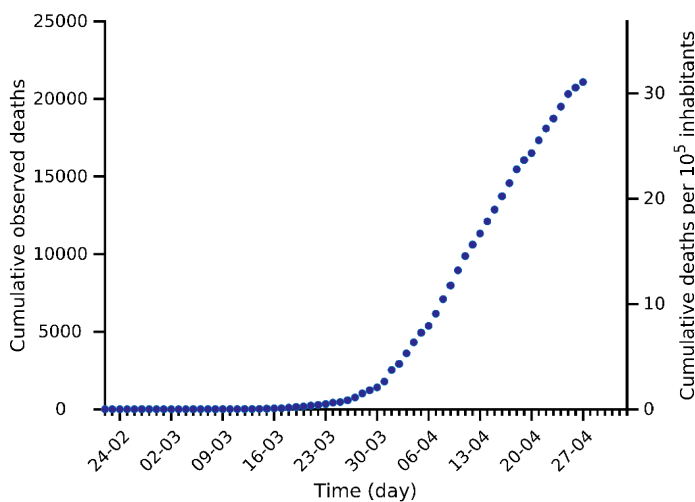
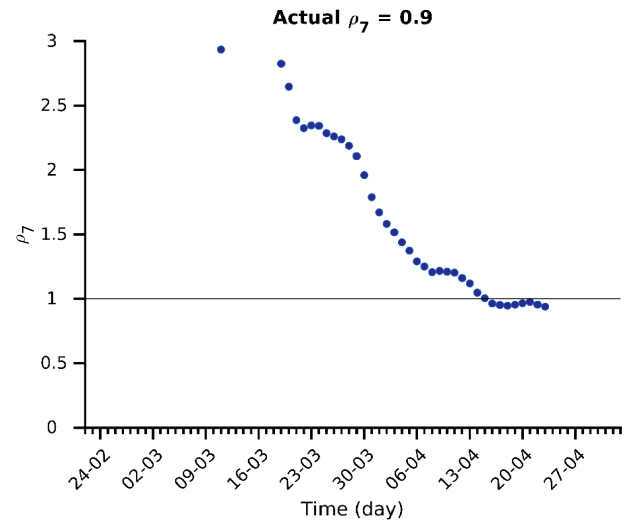
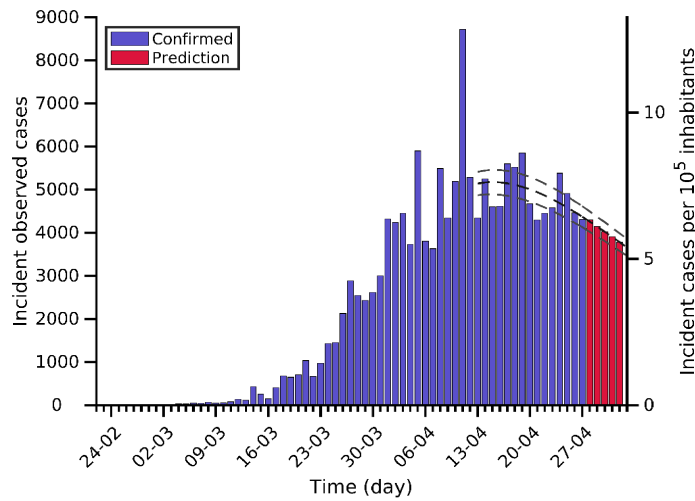
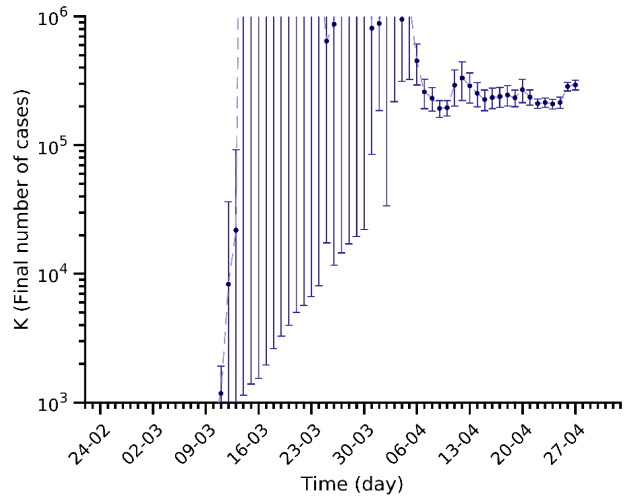
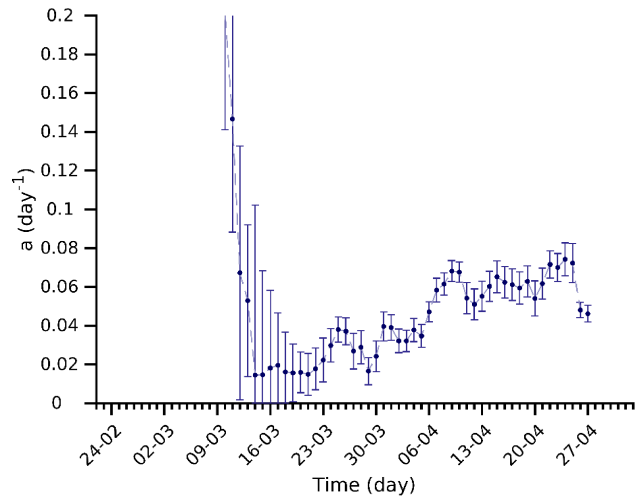
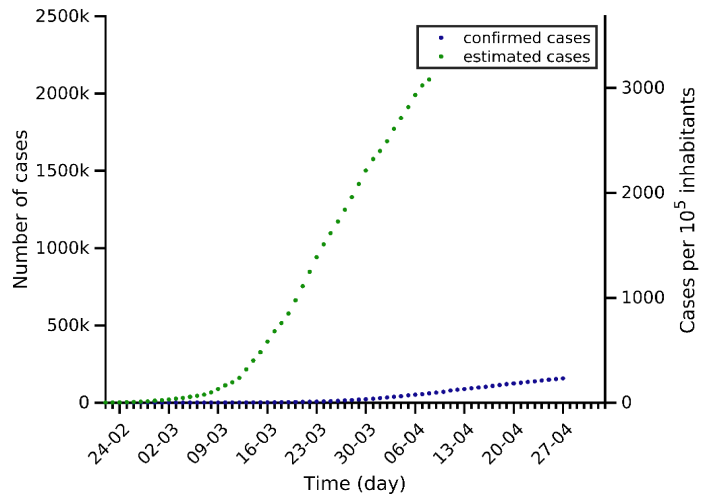
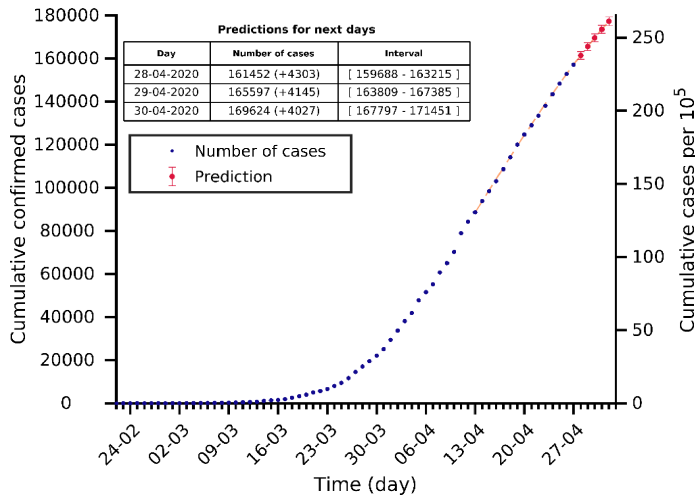
**Spain 27-04-2020. Population: 47.0M. Current cumulated incidence: 448/10<sup>5</sup>**



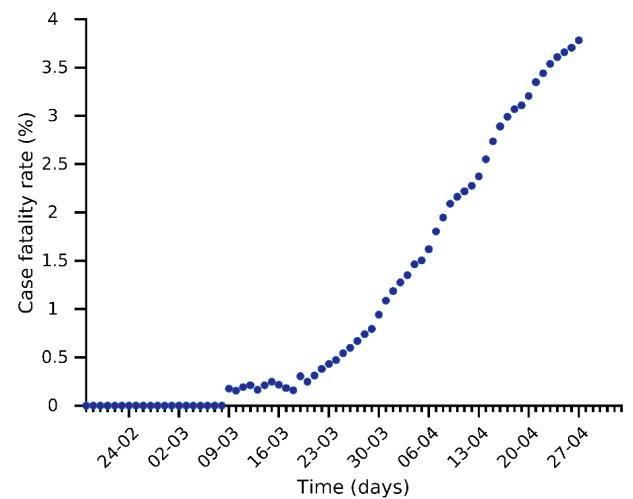
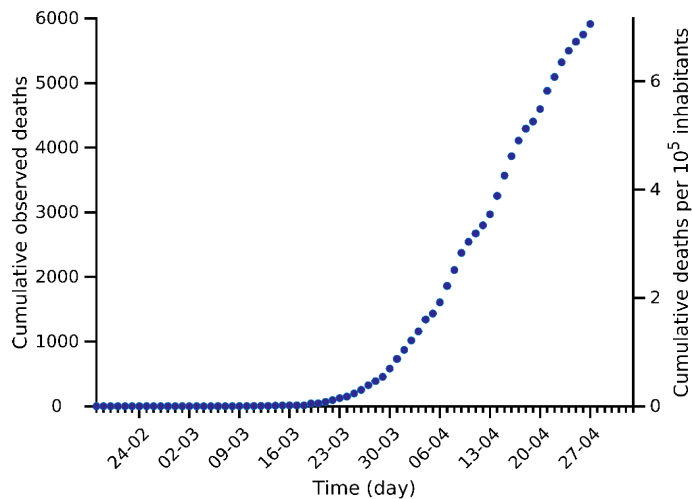
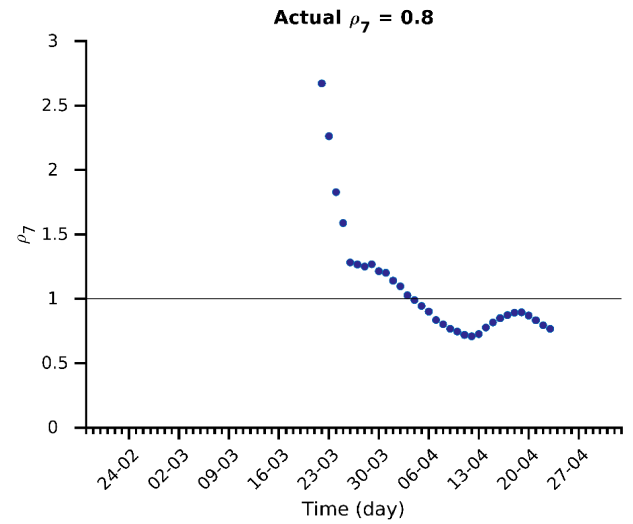
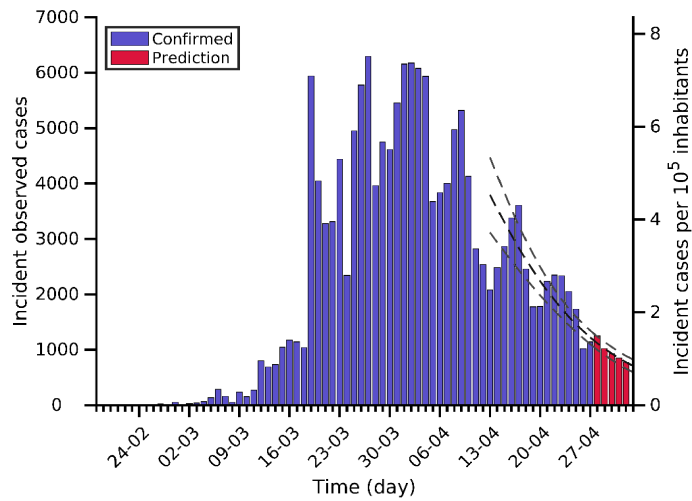
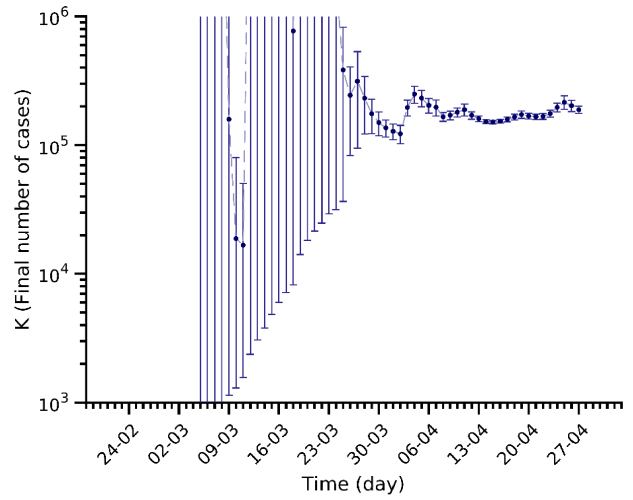
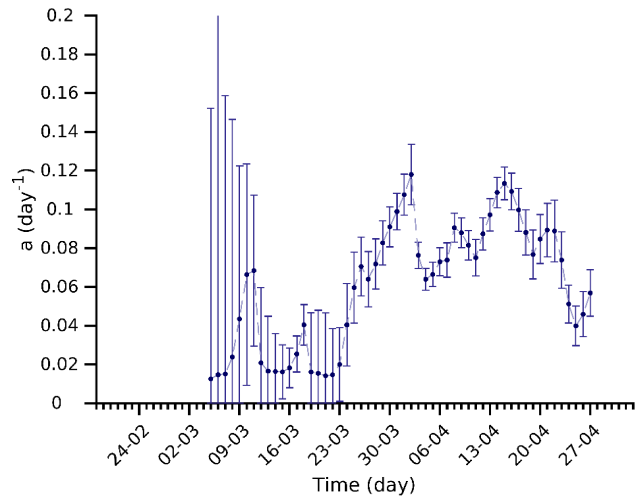
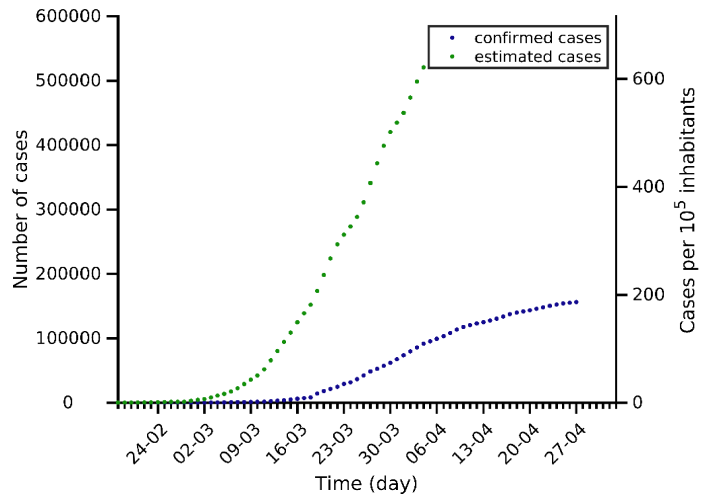
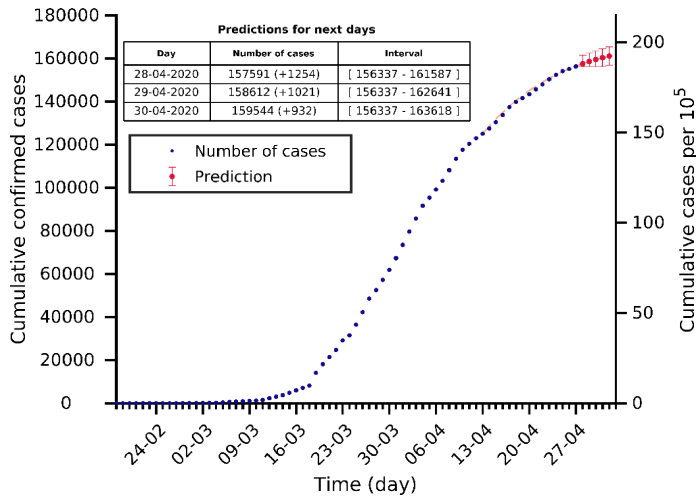
**Italy 27-04-2020. Population: 60.5M. Current cumulated incidence: 330/10<sup>5</sup>**



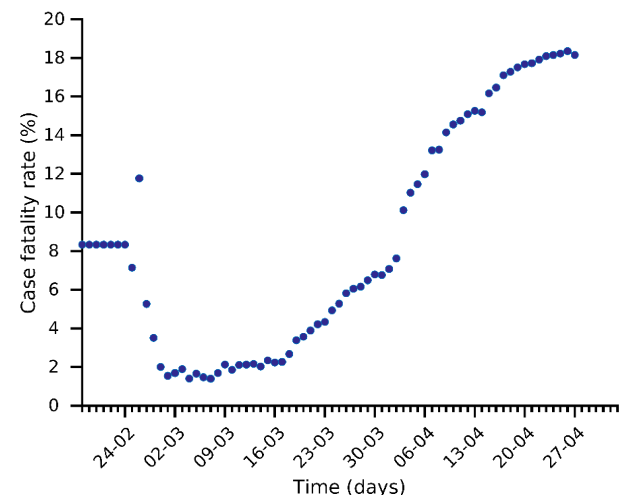
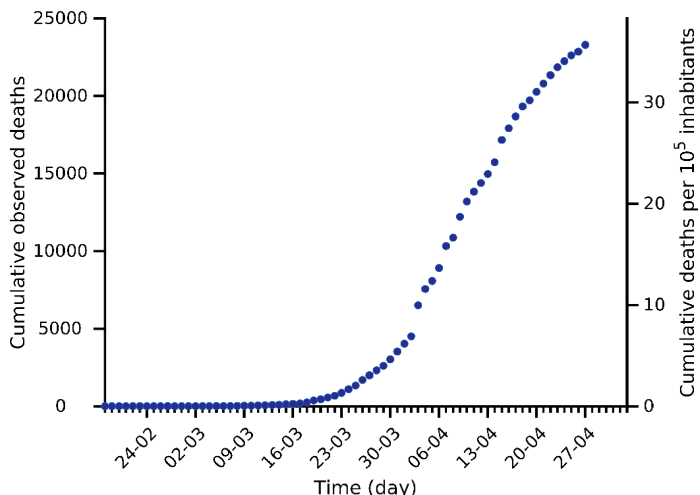
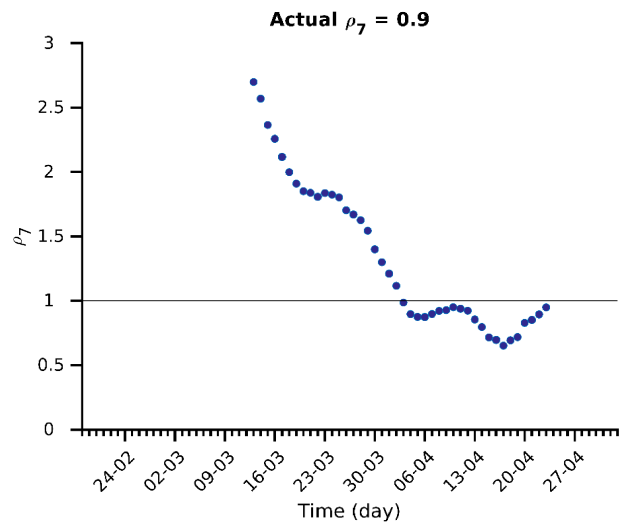
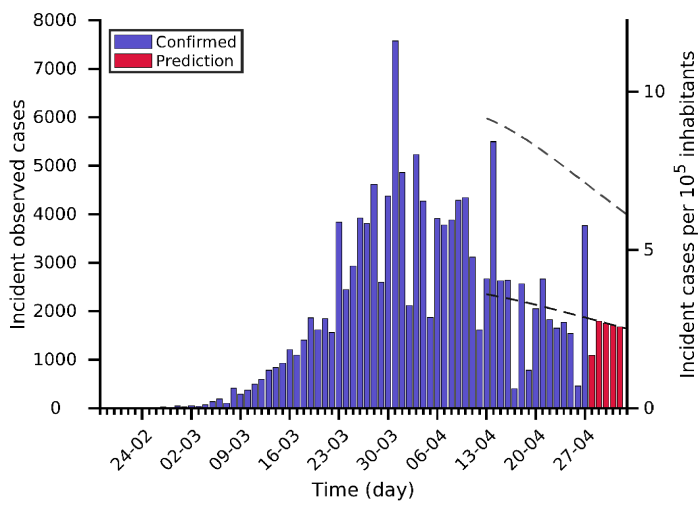
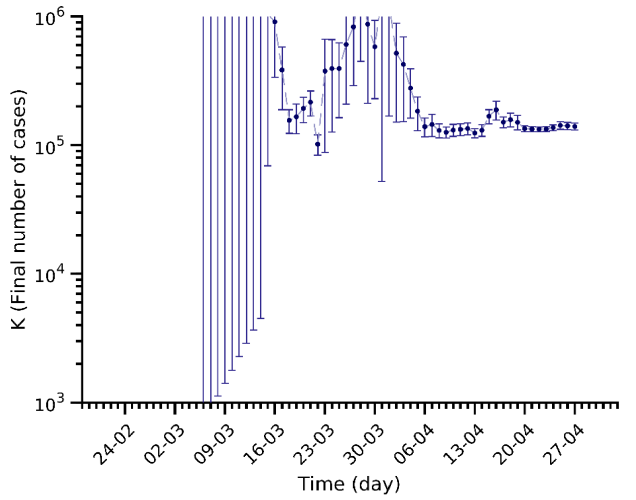
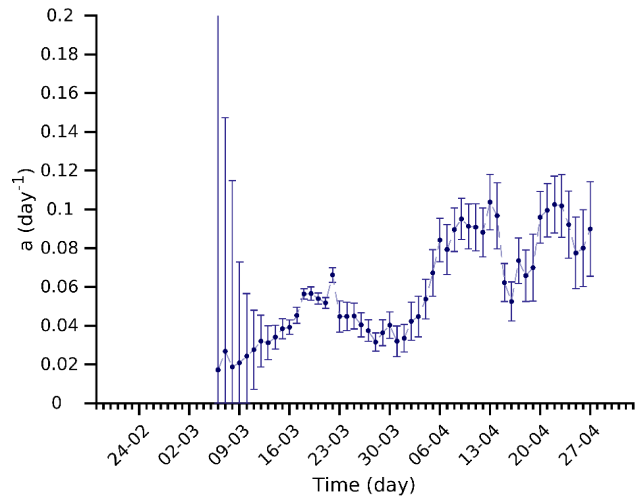
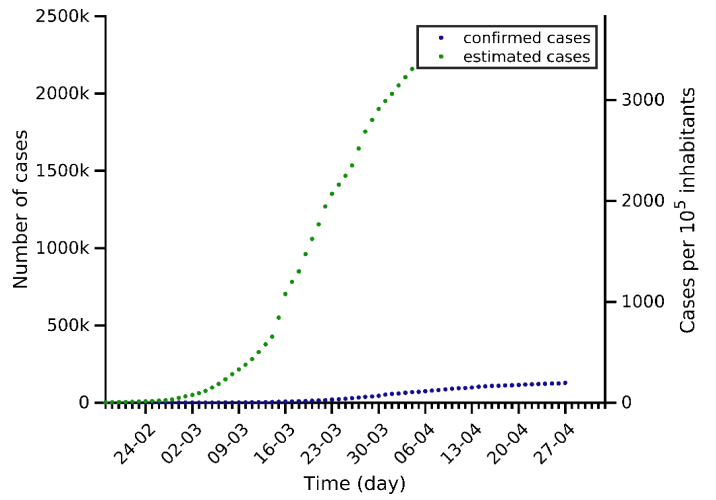
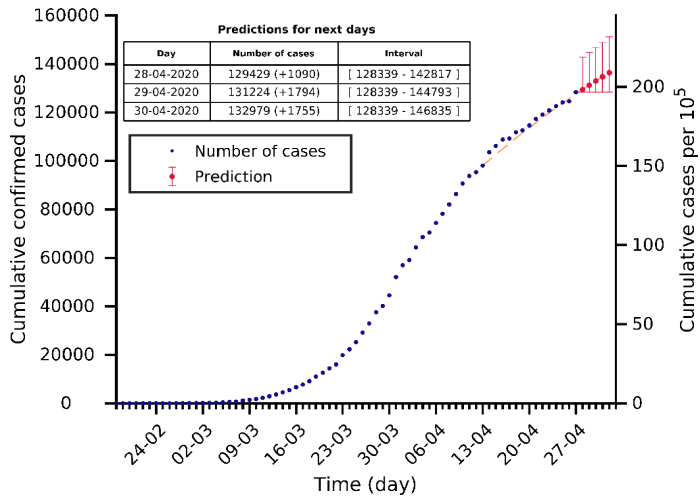
**UK 27-04-2020. Population: 67.9M. Current cumulated incidence: 231/10<sup>5</sup>**



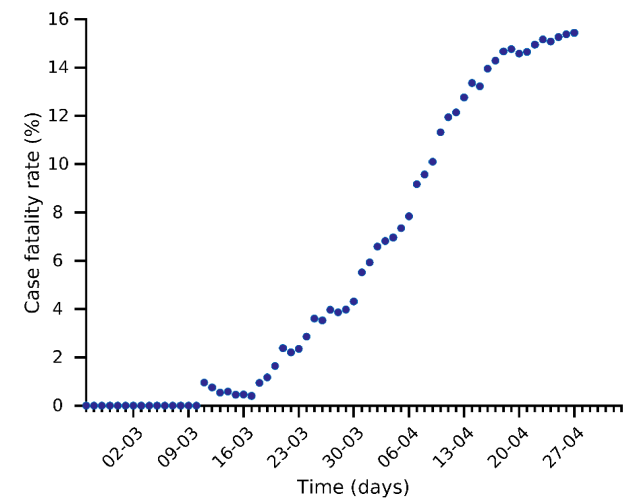
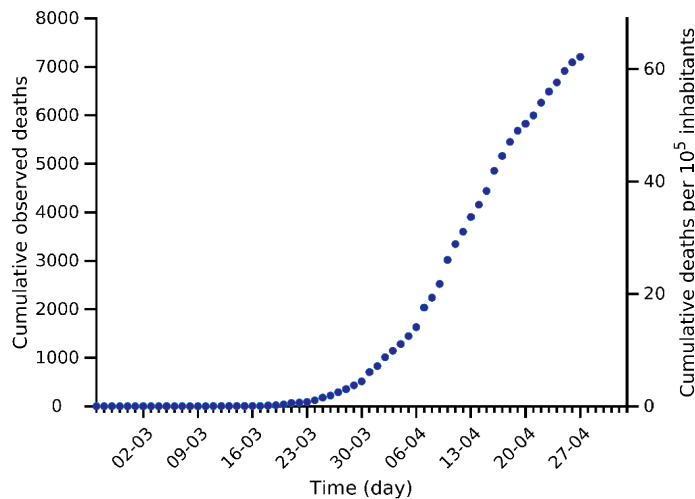
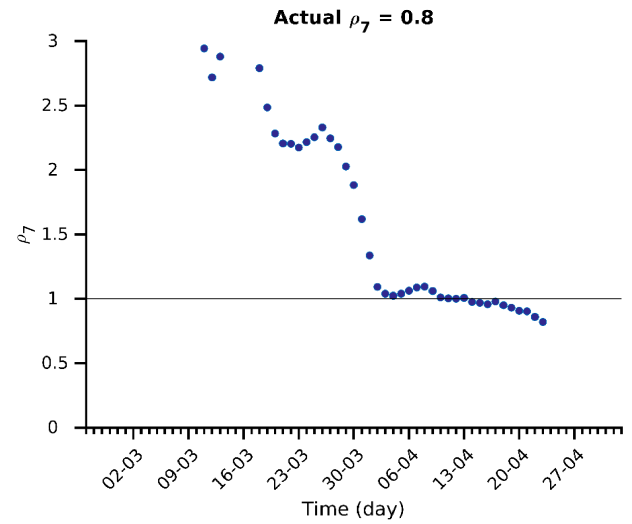
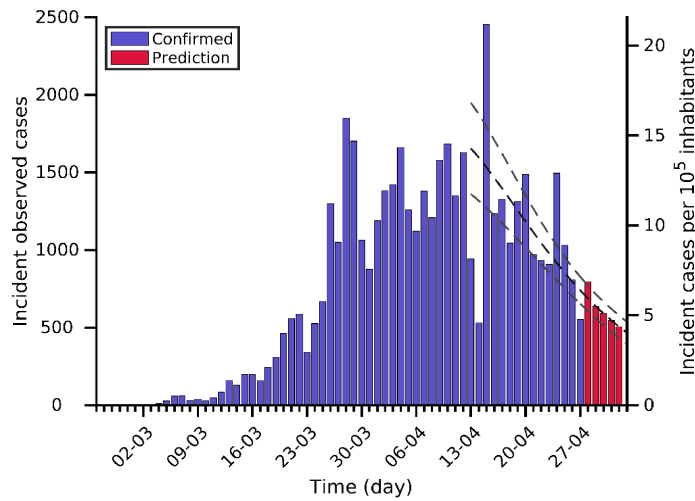
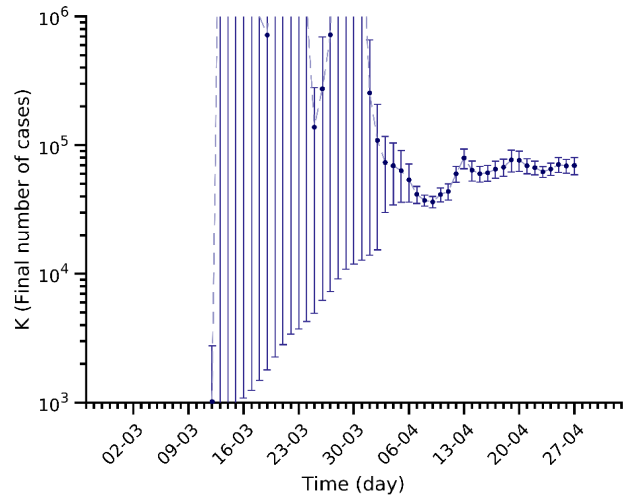
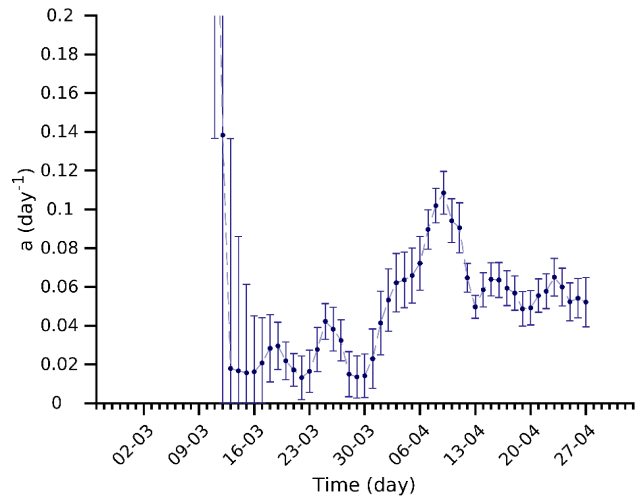
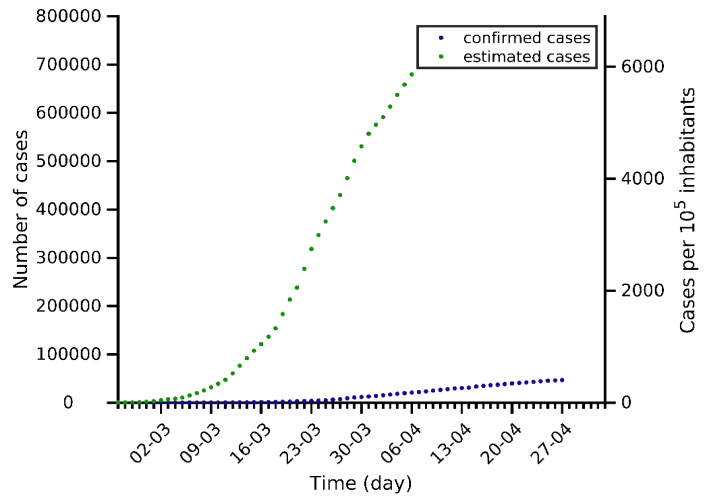
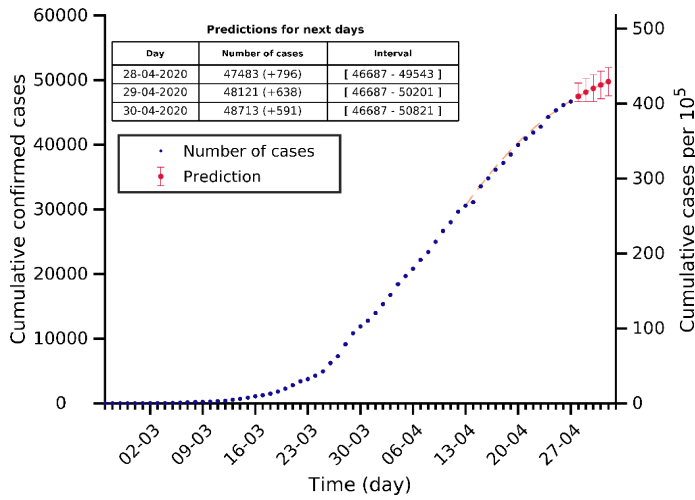
**Germany 27-04-2020. Population: 83.8M. Current cumulated incidence: 187/10<sup>5</sup>**



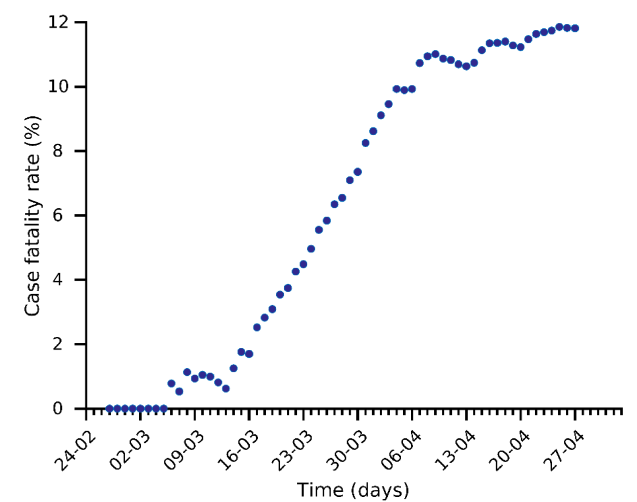
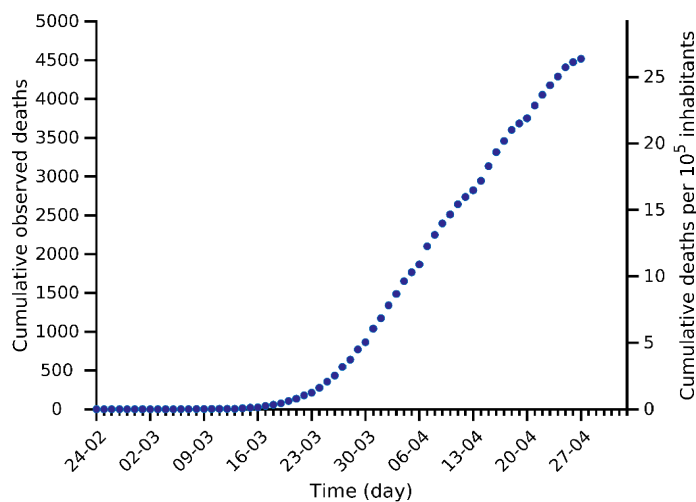
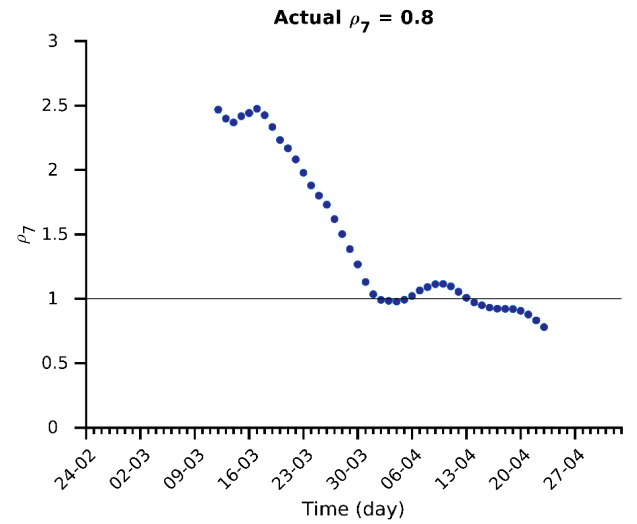
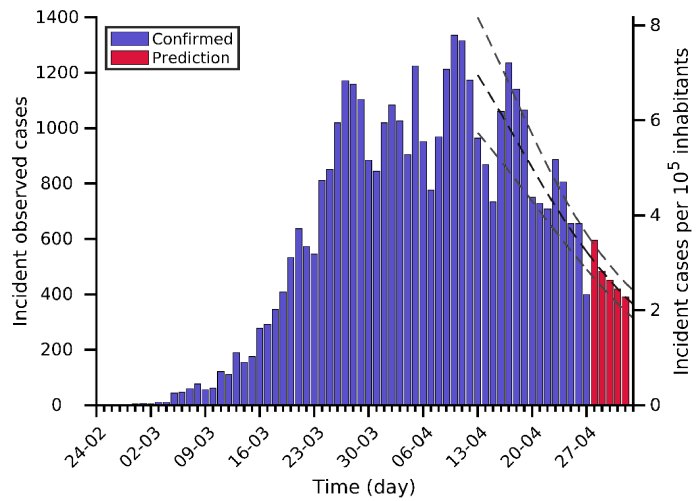
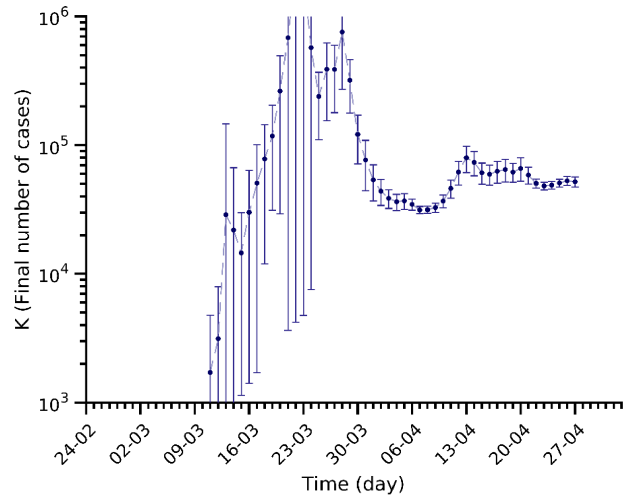
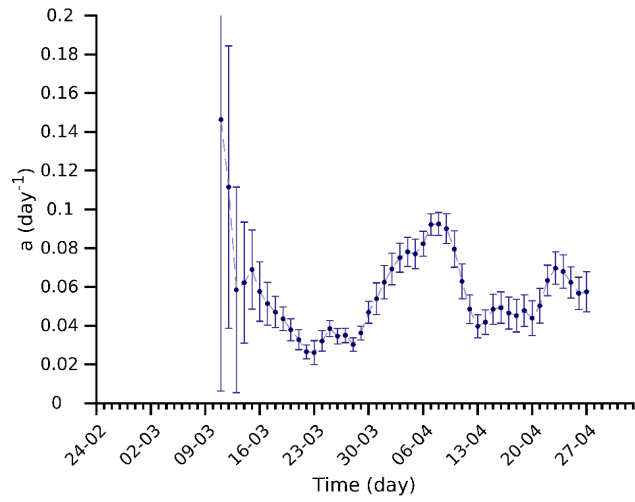
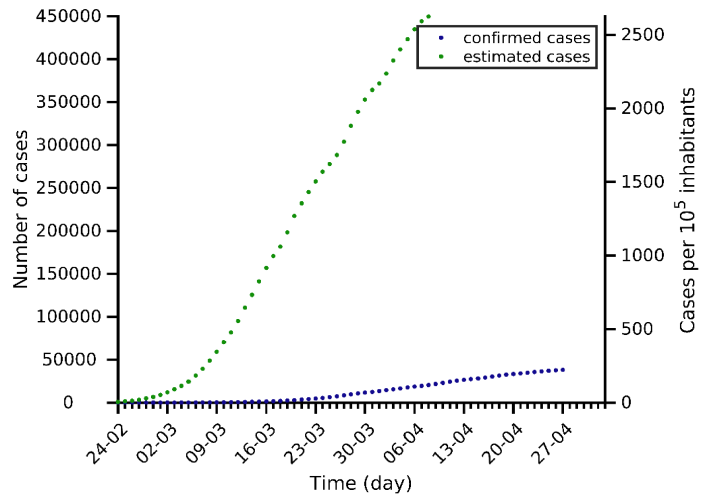
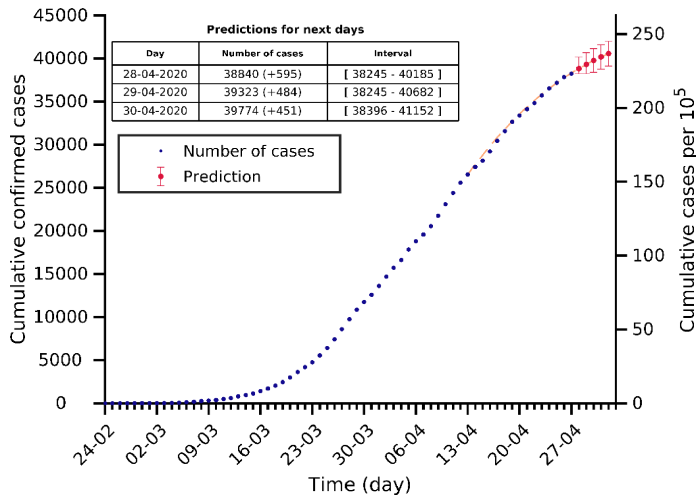
**France 27-04-2020. Population: 65.3M. Current cumulated incidence: 197/10<sup>5</sup>**



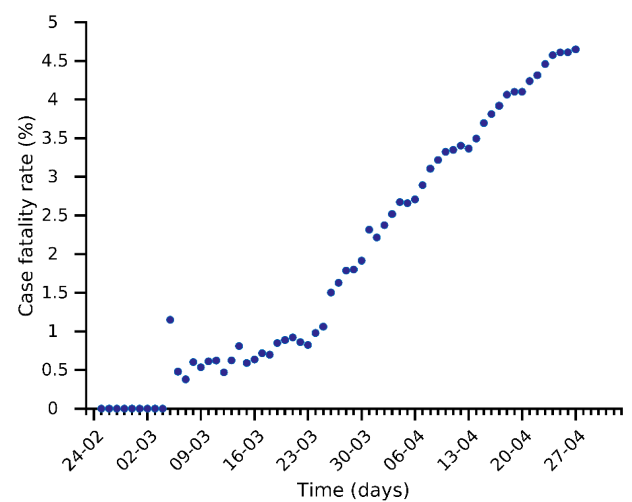
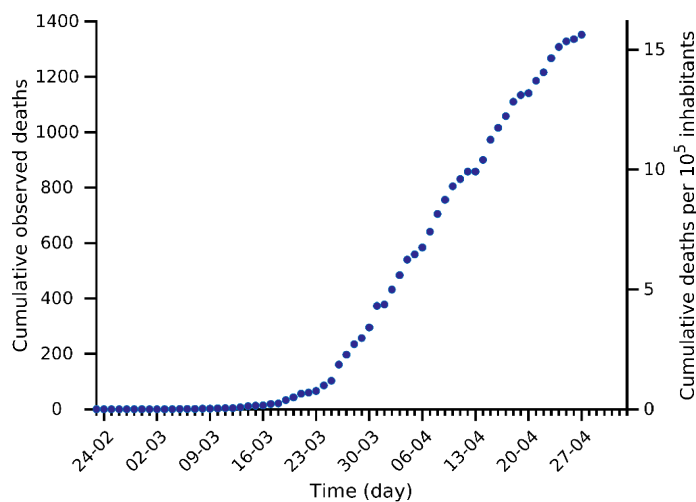
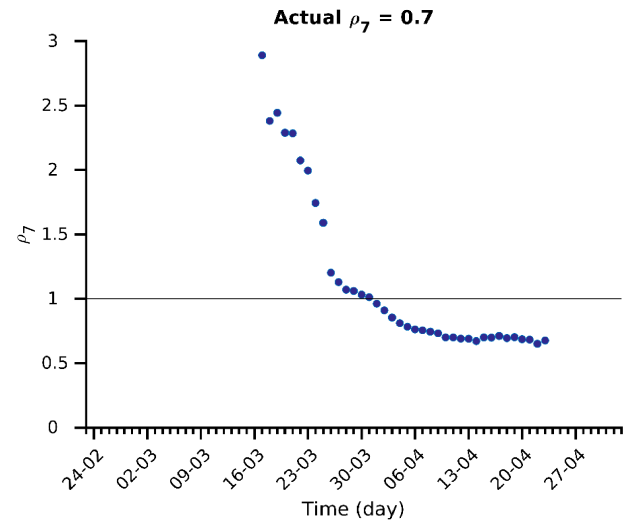
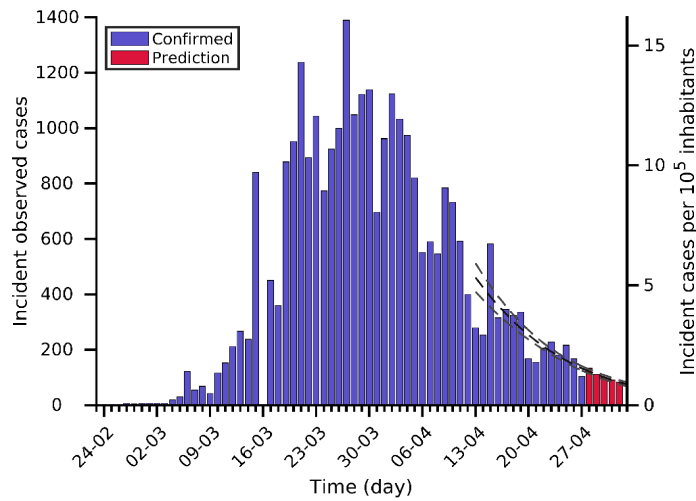
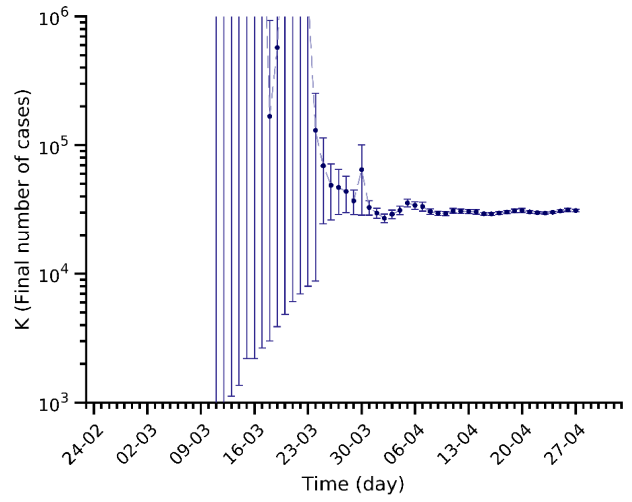
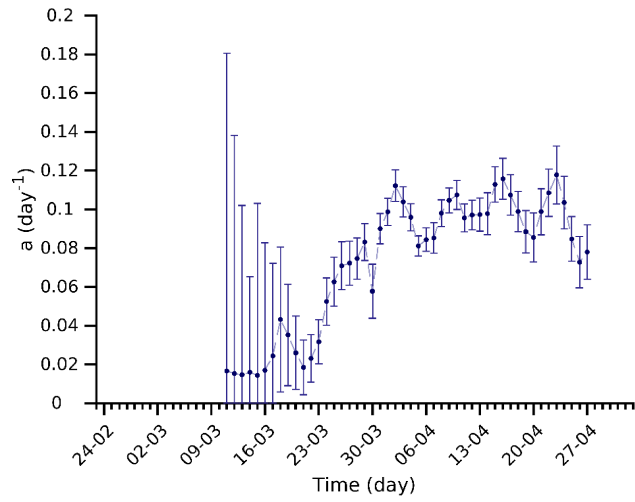
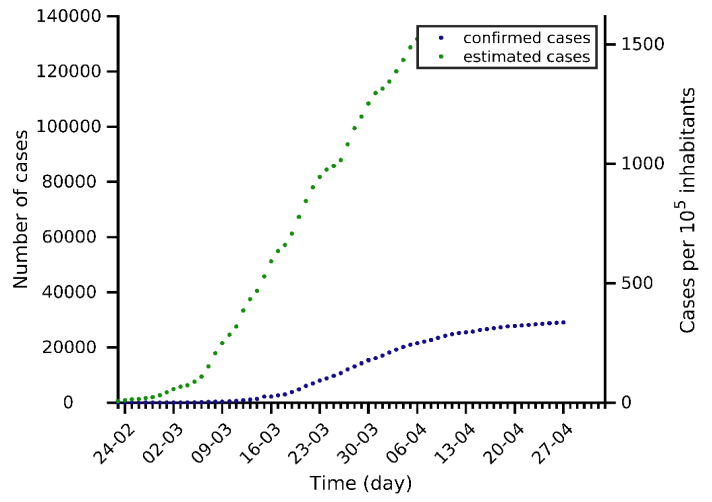
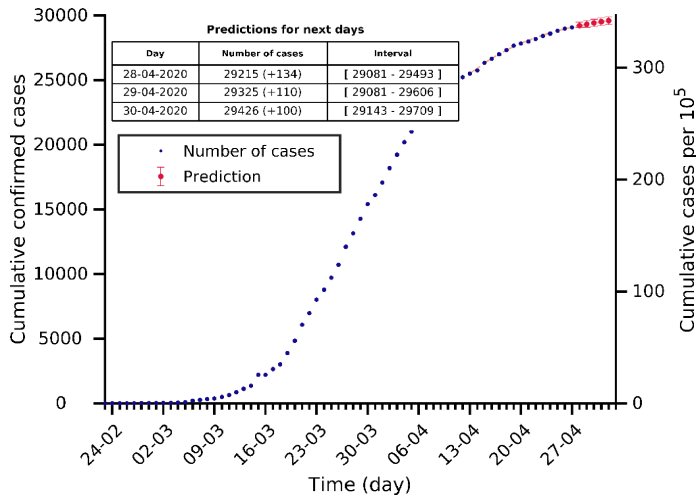
**Belgium 27-04-2020. Population: 11.6M. Current cumulated incidence: 403/10<sup>5</sup>**



**Netherlands 27-04-2020. Population: 17.1M. Current cumulated incidence: 223/10<sup>5</sup>**

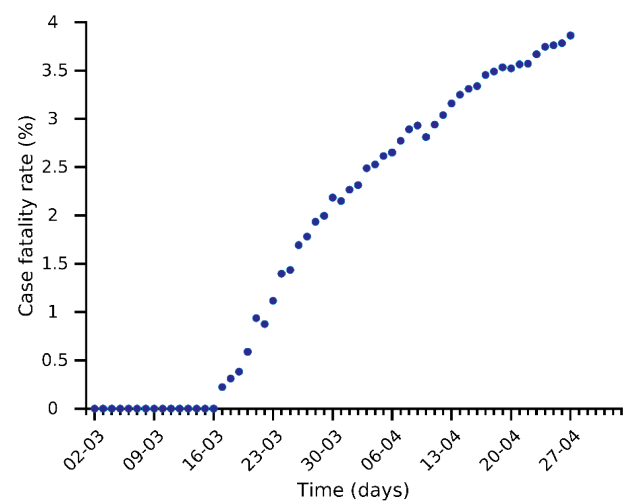
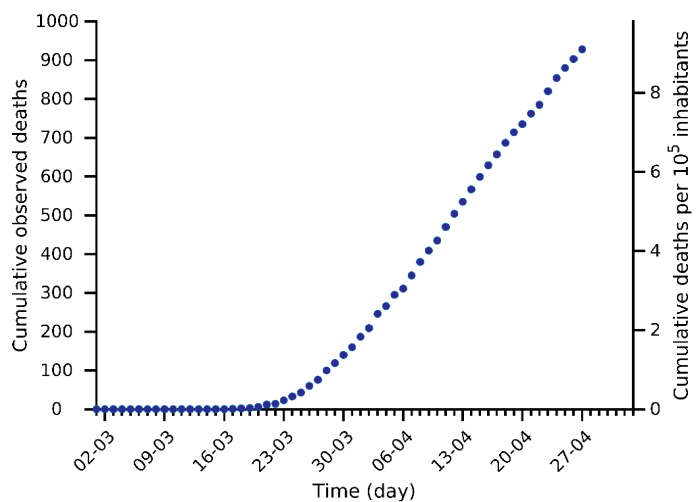
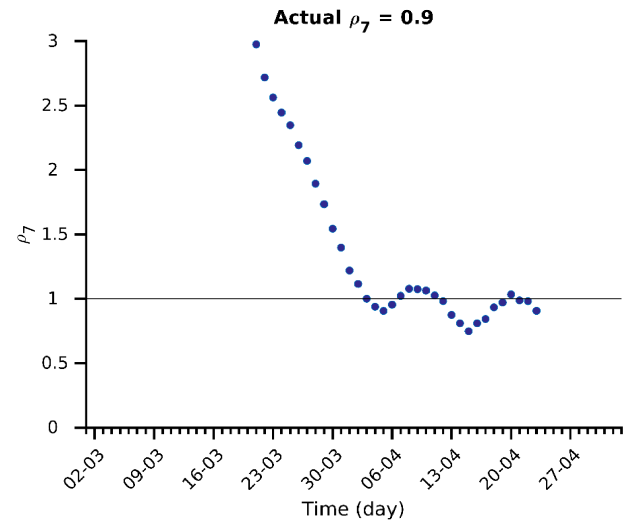
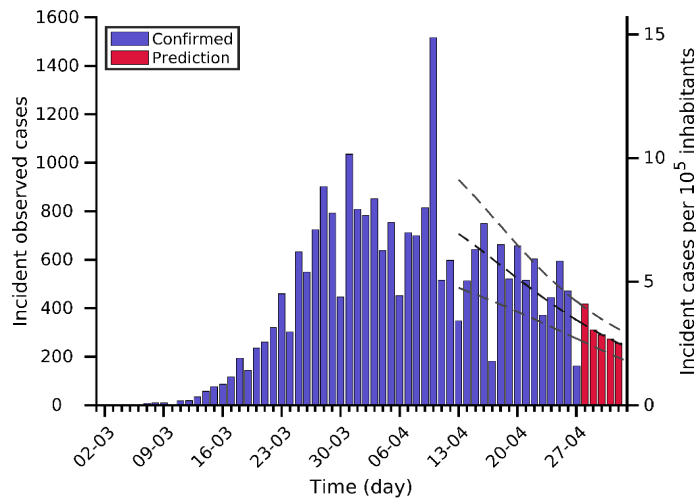
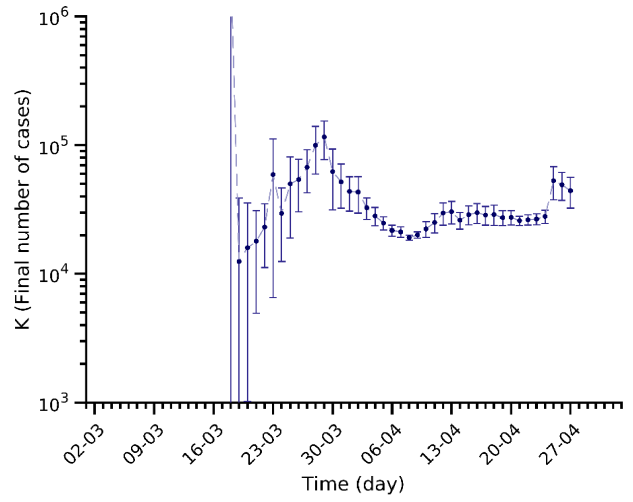
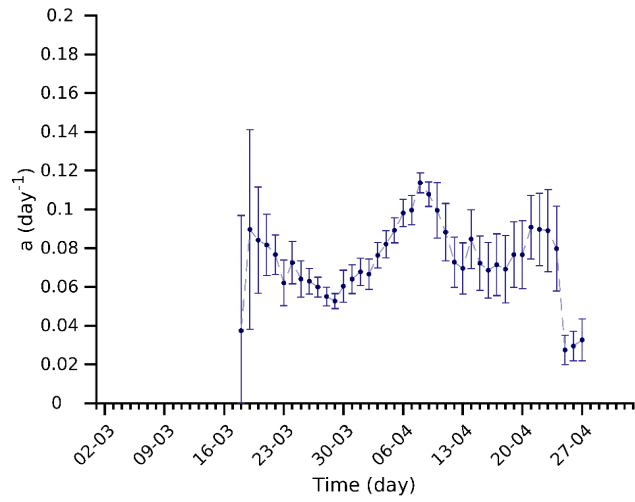
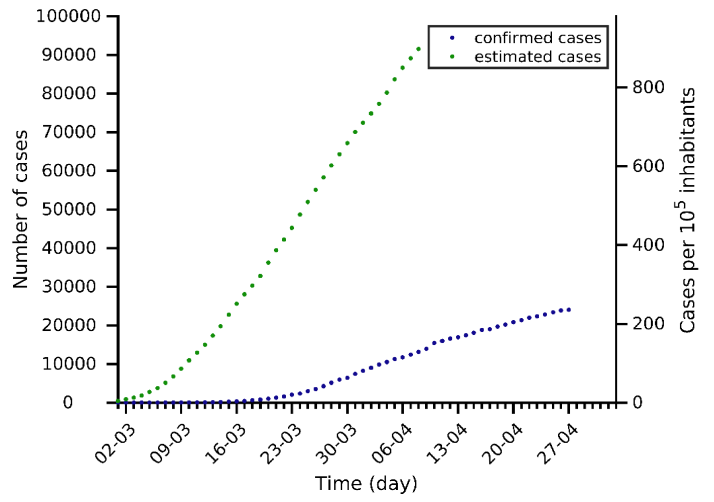
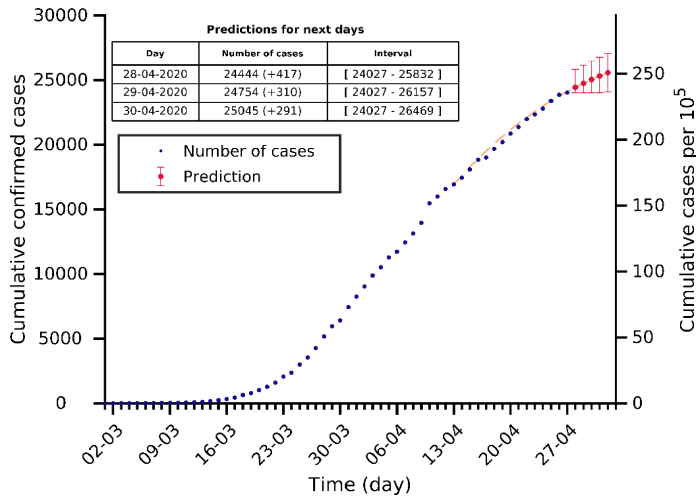


**Switzerland 27-04-2020. Population: 8.7M. Current cumulated incidence: 336/10<sup>5</sup>**

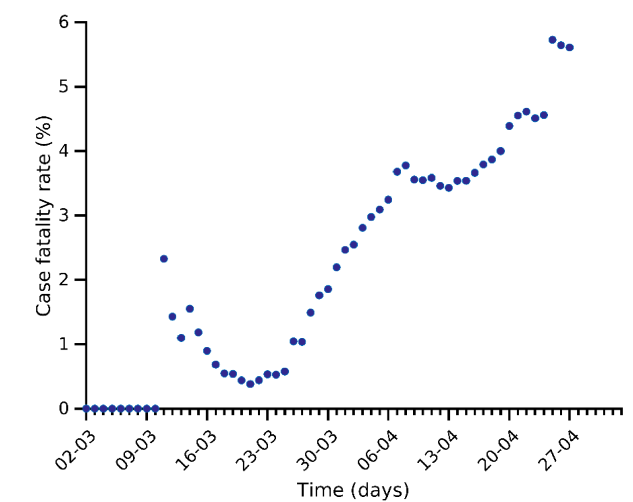
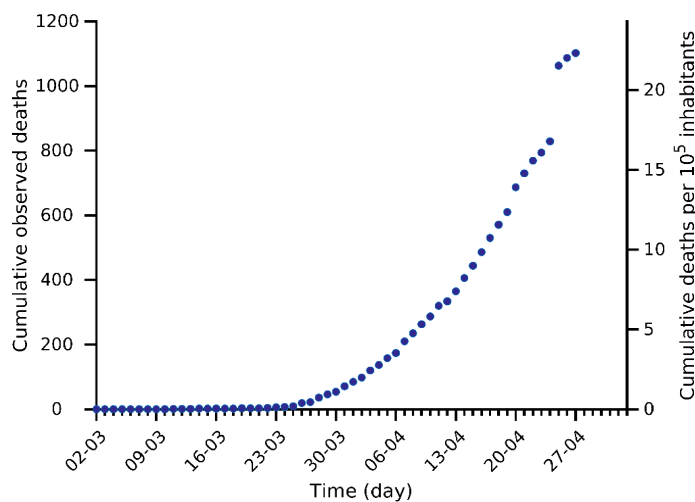
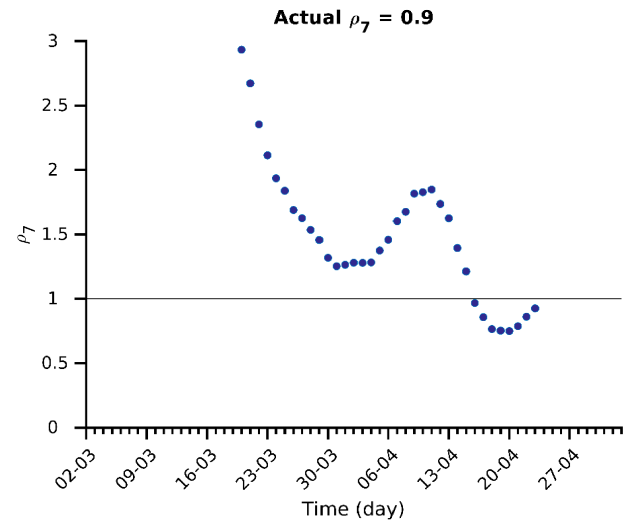
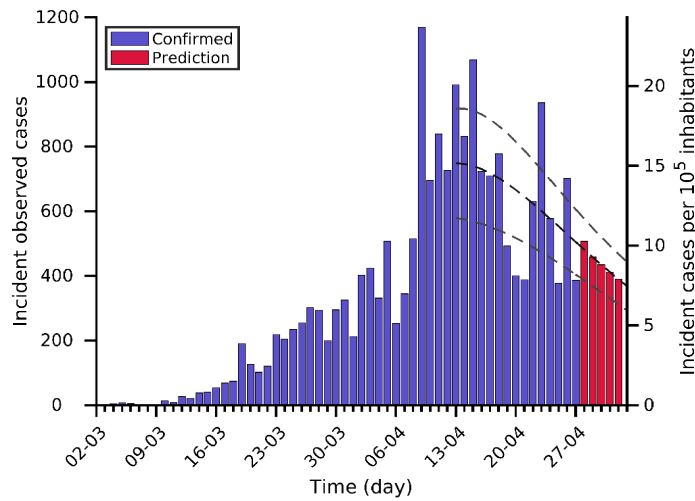
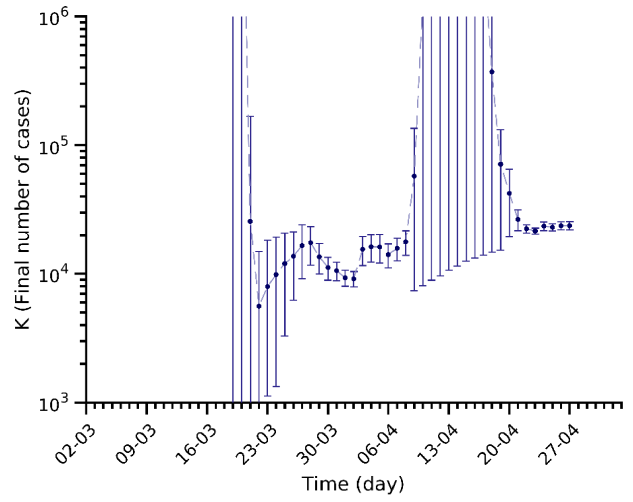
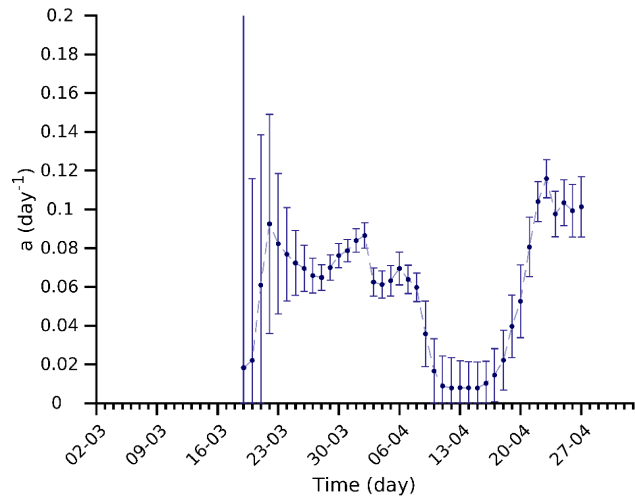
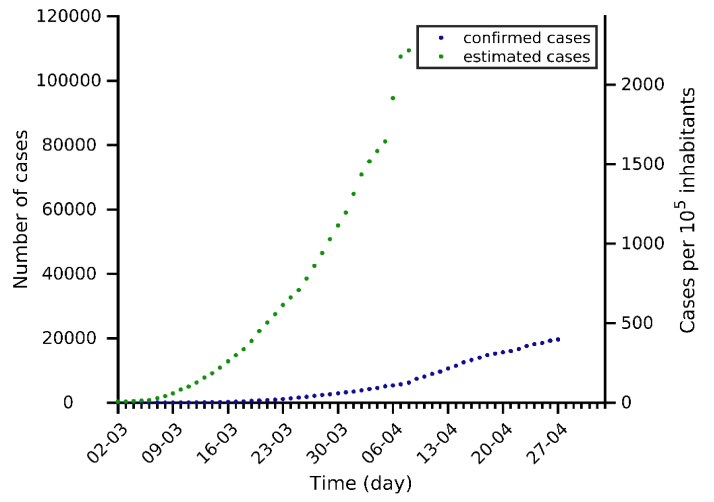
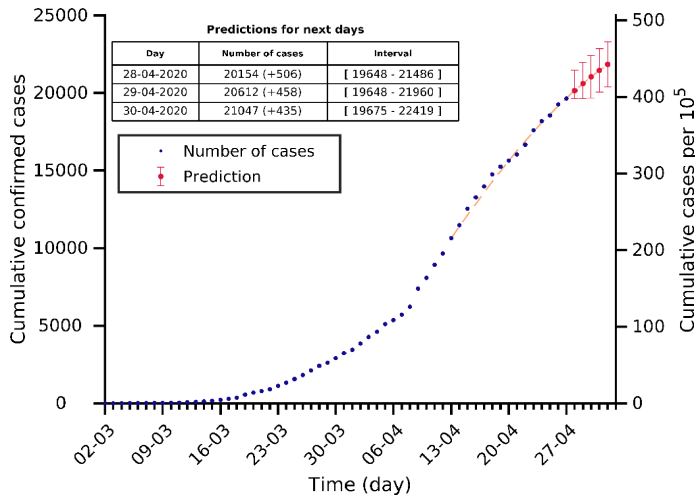




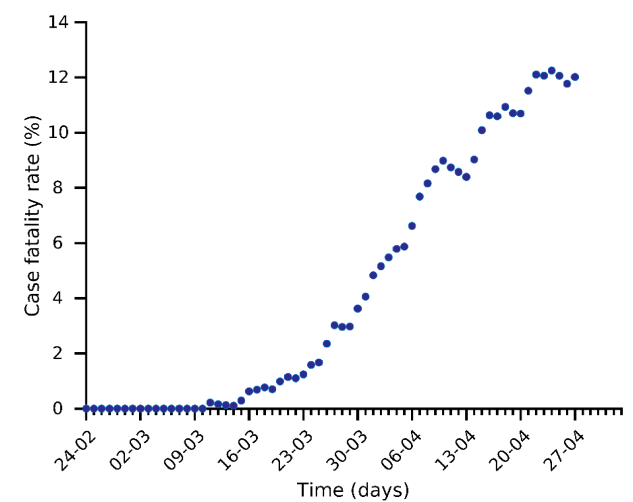
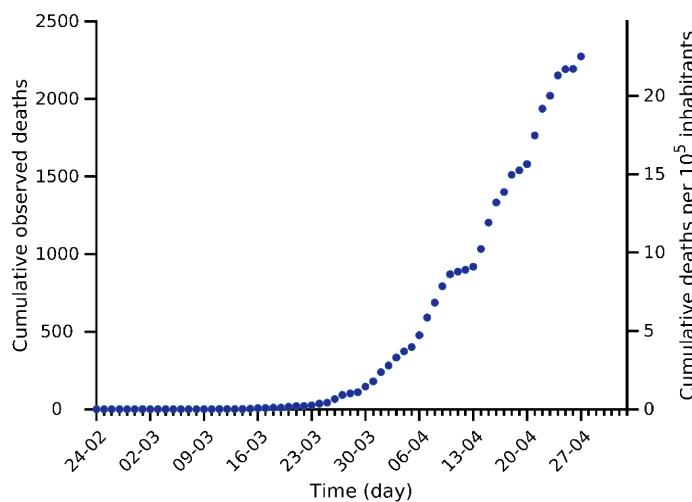
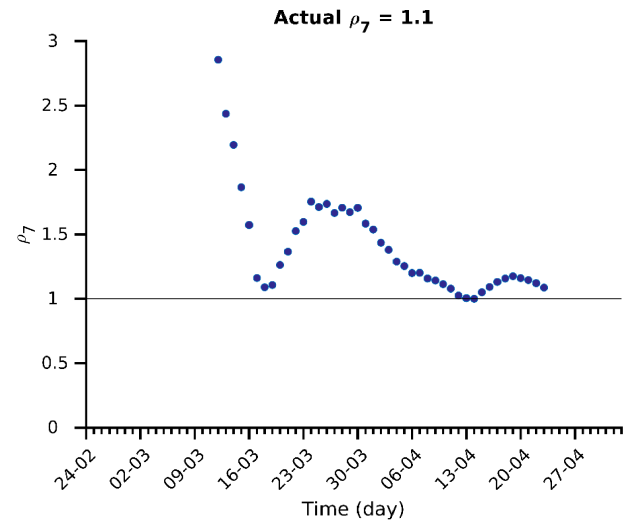
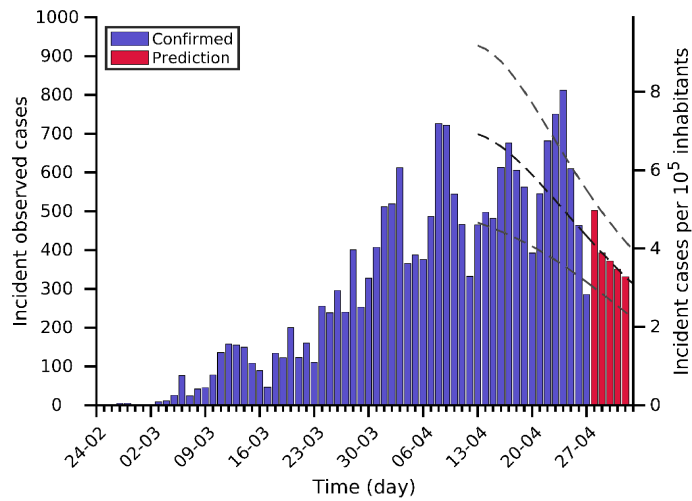
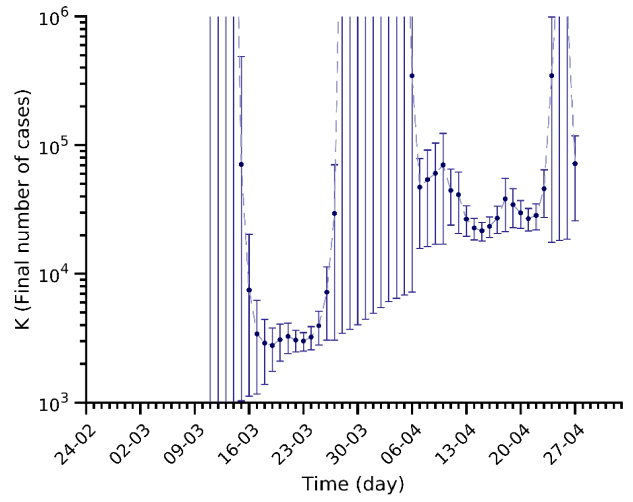
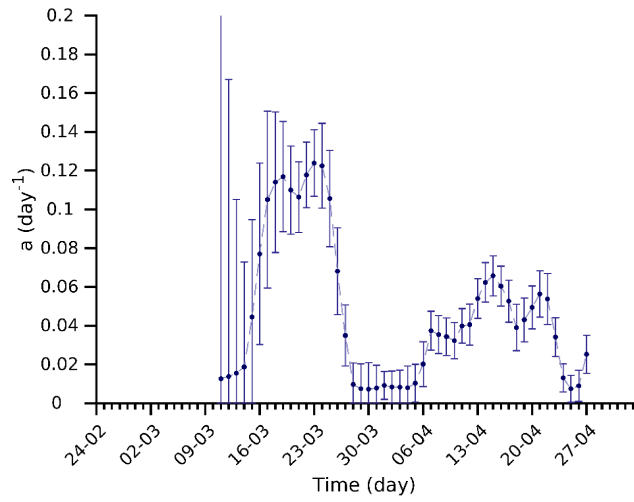
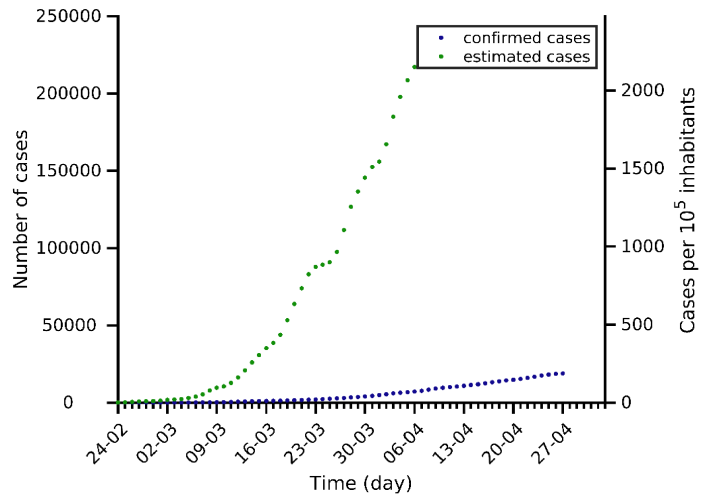
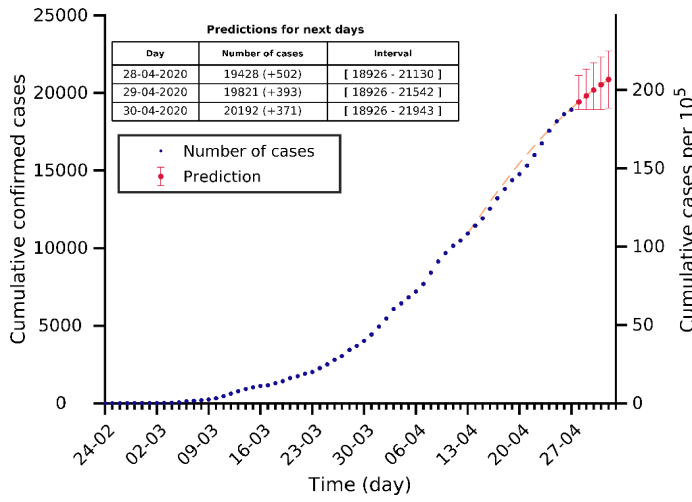
**Portugal 27-04-2020. Population: 10.2M. Current cumulated incidence: 236/10<sup>5</sup>**



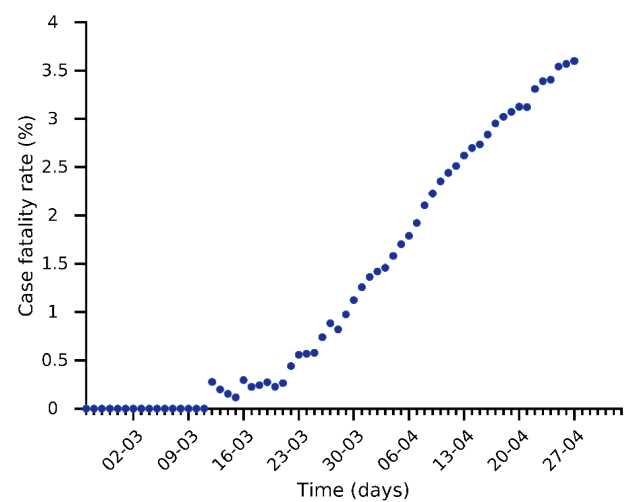
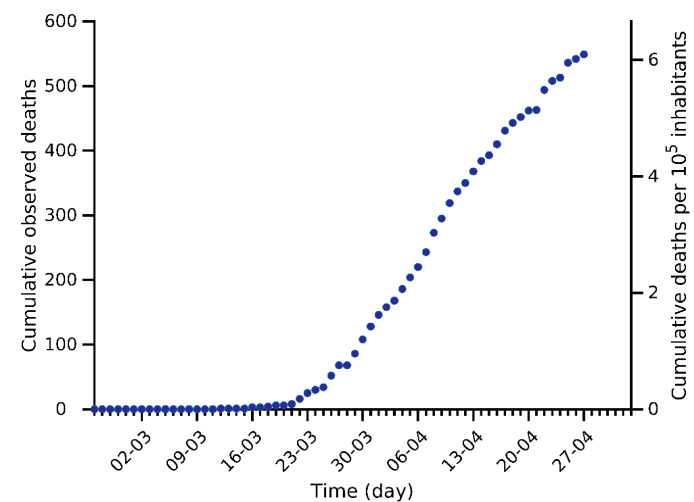
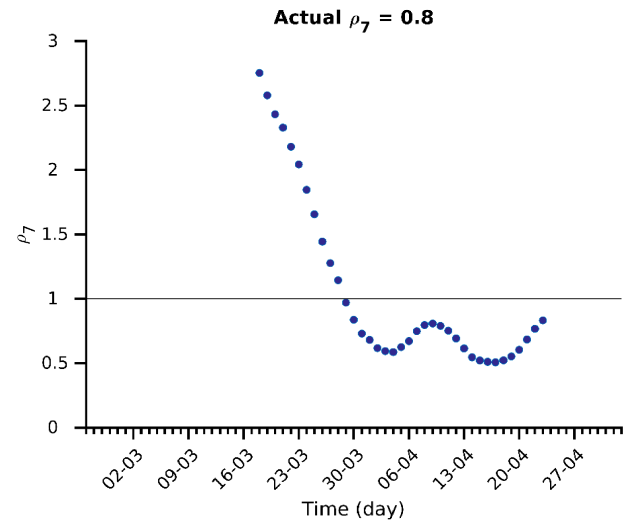
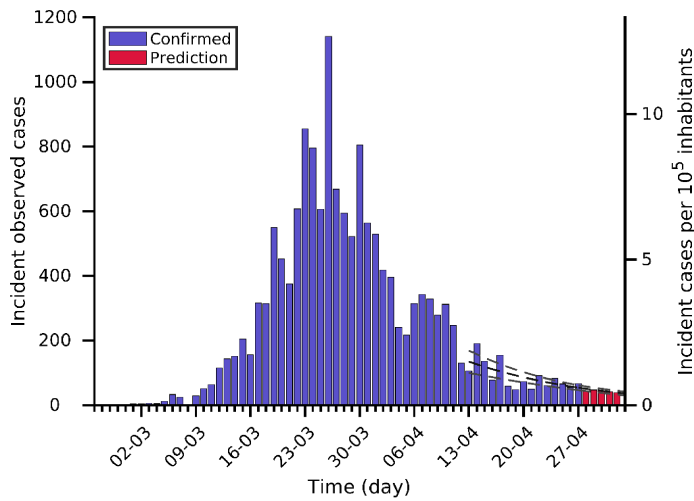
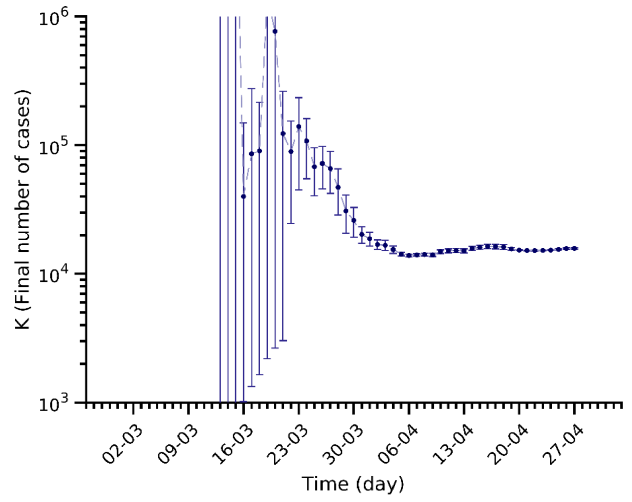
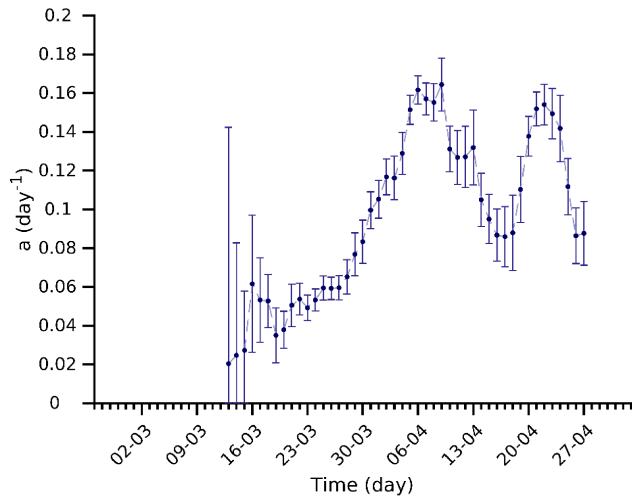
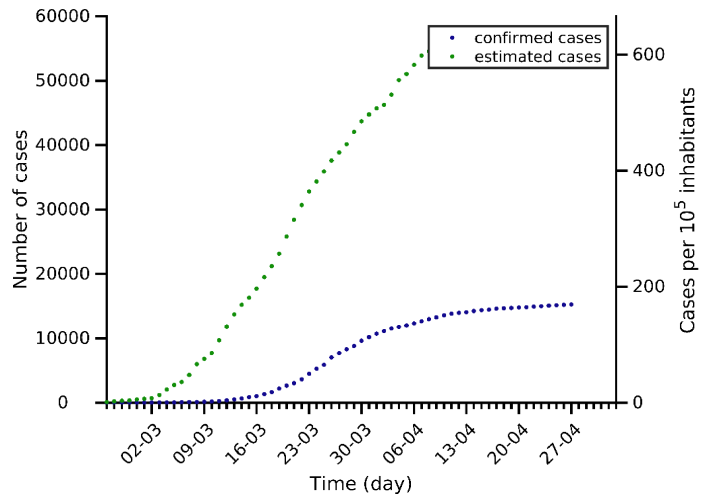
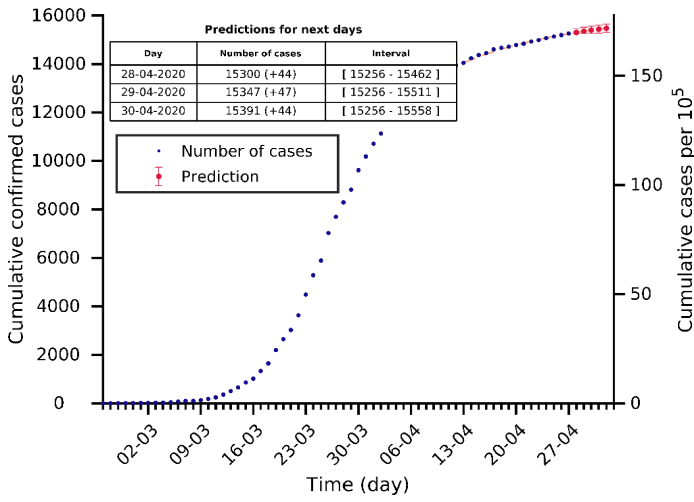
Ireland 27-04-2020. Population: 4.9M. Current cumulated incidence: 398/10<sup>5</sup>



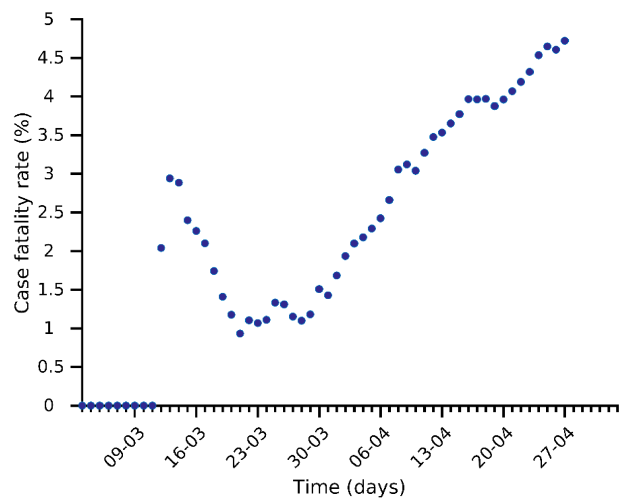
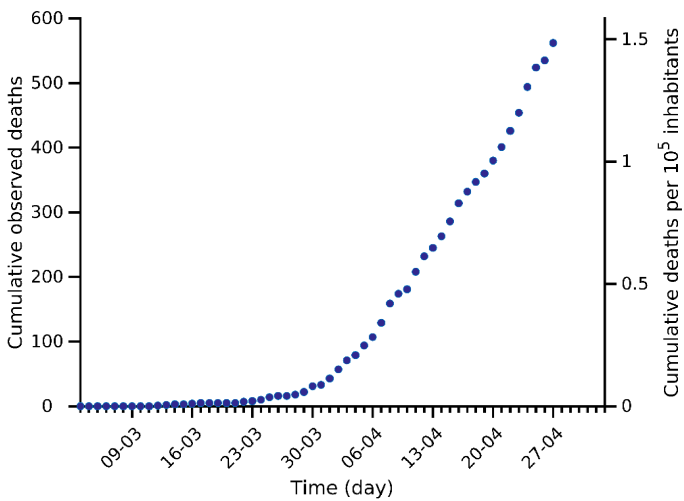
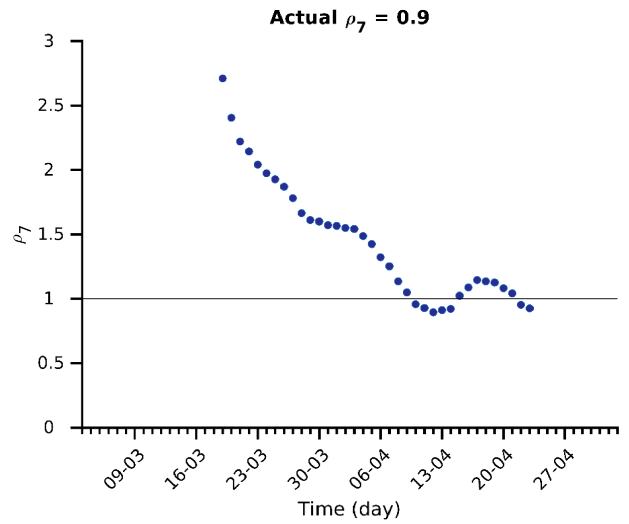
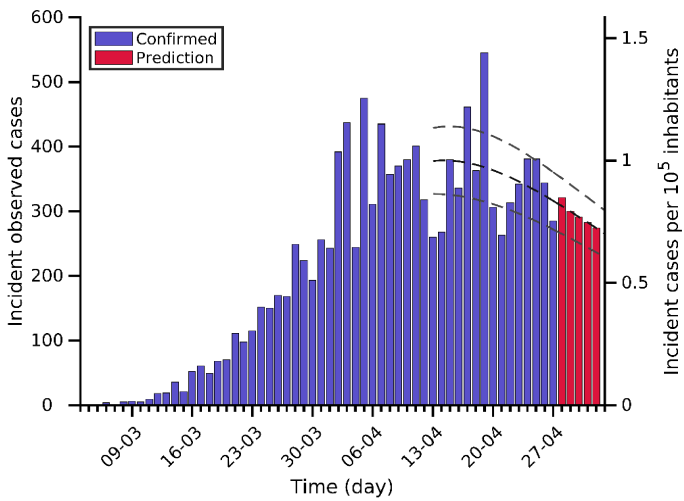
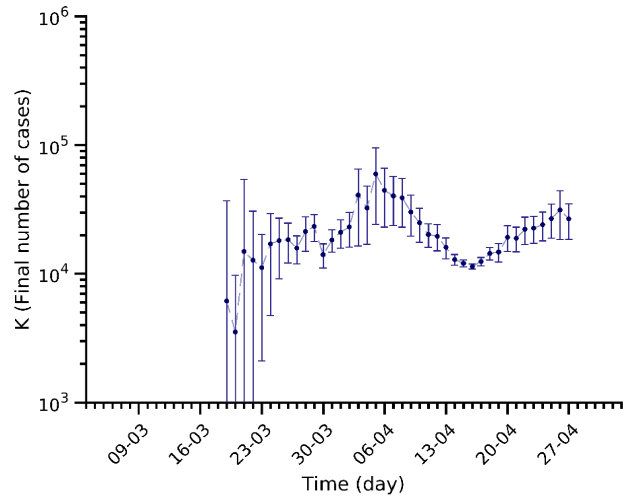
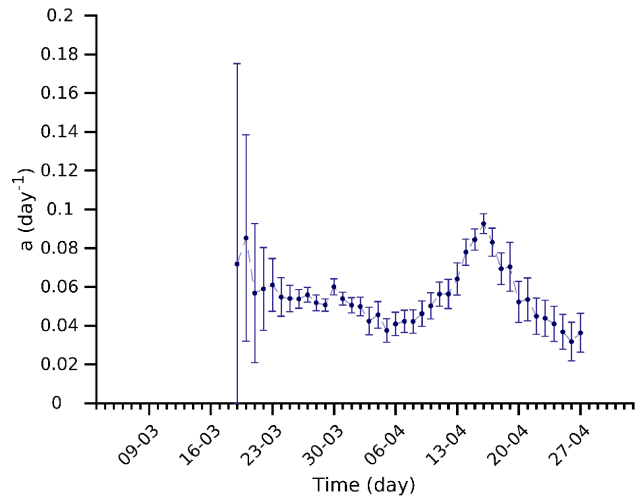
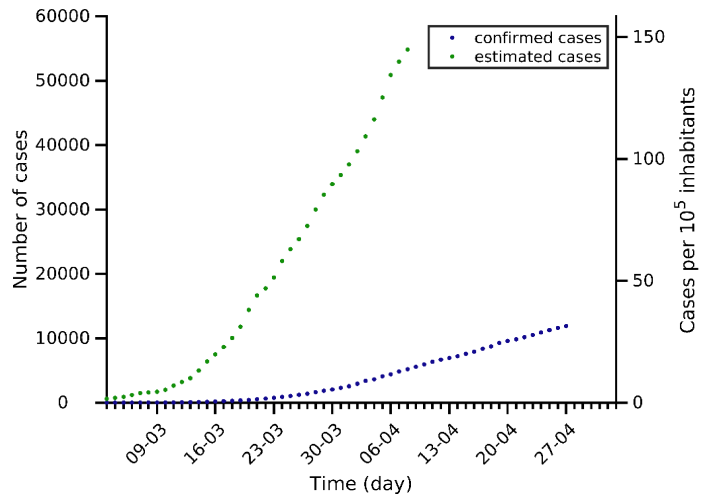
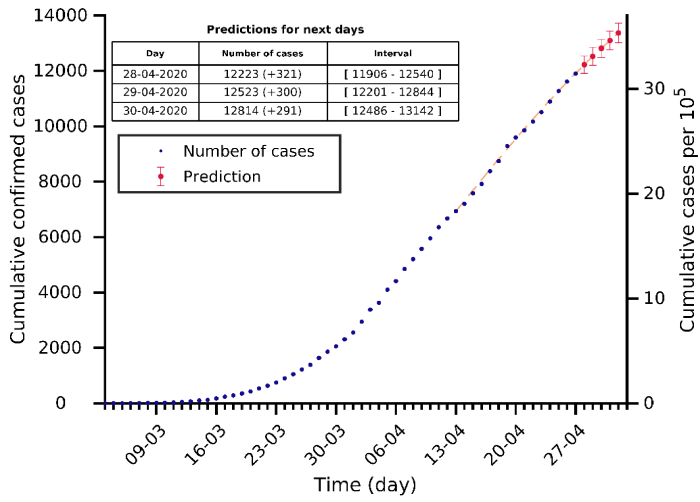
**Sweden 27-04-2020. Population: 10.1M. Current cumulated incidence: 187/10<sup>5</sup>**



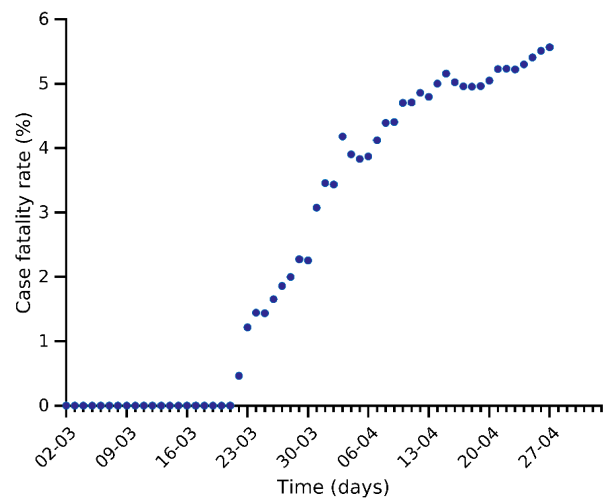
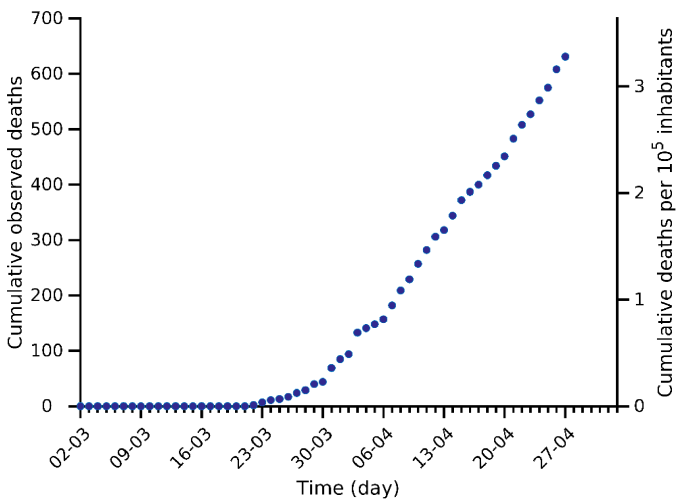
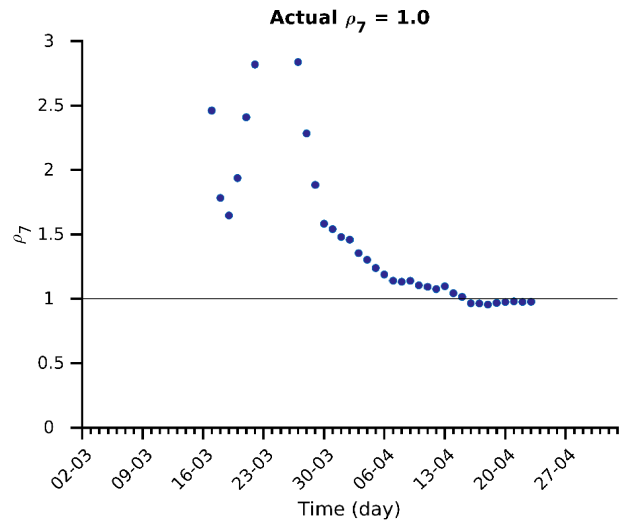
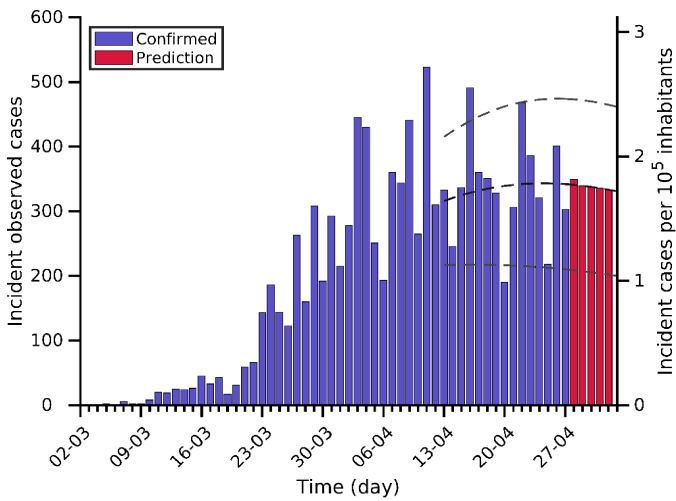
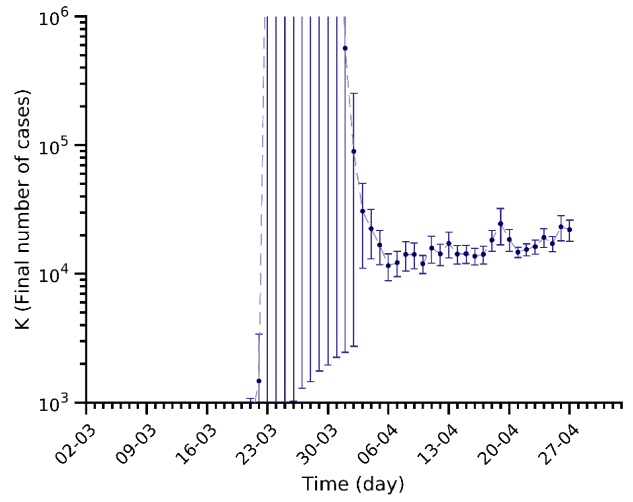
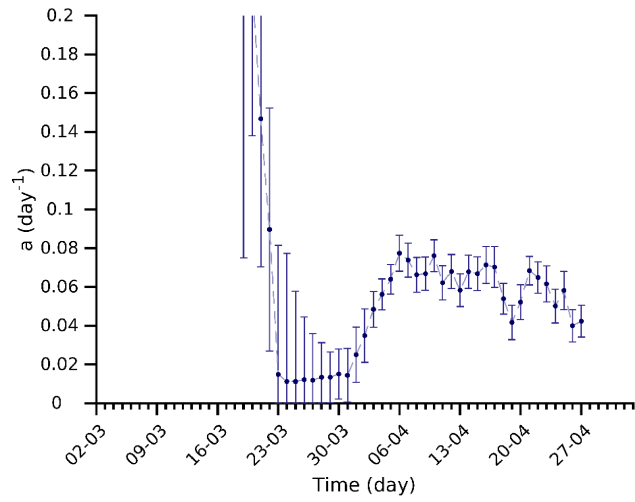
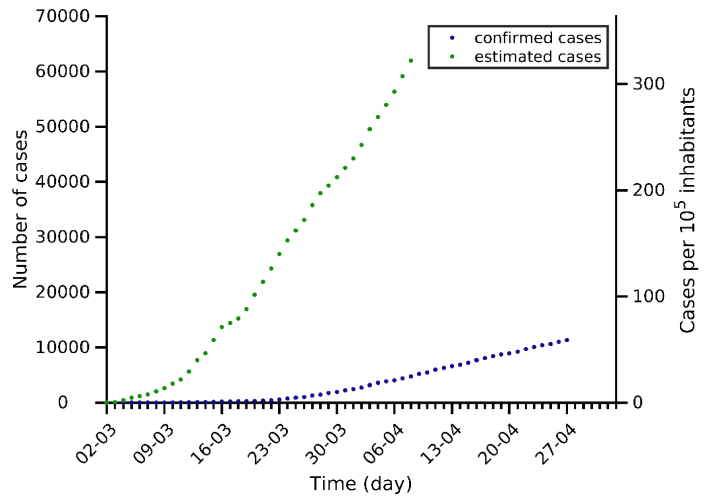
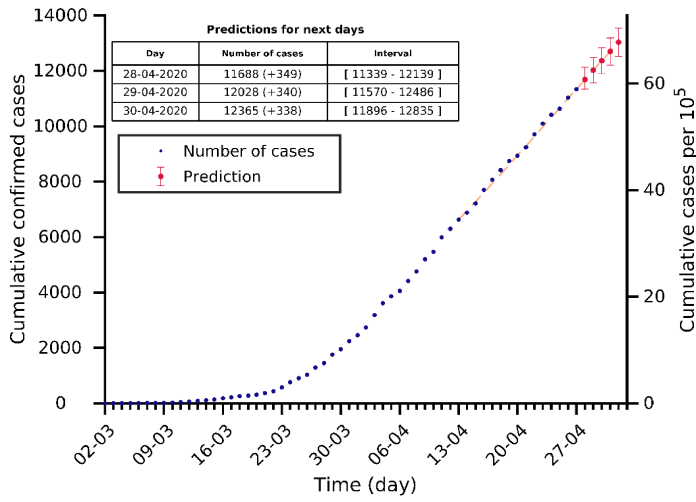
**Austria 27-04-2020. Population: 9.0M. Current cumulated incidence: 169/10<sup>5</sup>**



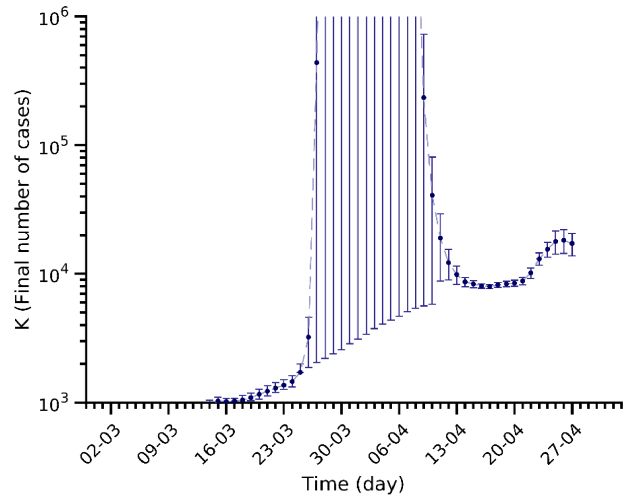
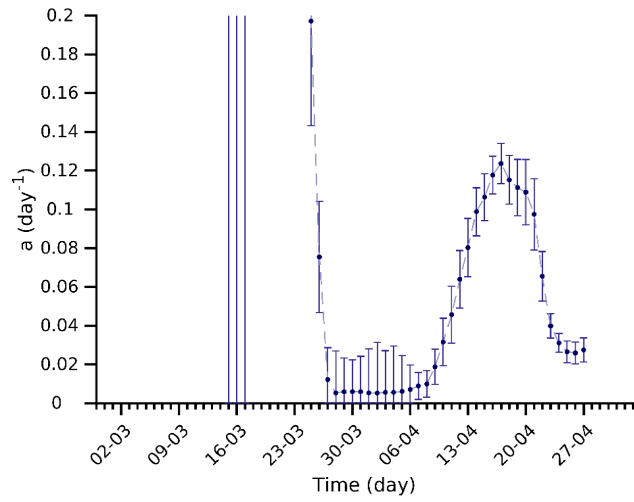
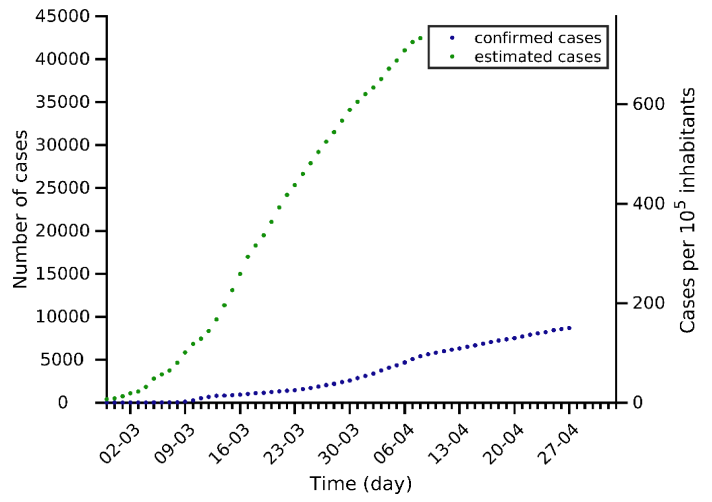
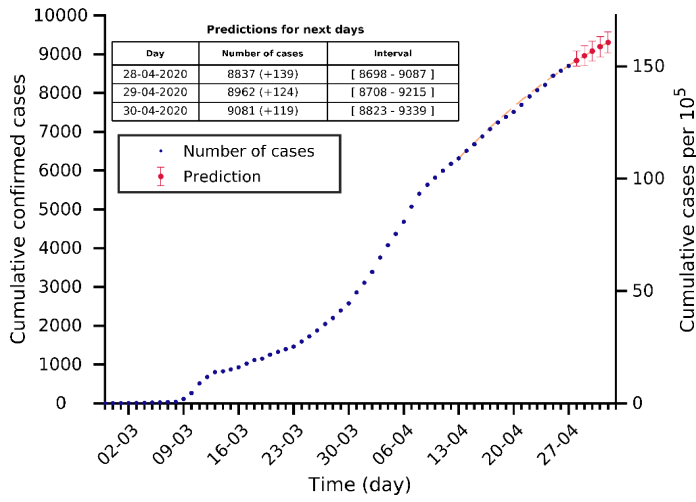
**Poland 27-04-2020. Population: 37.8M. Current cumulated incidence: 31/10<sup>5</sup>**



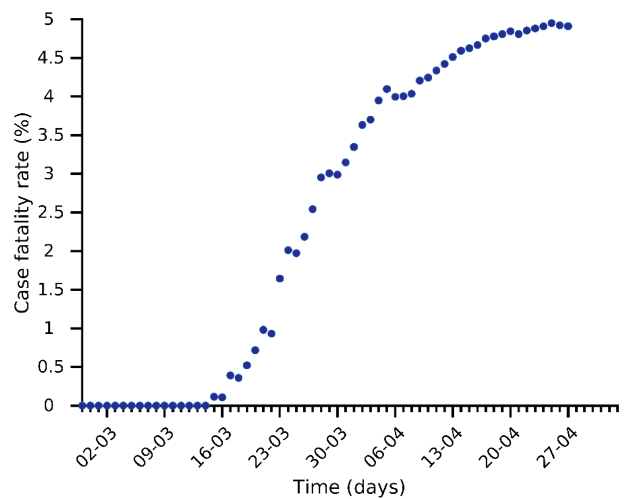
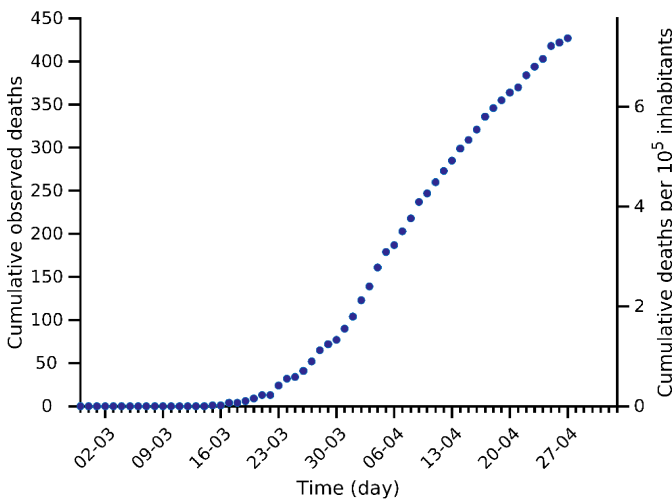
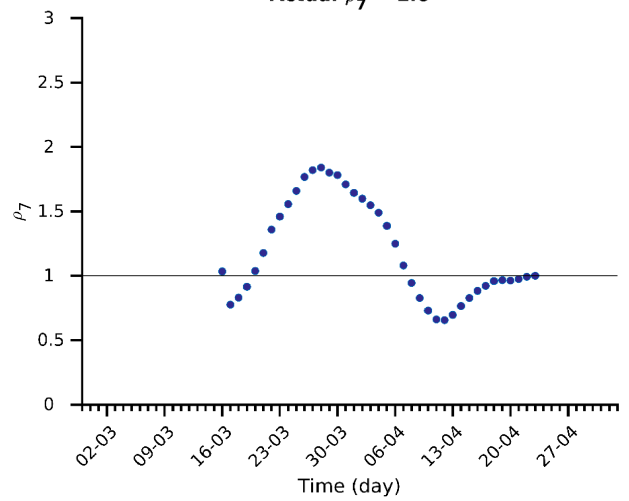
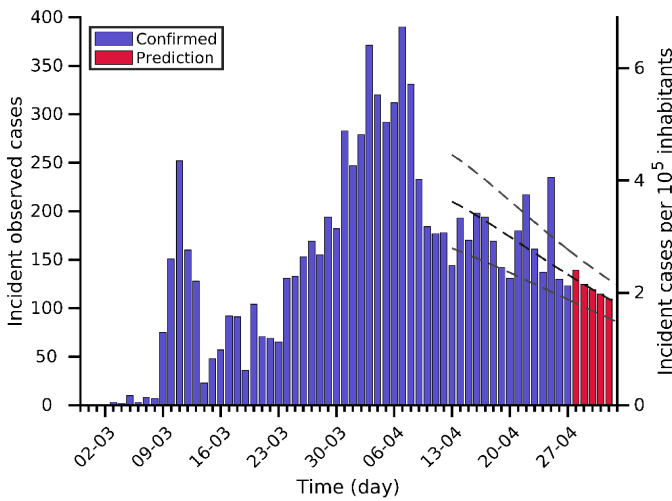
**Romania 27-04-2020. Population: 19.2M. Current cumulated incidence: 59/10<sup>5</sup>**



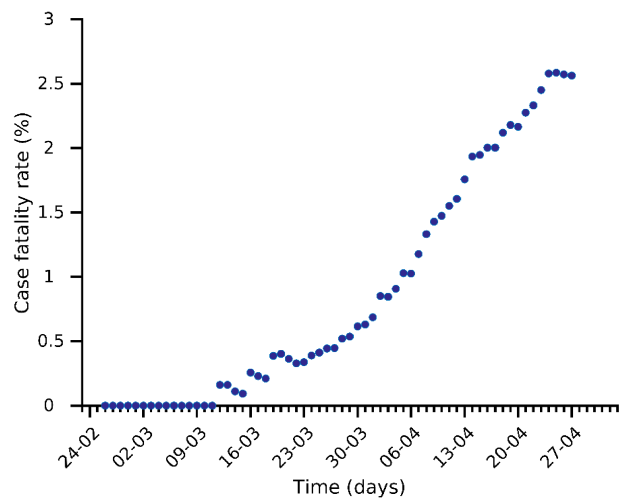
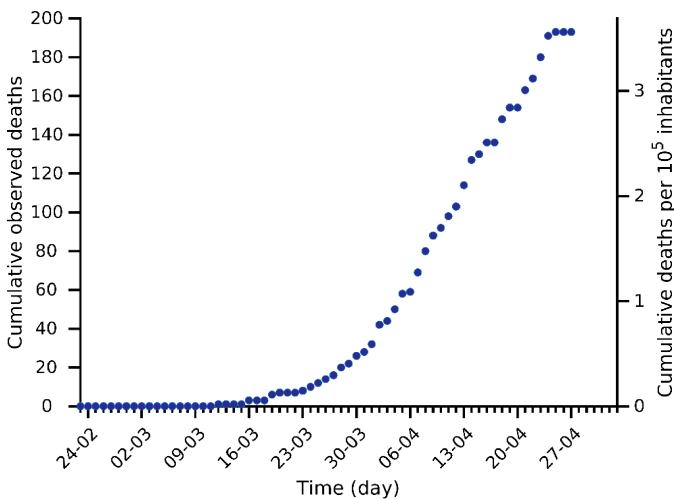
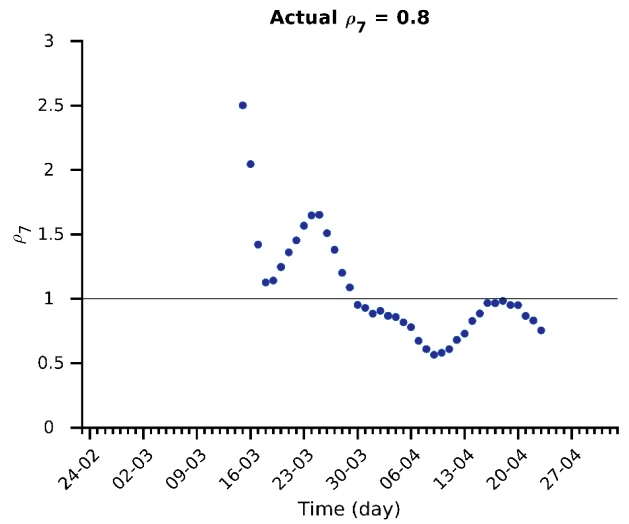
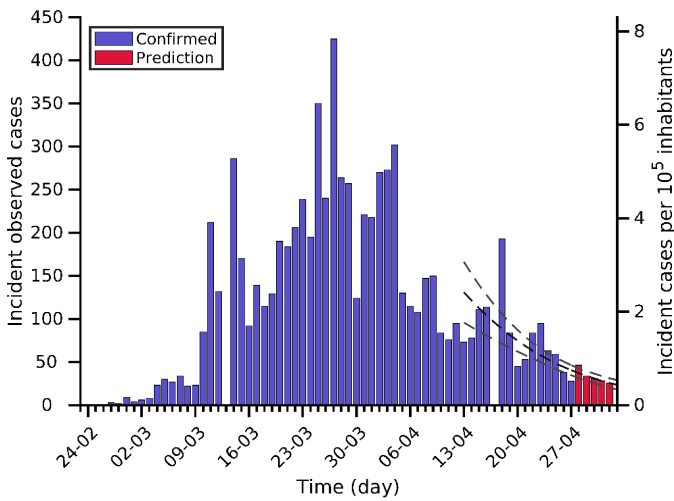
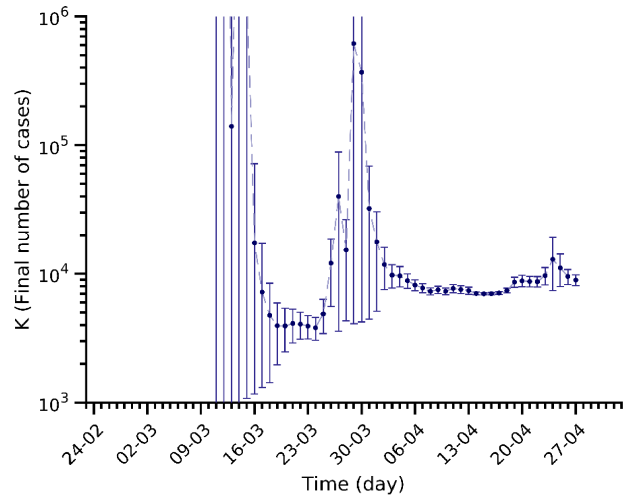
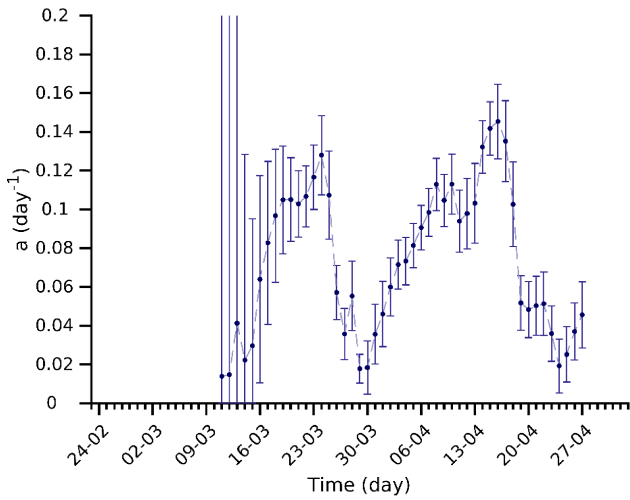
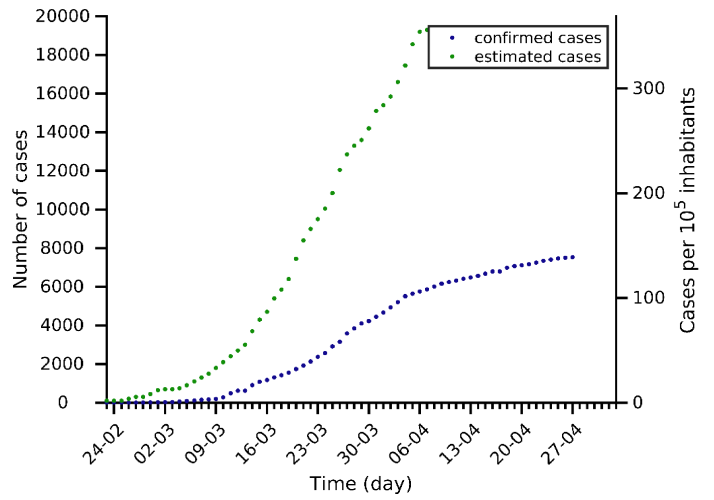
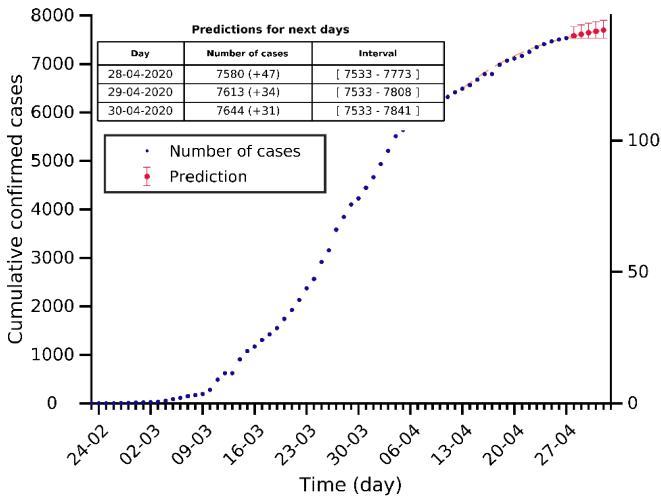
**Denmark 27-04-2020. Population: 5.8M. Current cumulated incidence: 150/10<sup>5</sup>**



**Actual  $\rho_7 = 1.0$**

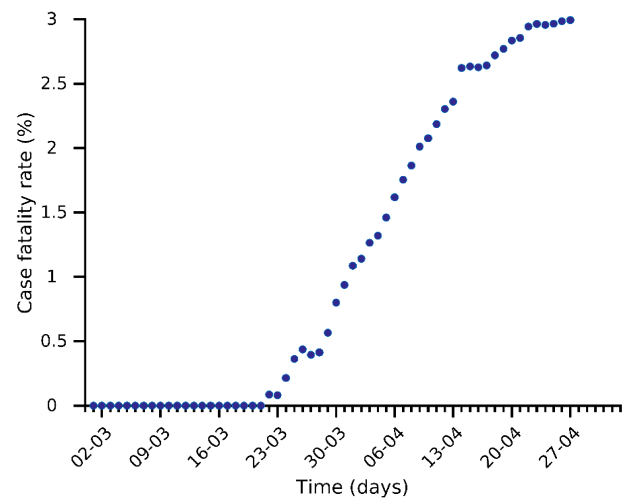
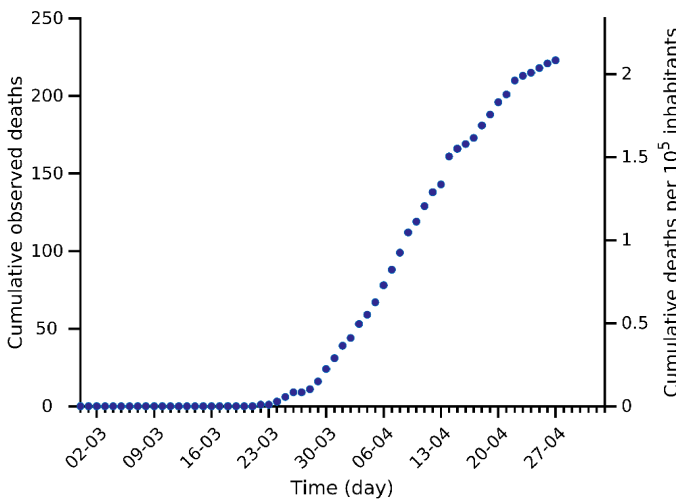
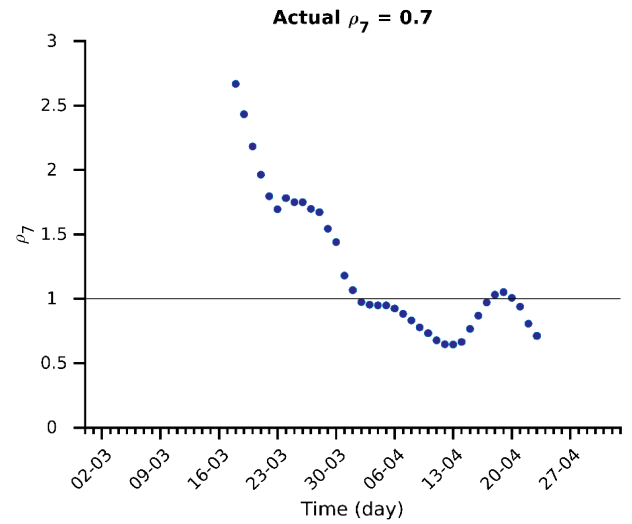
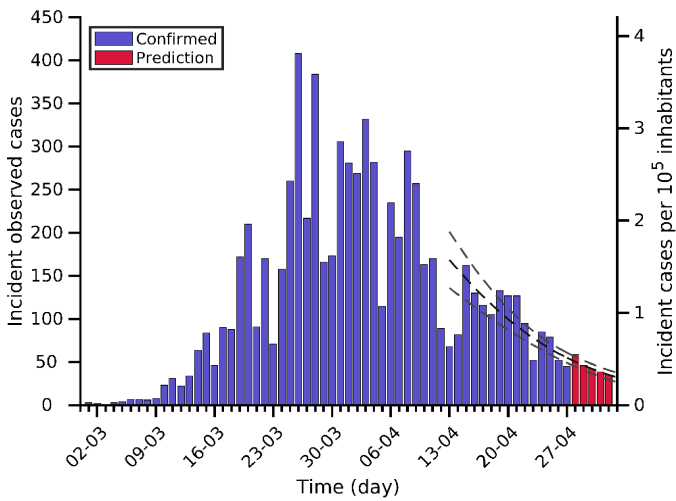
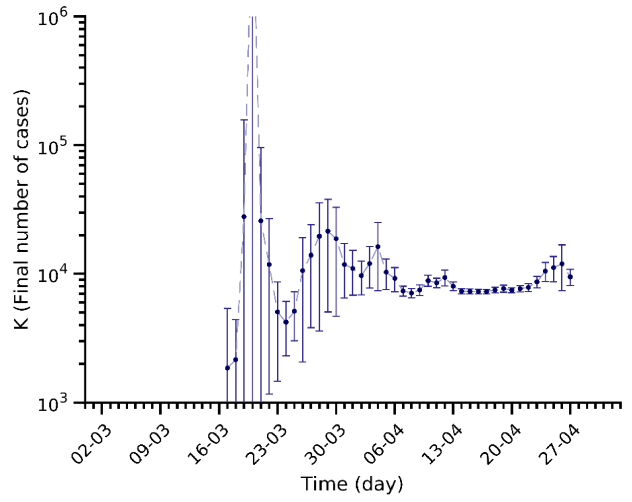
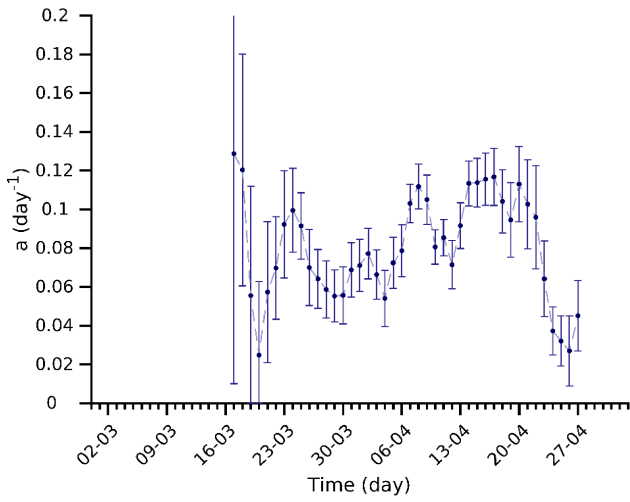
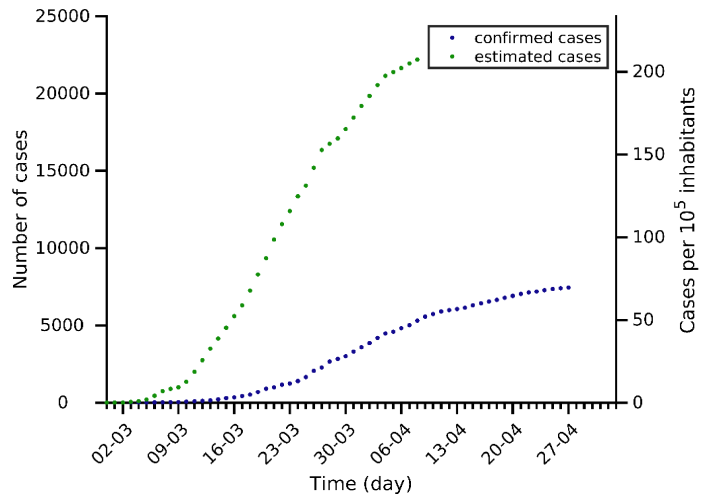
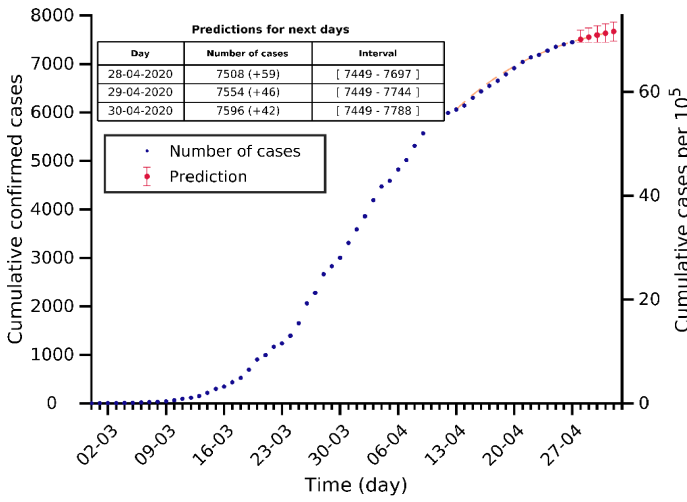


**Norway 27-04-2020. Population: 5.4M. Current cumulated incidence: 139/10<sup>5</sup>**

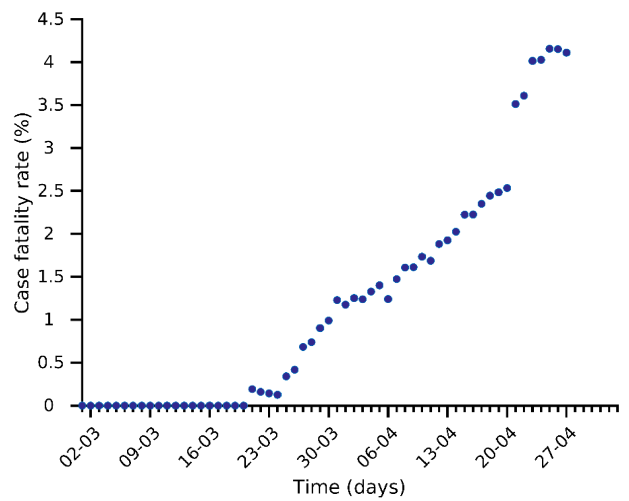
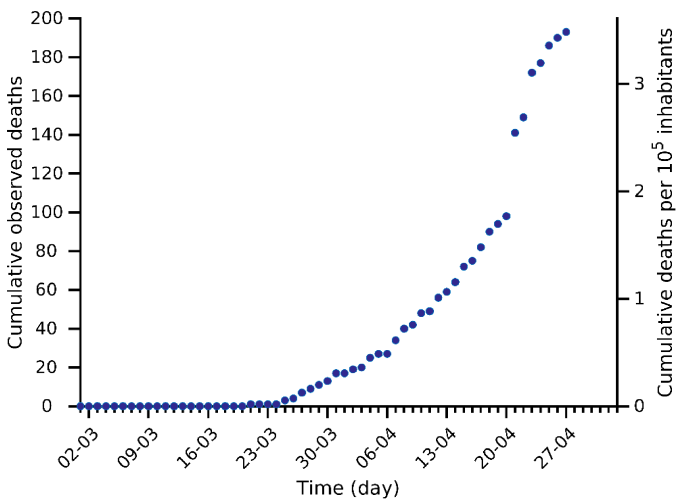
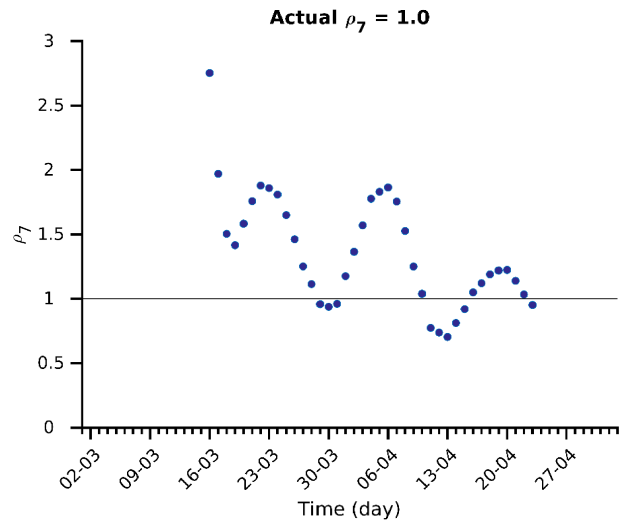
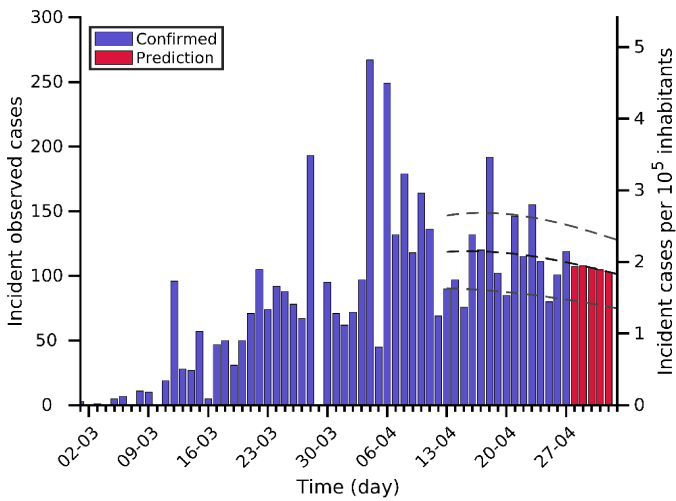
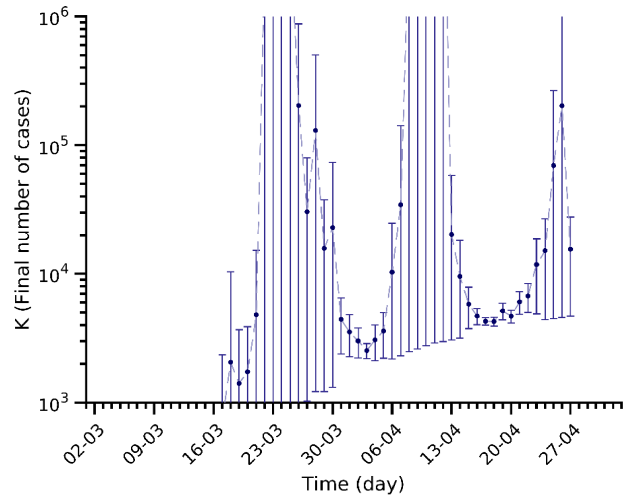
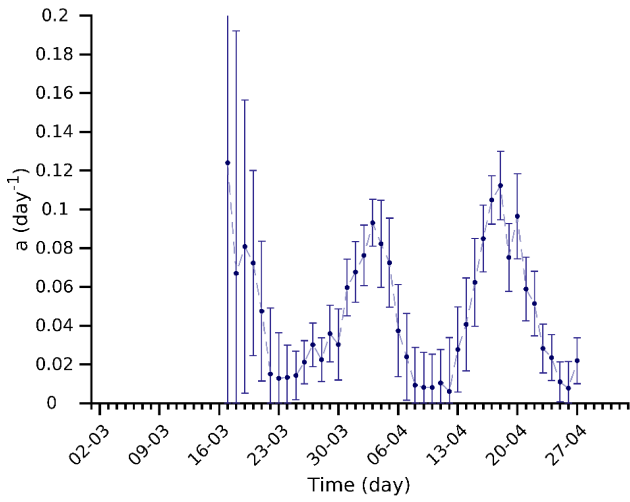
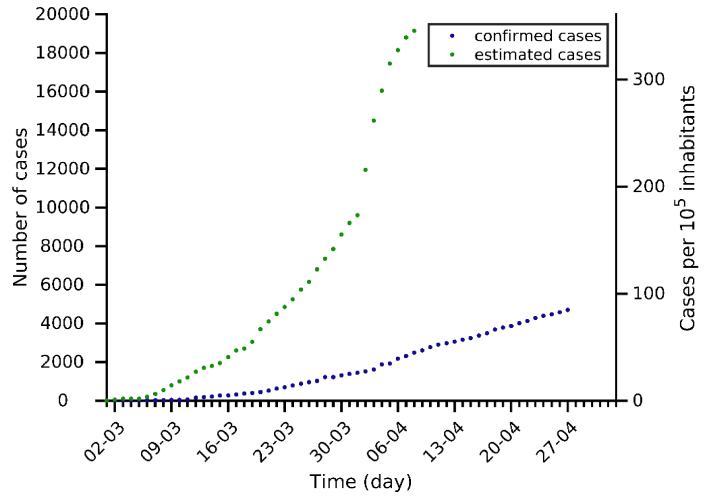
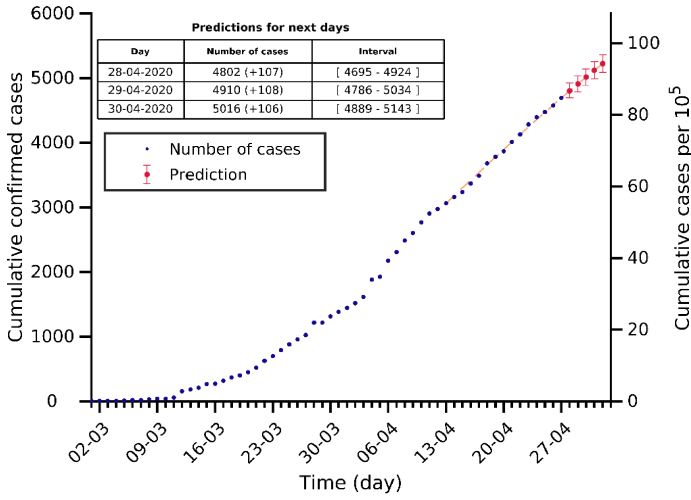




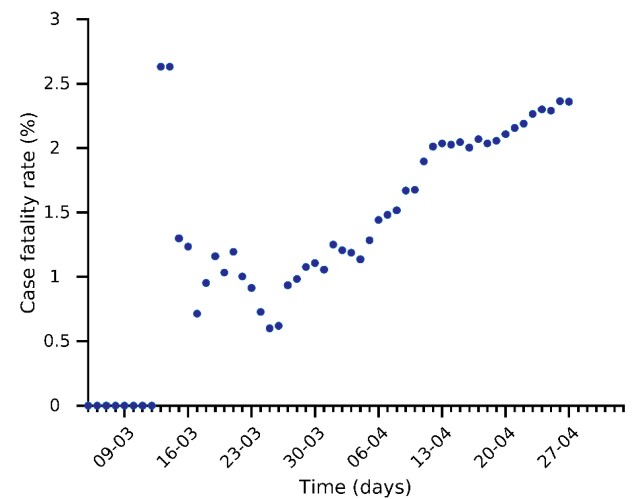
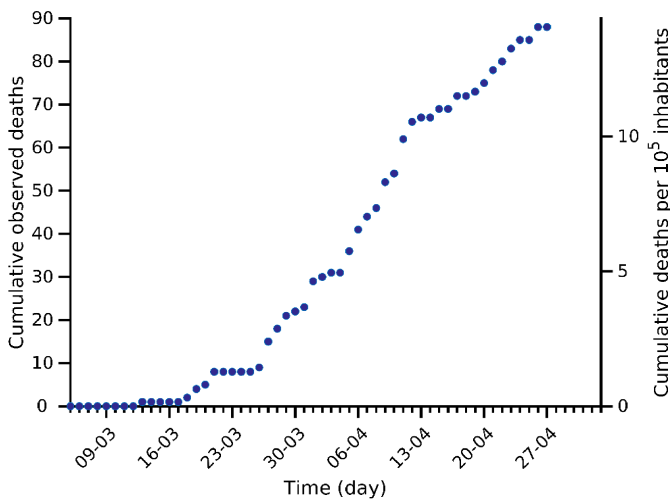
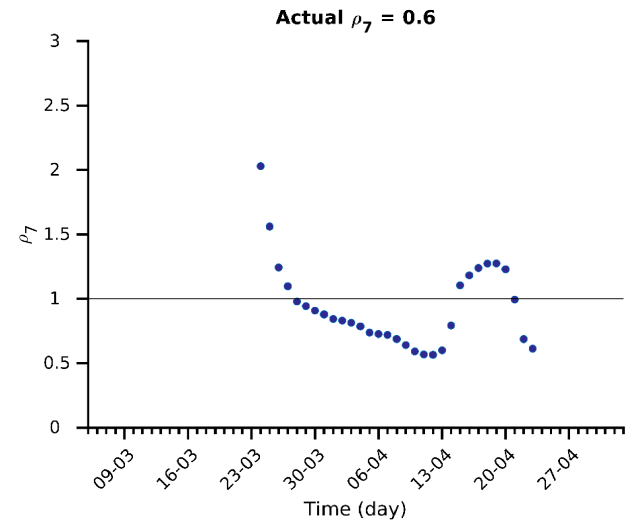
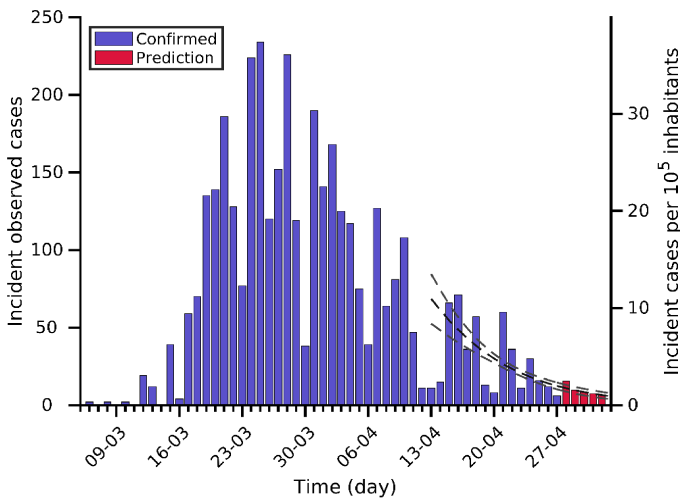
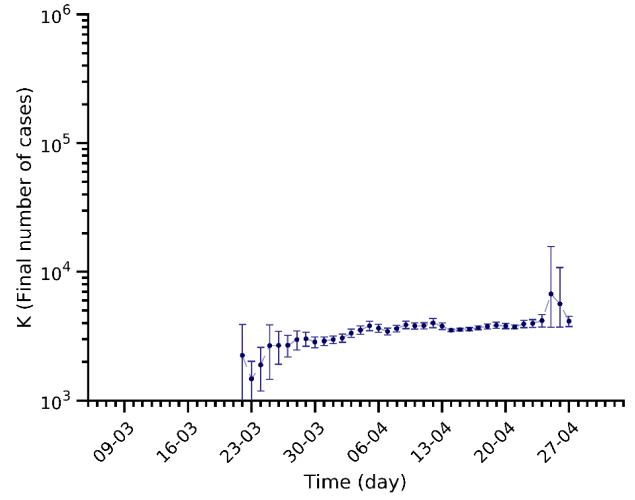
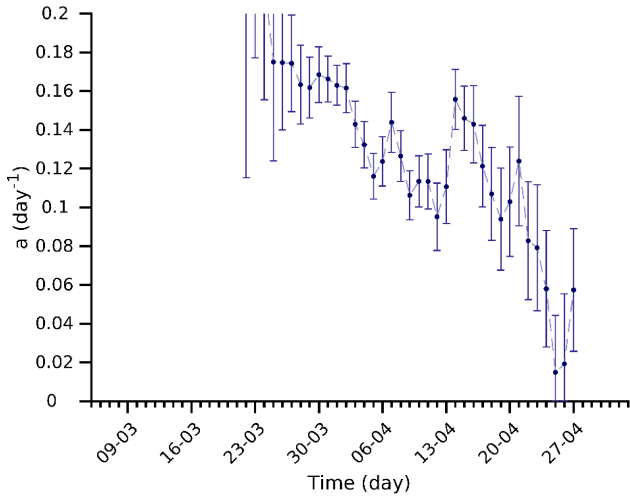
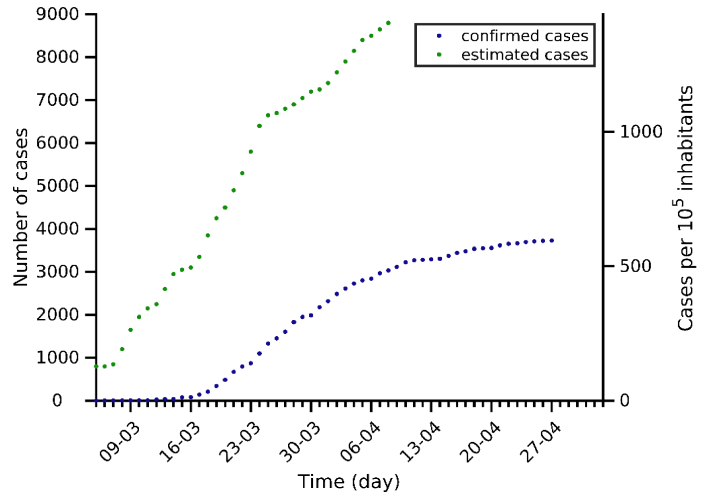
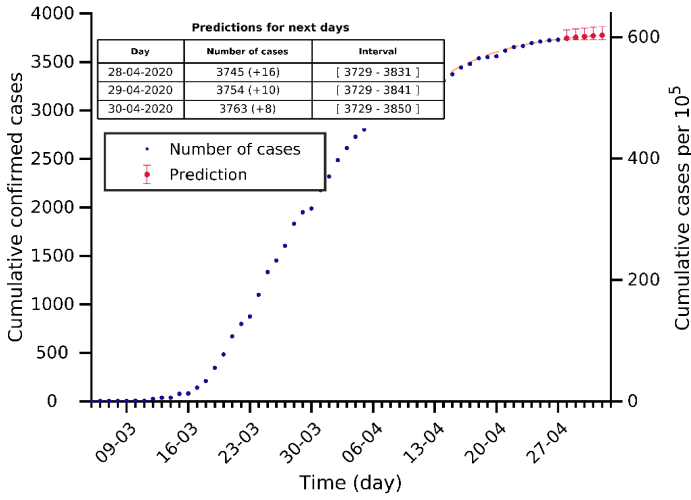
**Czech Rep 27-04-2020. Population: 10.7M. Current cumulated incidence: 70/10<sup>5</sup>**



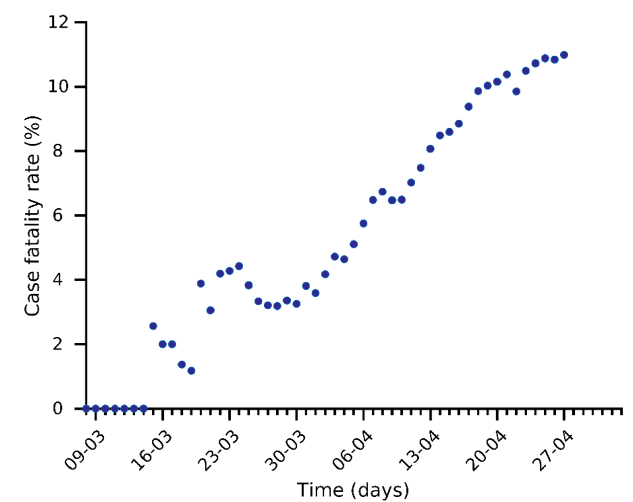
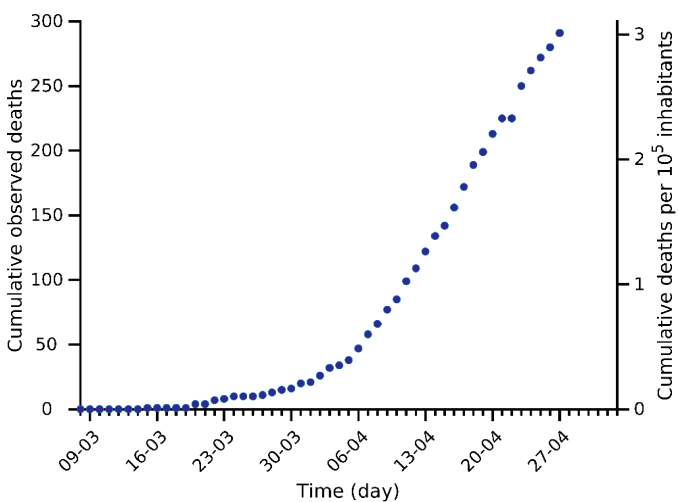
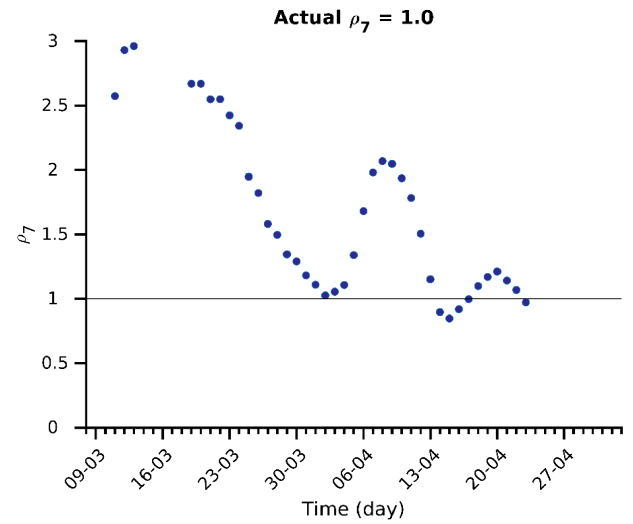
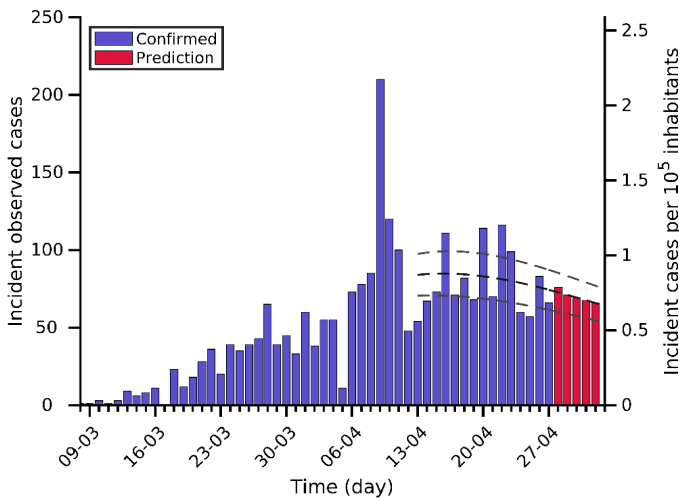
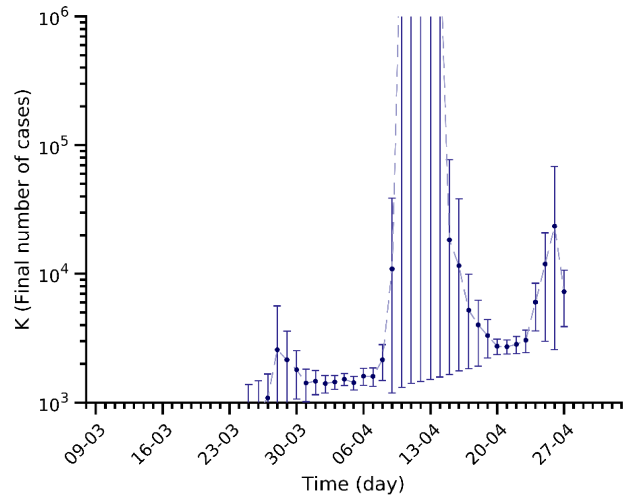
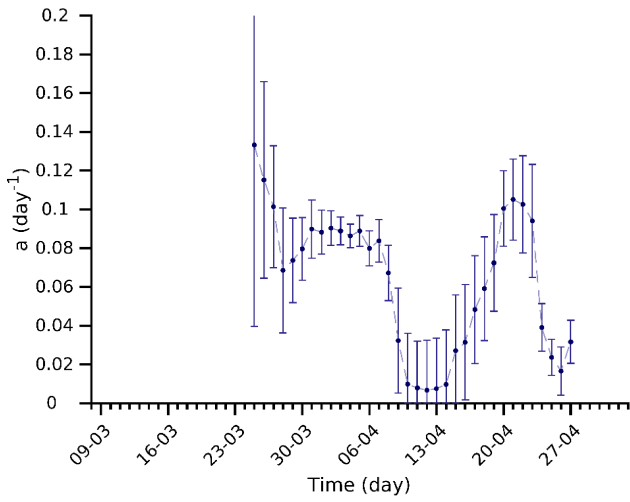
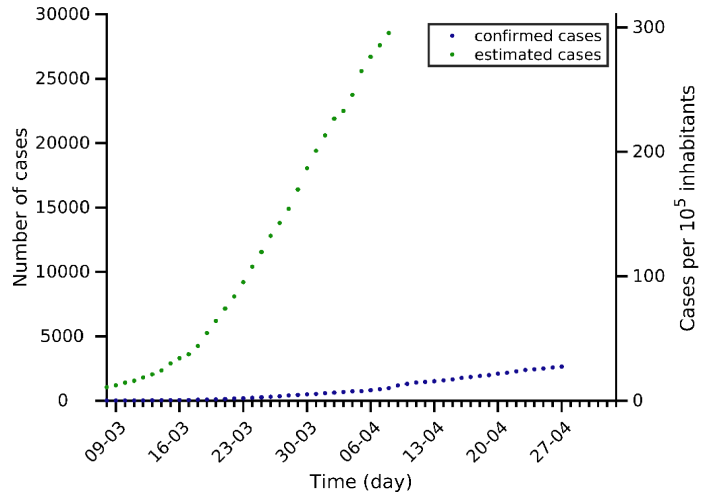
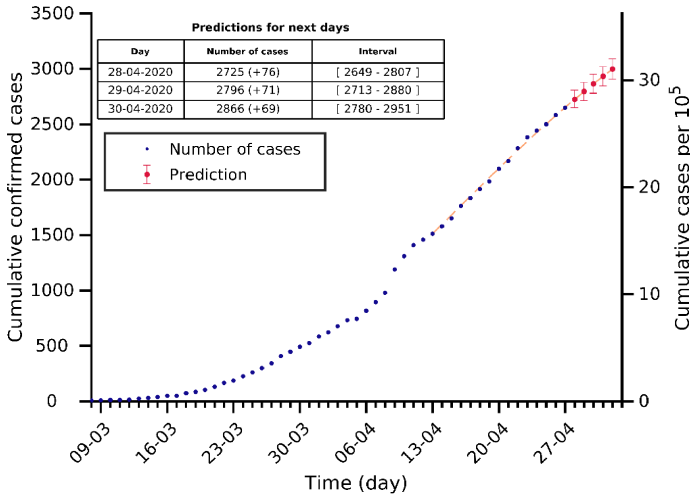
**Finland 27-04-2020. Population: 5.5M. Current cumulated incidence: 85/10<sup>5</sup>**



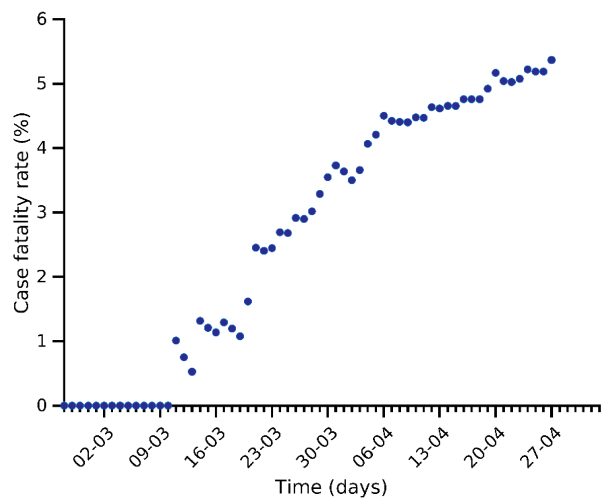
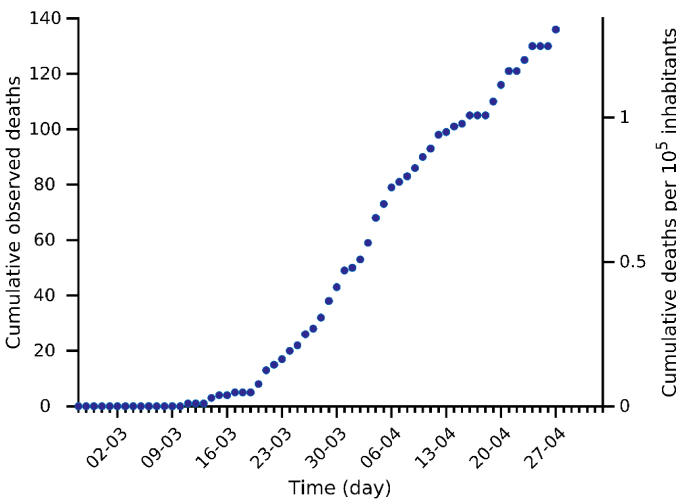
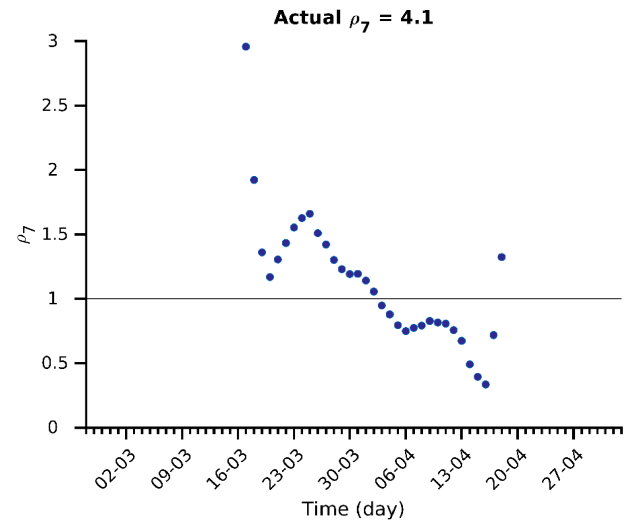
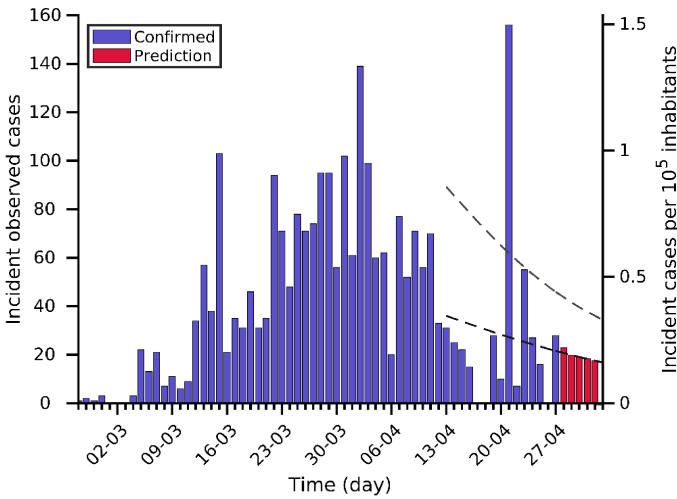
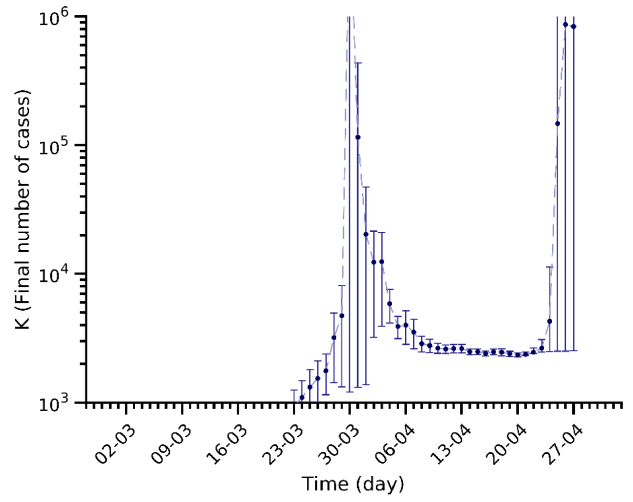
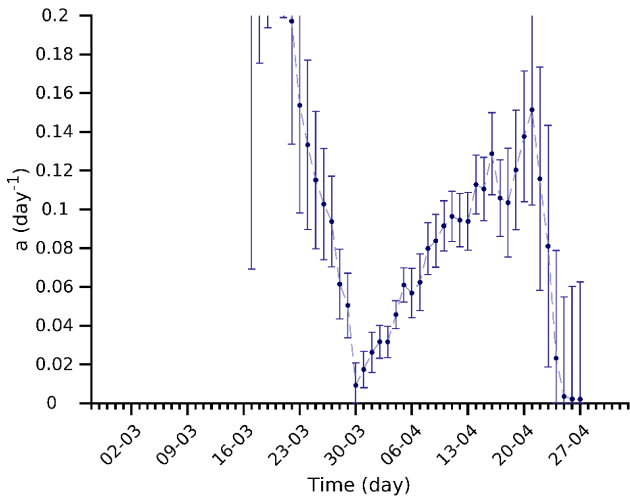
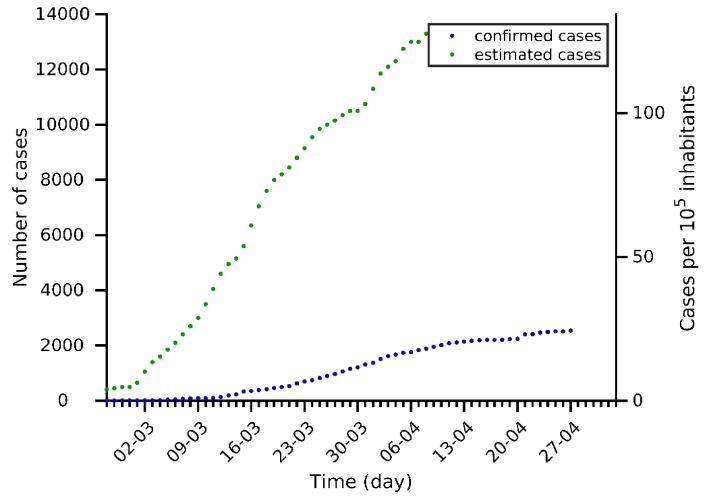
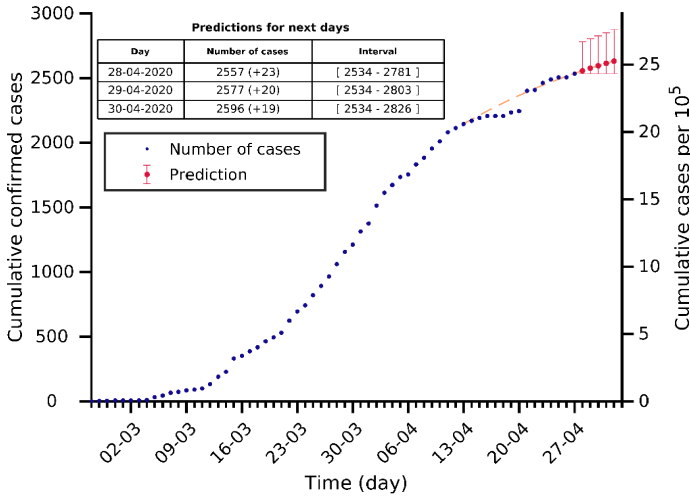
**Luxembourg 27-04-2020. Population: 0.6M. Current cumulated incidence: 596/10<sup>5</sup>**



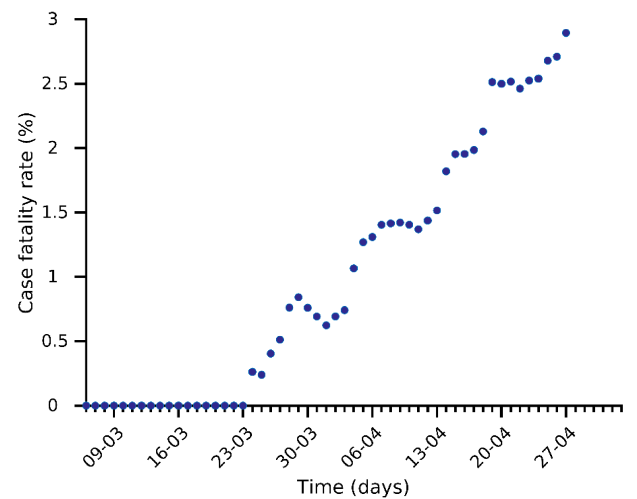
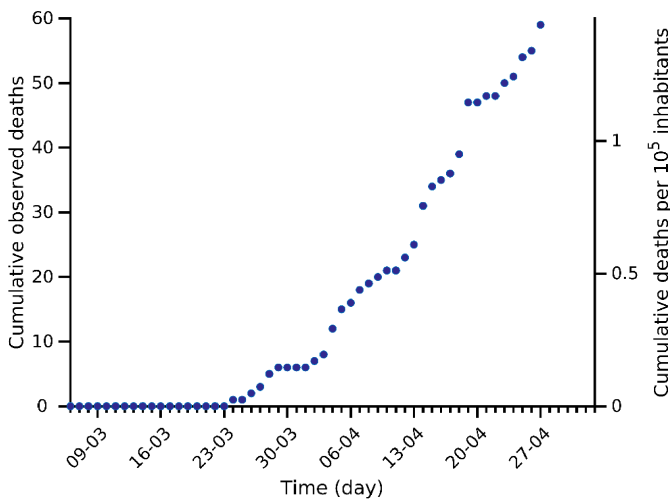
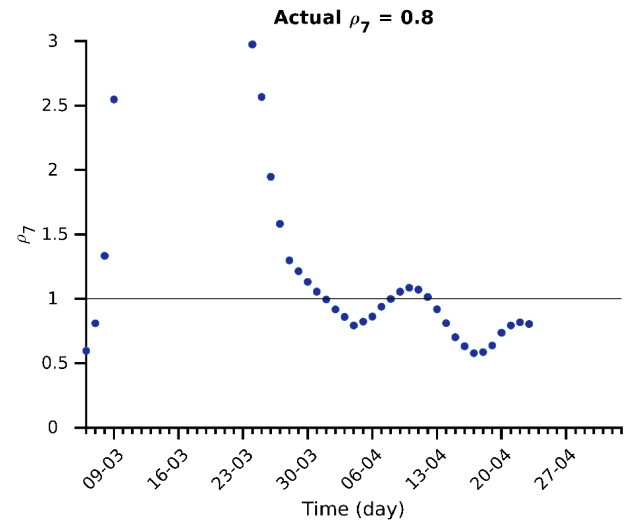
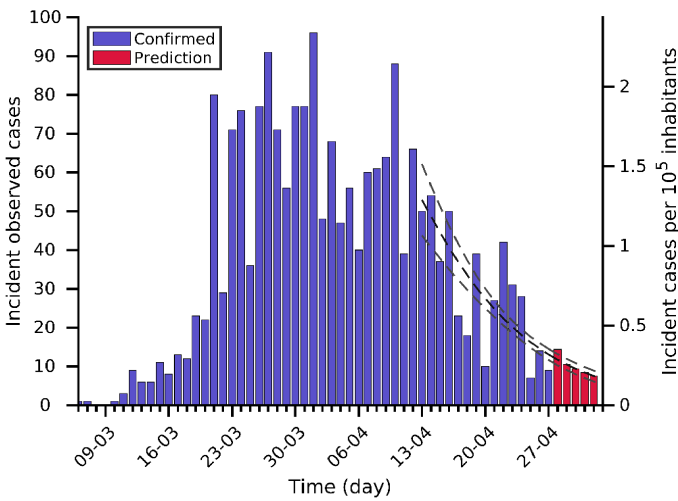
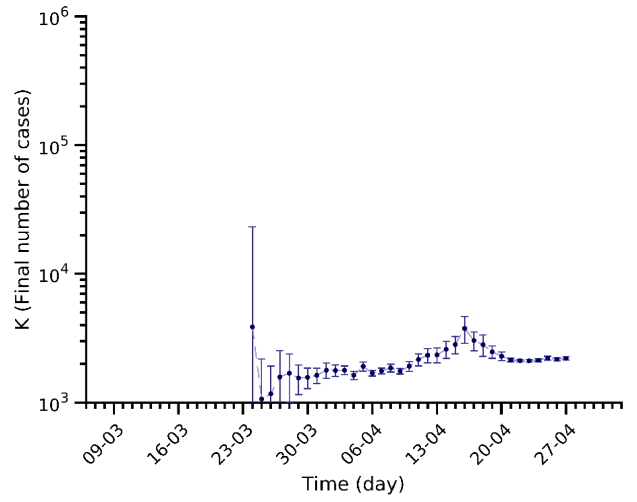
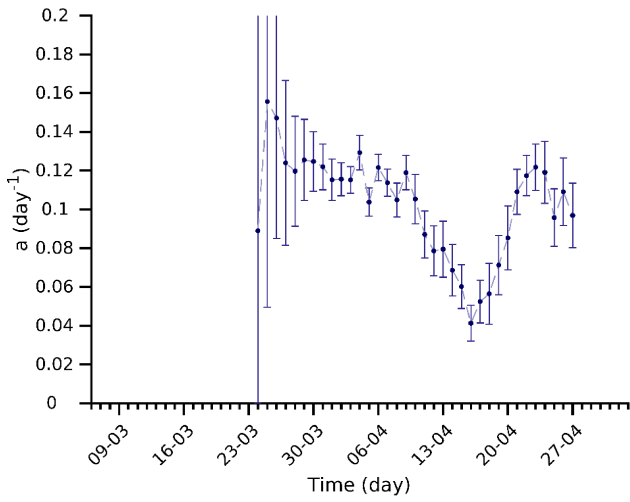
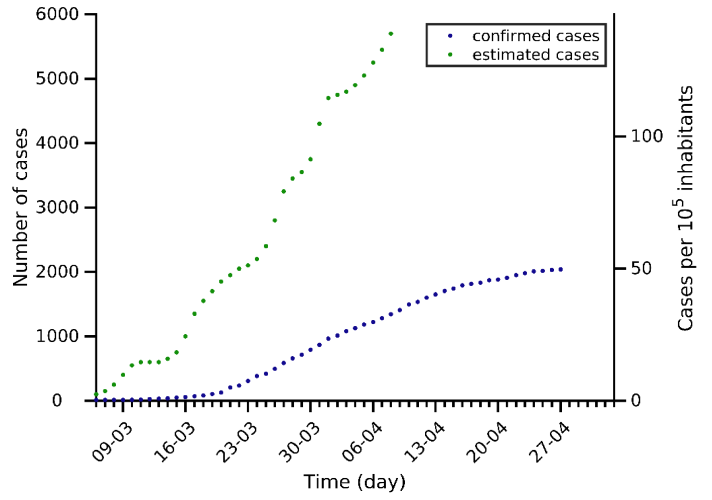
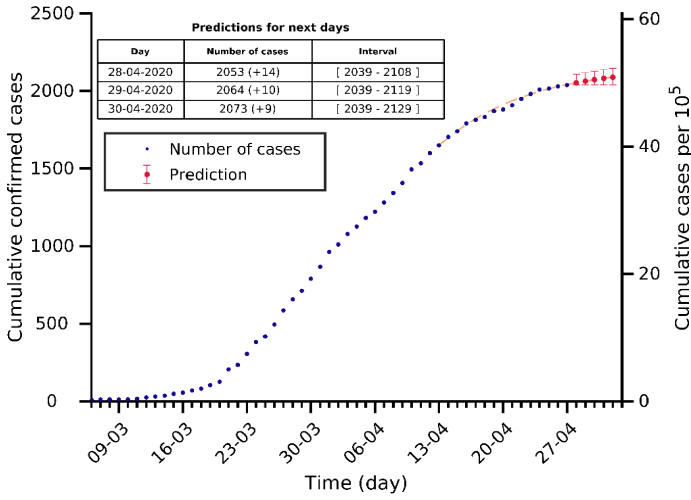
**Hungary 27-04-2020. Population: 9.7M. Current cumulated incidence: 27/10<sup>5</sup>**



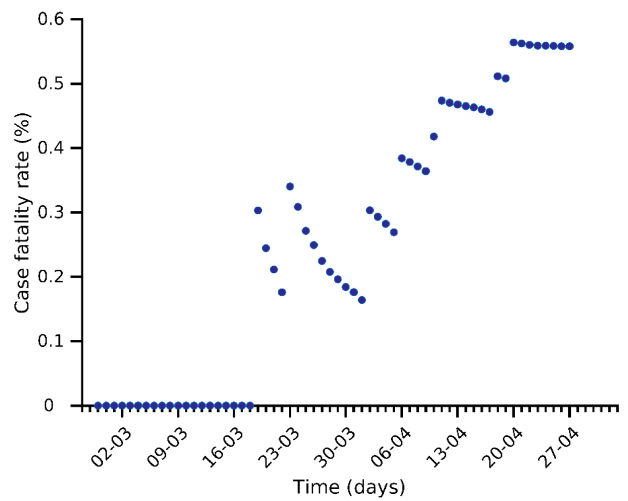
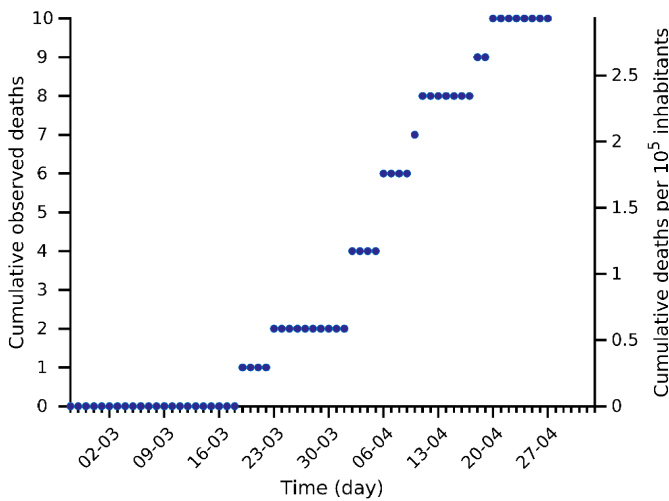
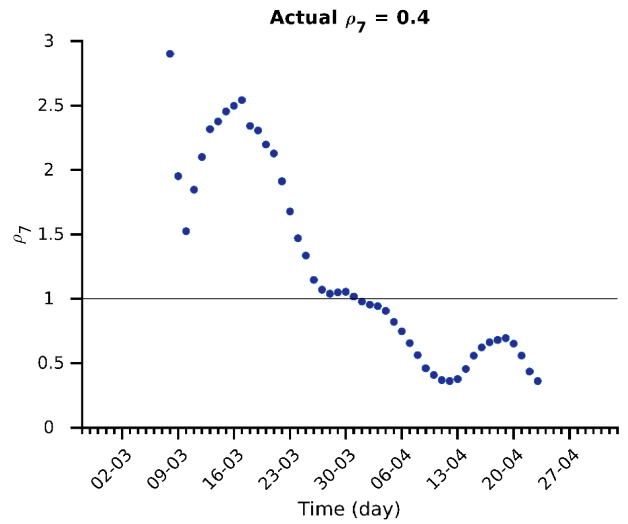
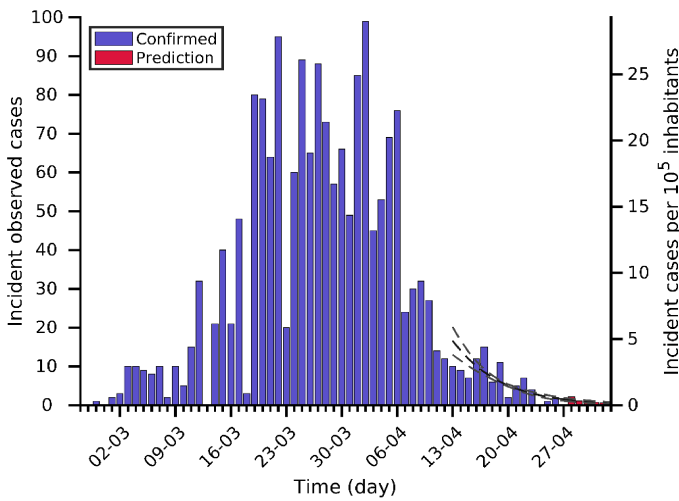
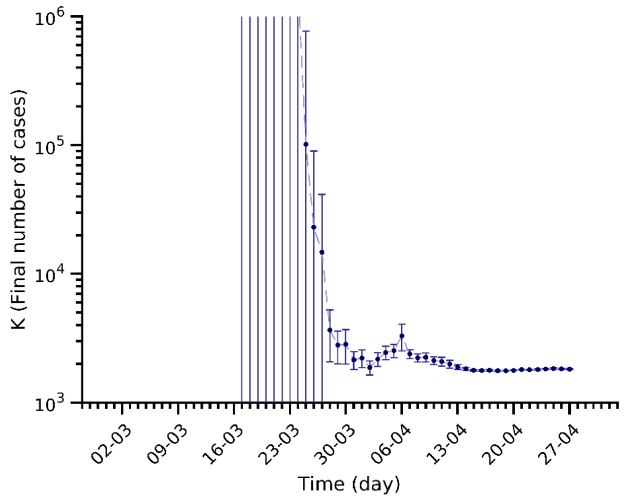
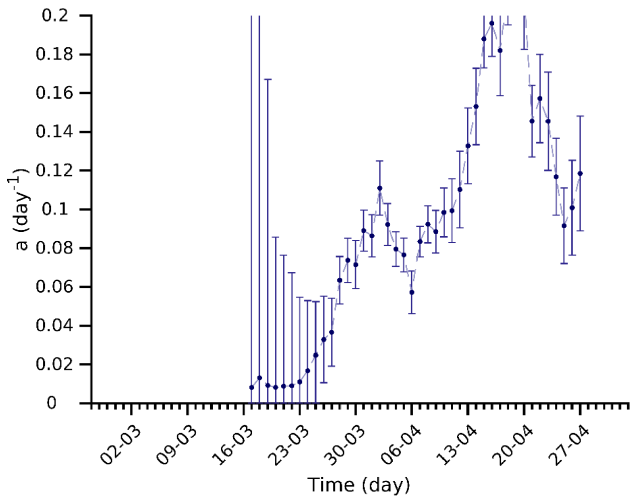
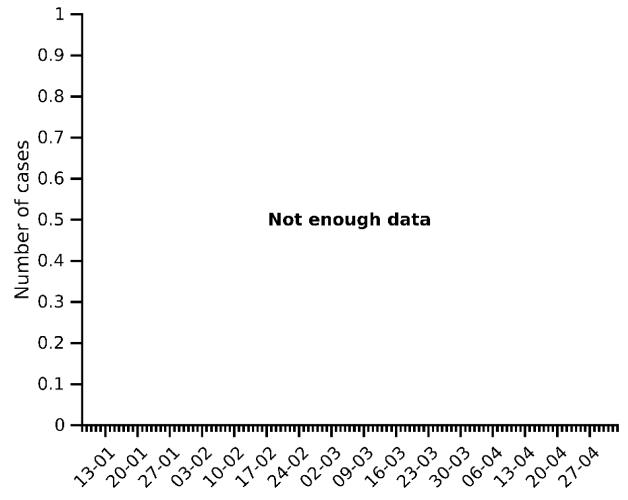
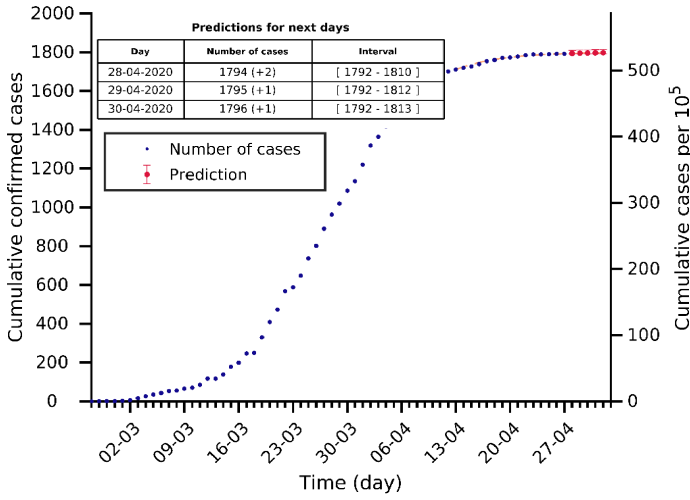
**Greece 27-04-2020. Population: 10.4M. Current cumulated incidence: 24/10<sup>5</sup>**



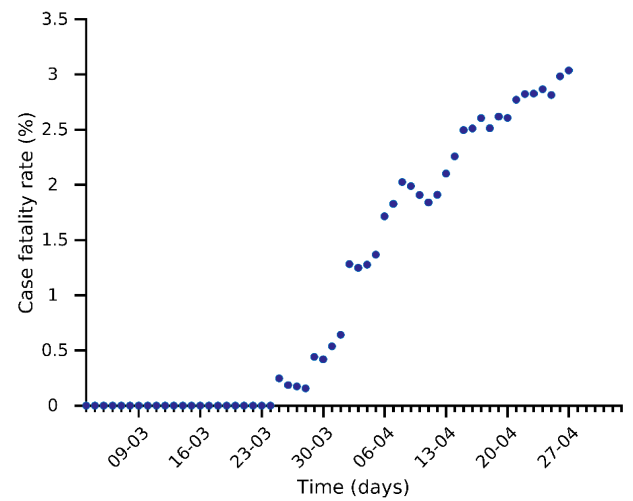
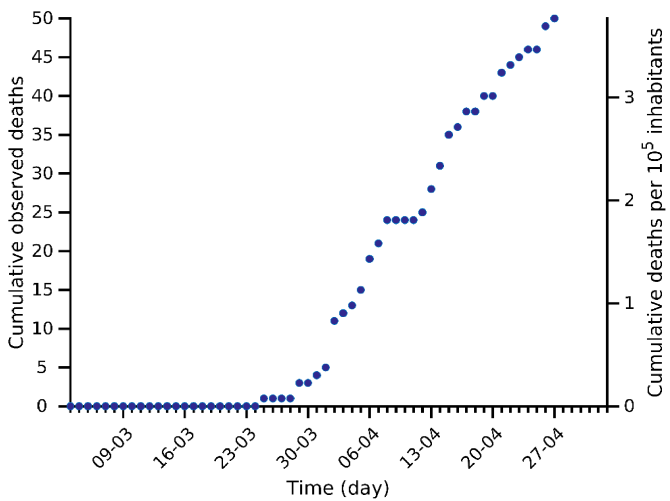
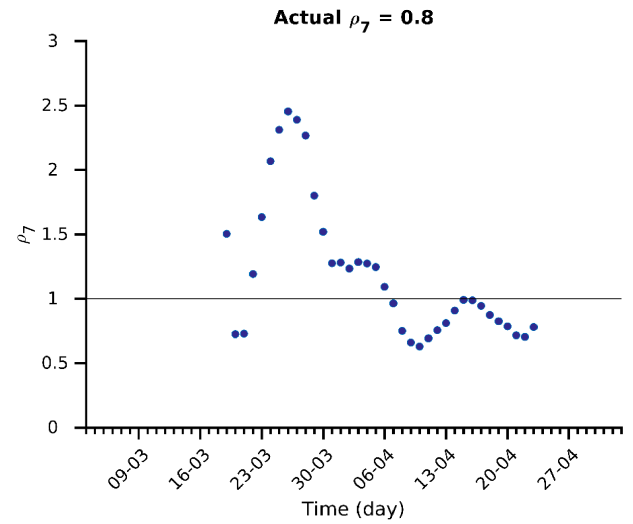
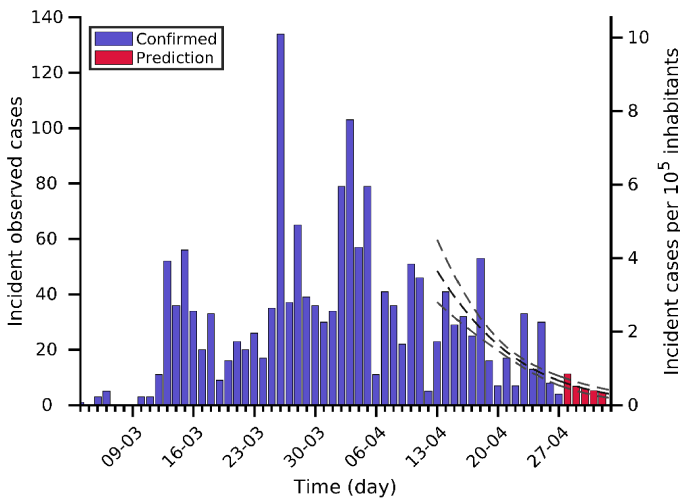
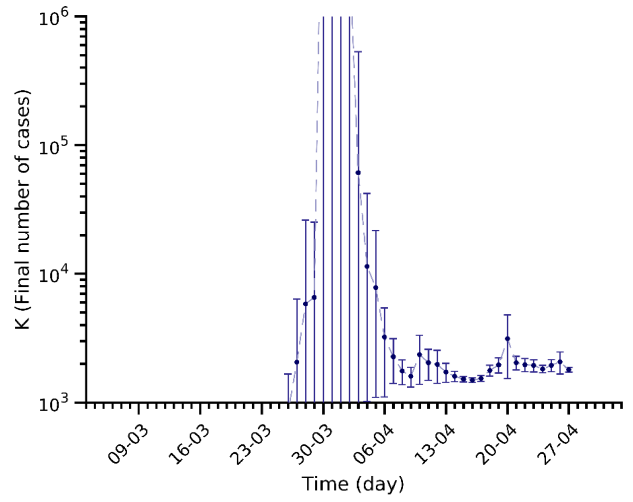
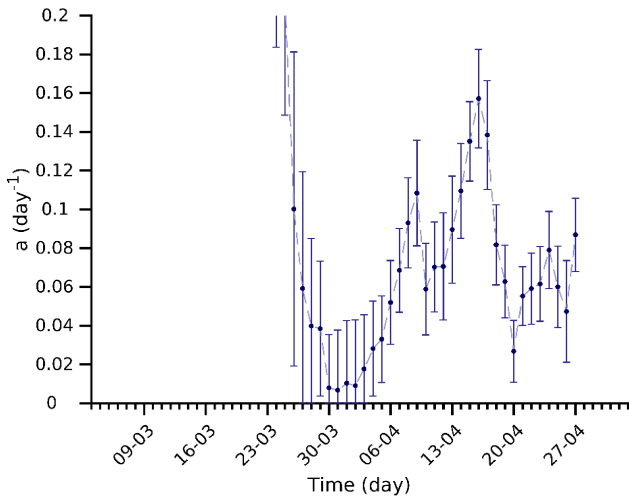
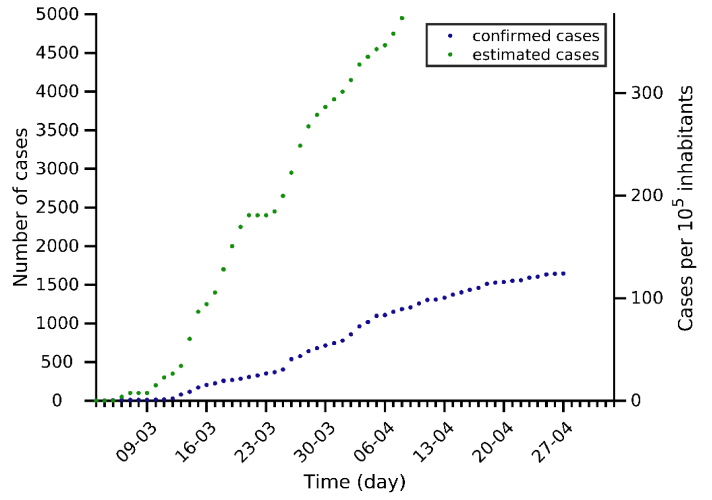
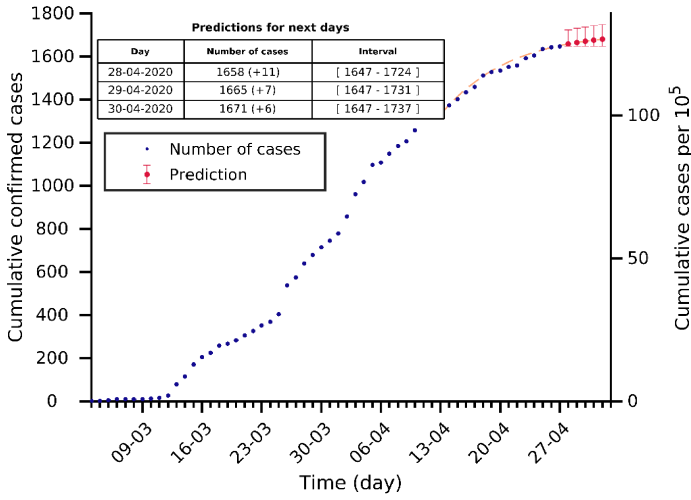
**Croatia 27-04-2020. Population: 4.1M. Current cumulated incidence: 50/10<sup>5</sup>**



Iceland 27-04-2020. Population: 0.3M. Current cumulated incidence: 525/10<sup>5</sup>

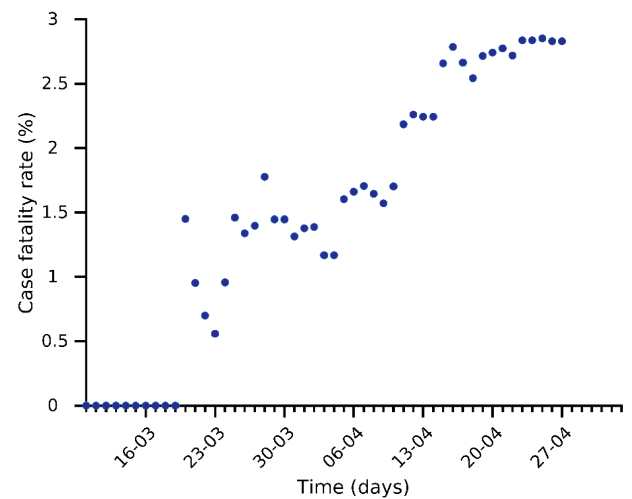
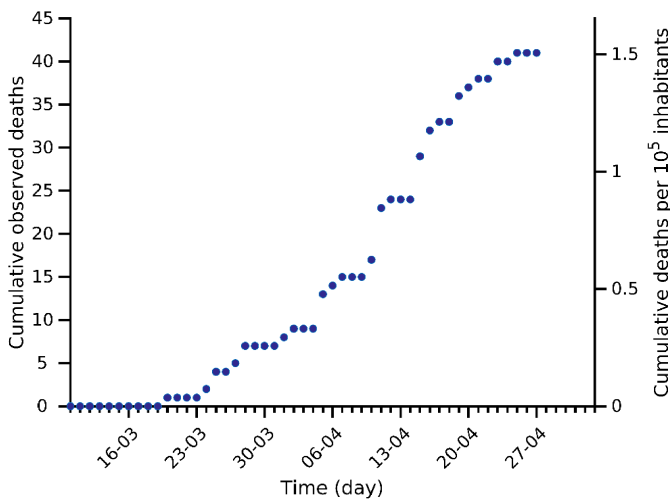
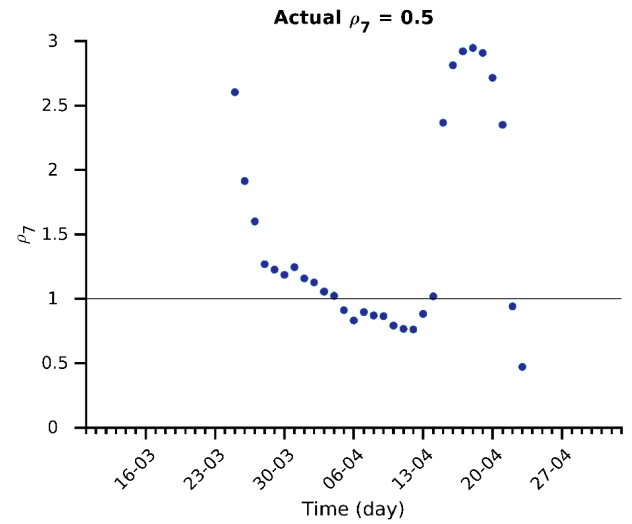
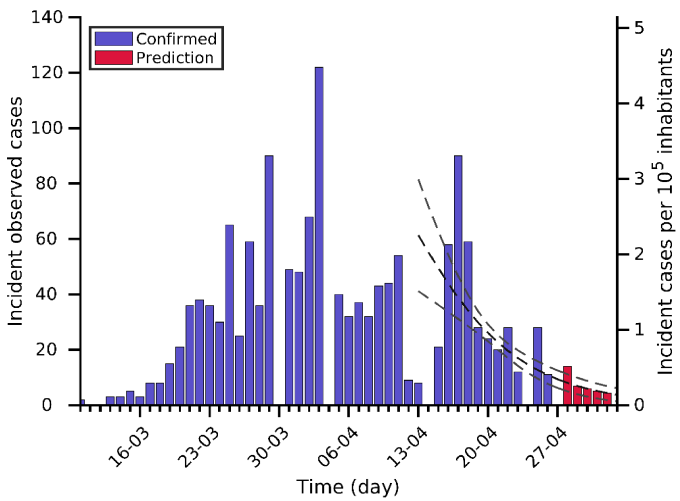
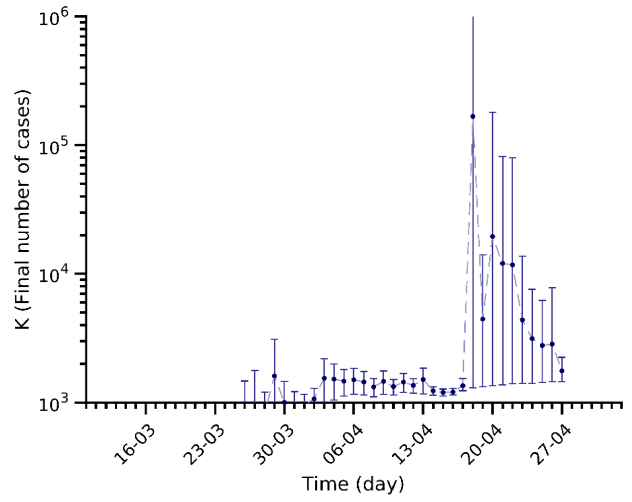
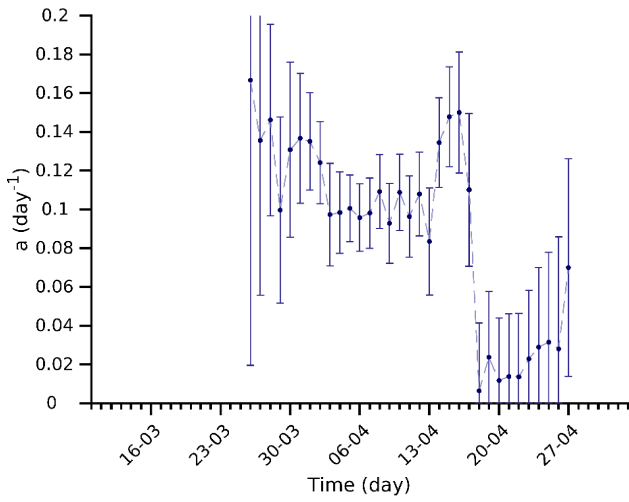
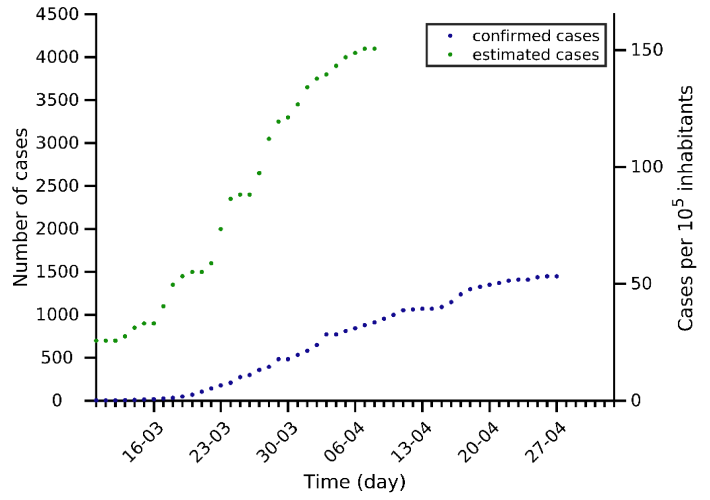
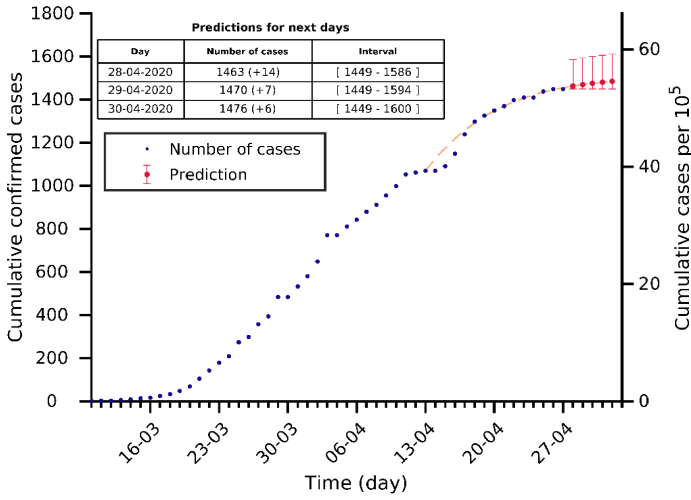


**Estonia 27-04-2020. Population: 1.3M. Current cumulated incidence: 124/10<sup>5</sup>**

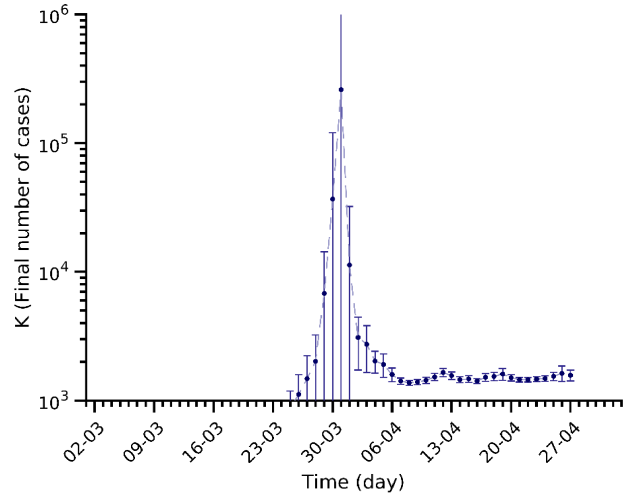
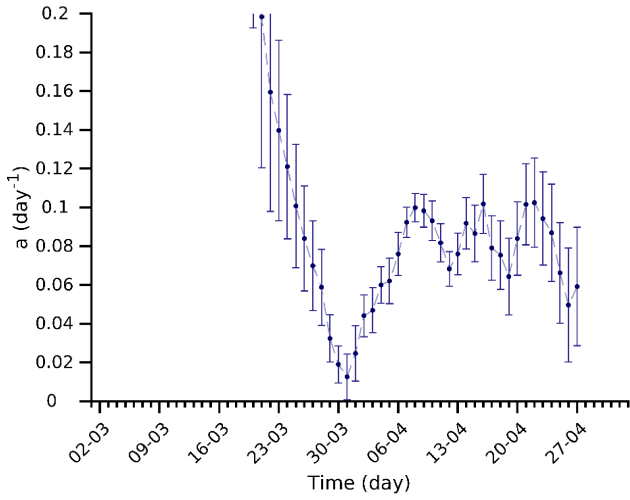
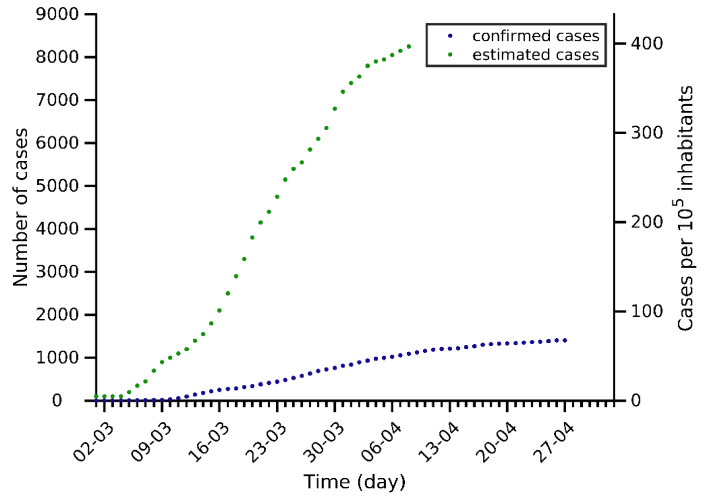
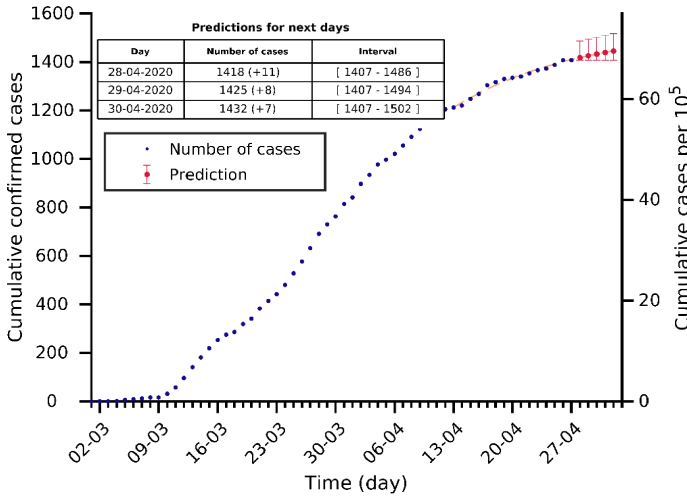




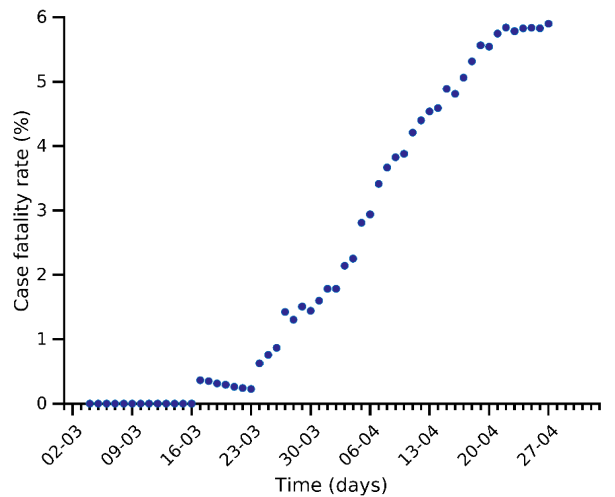
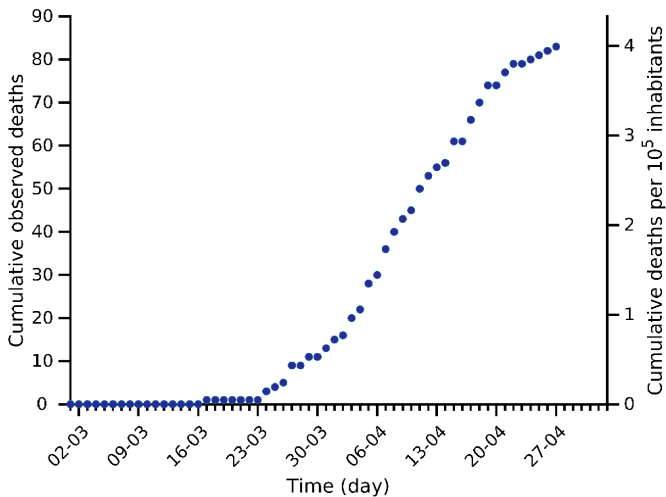
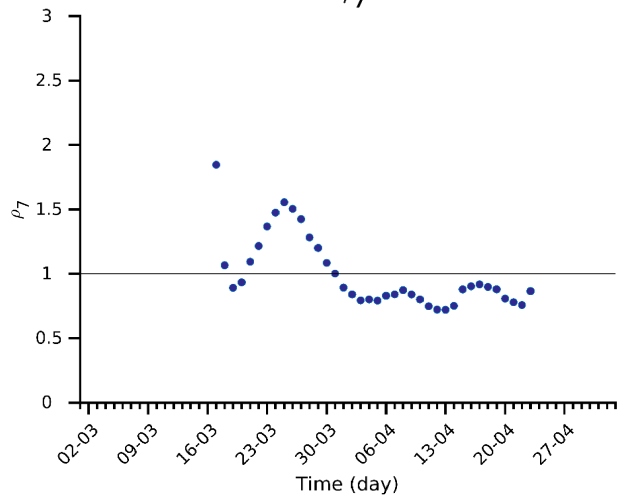
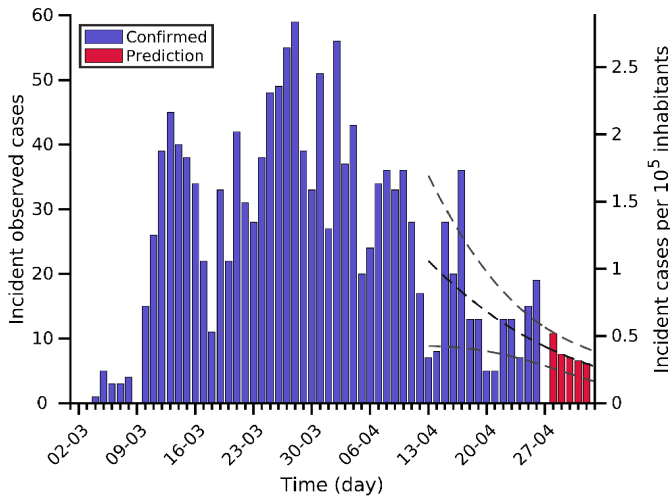
**Lithuania 27-04-2020. Population: 2.7M. Current cumulated incidence: 53/10<sup>5</sup>**



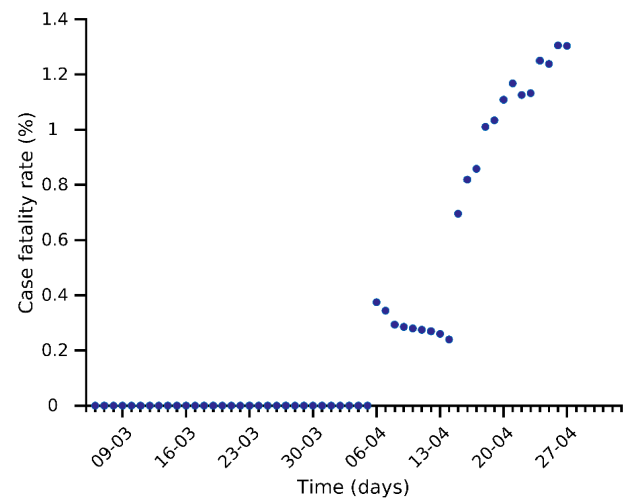
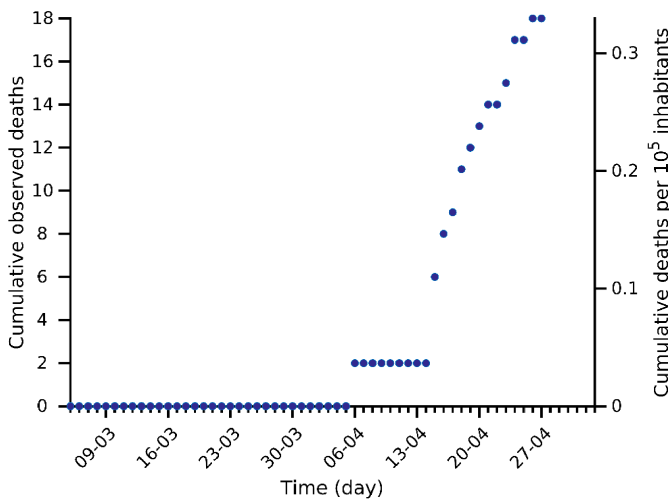
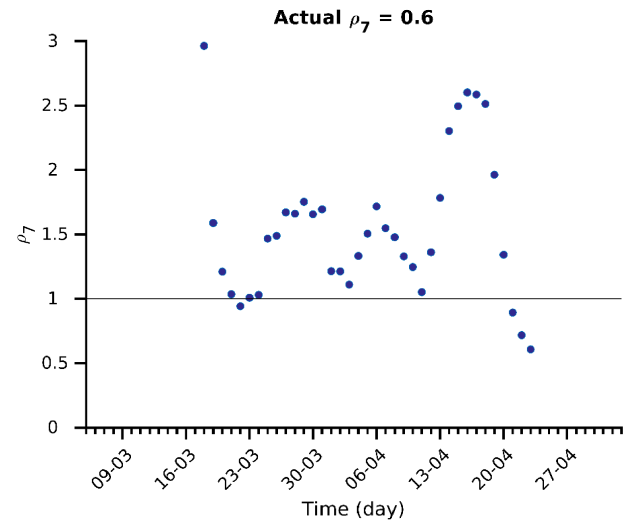
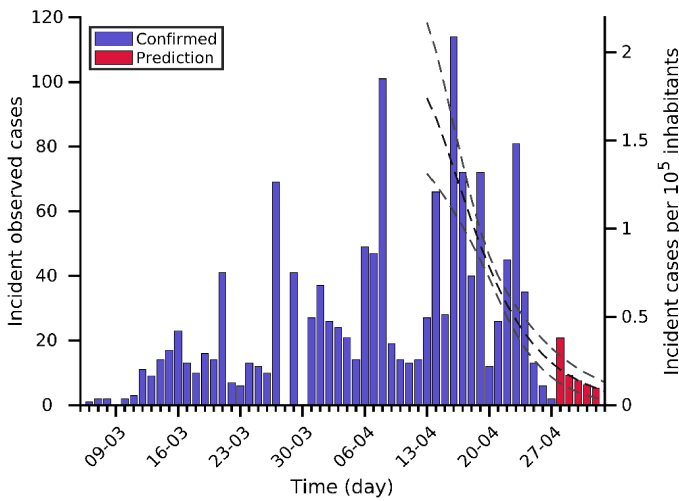
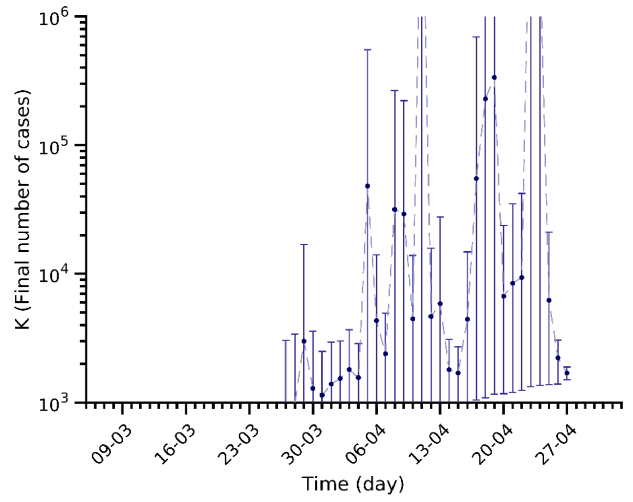
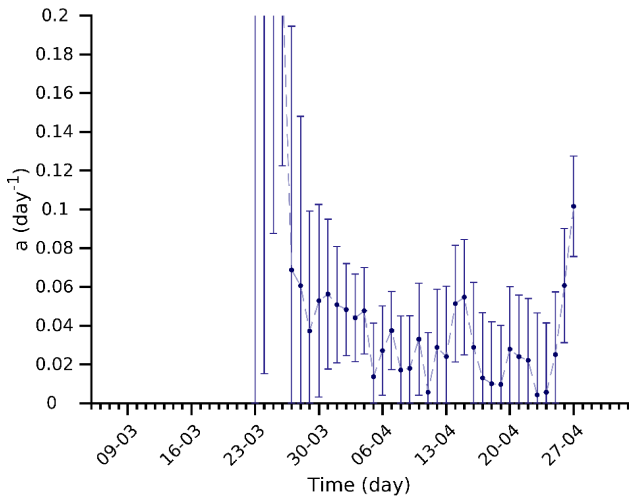
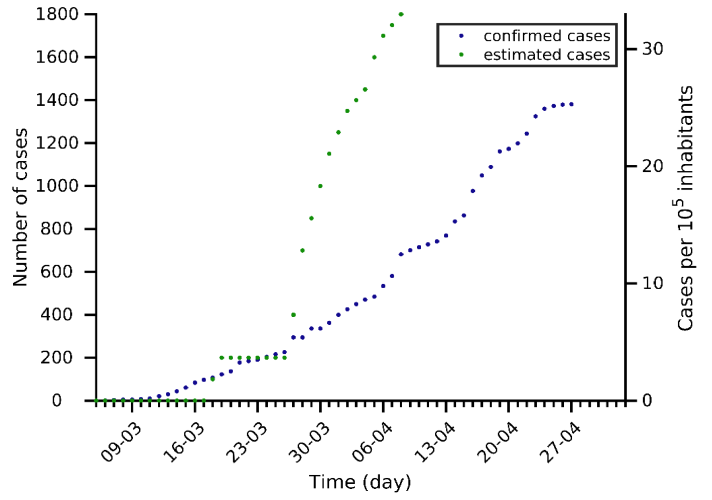
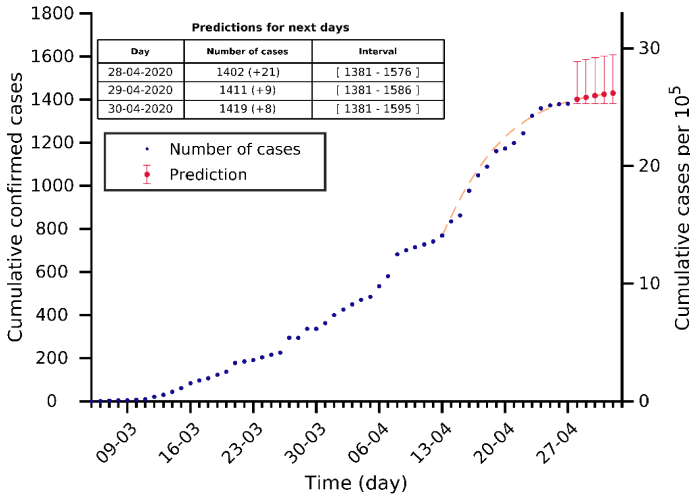
**Slovenia 27-04-2020. Population: 2.1M. Current cumulated incidence: 68/10<sup>5</sup>**



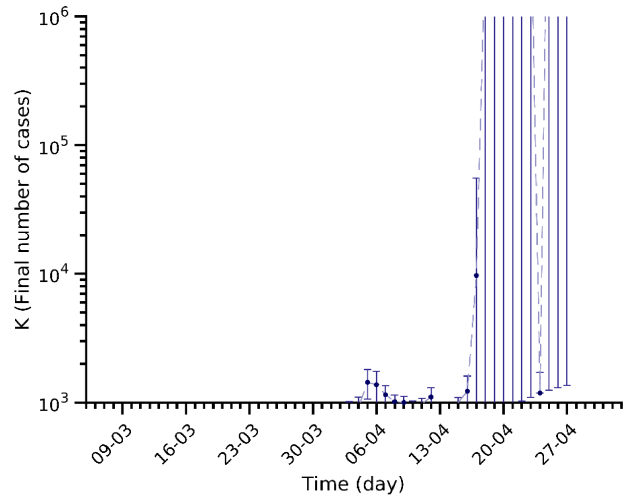
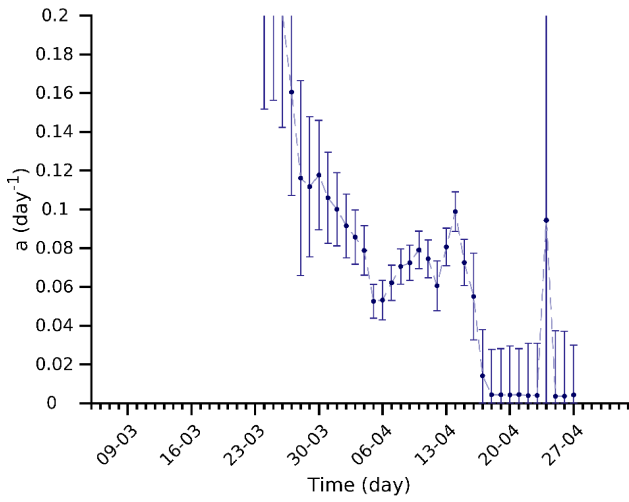
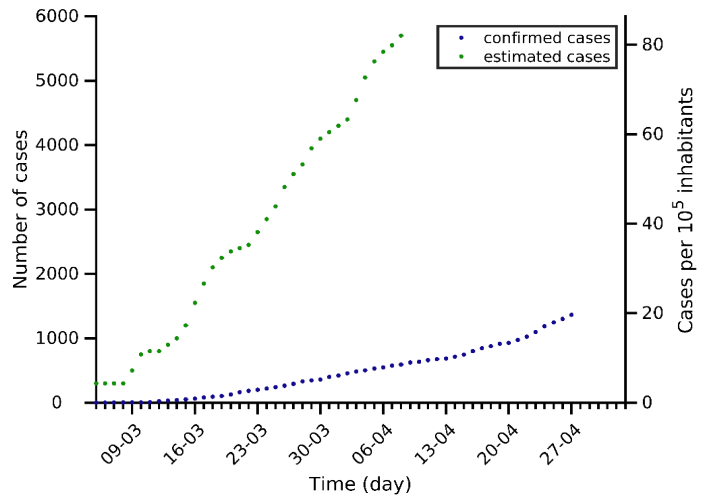
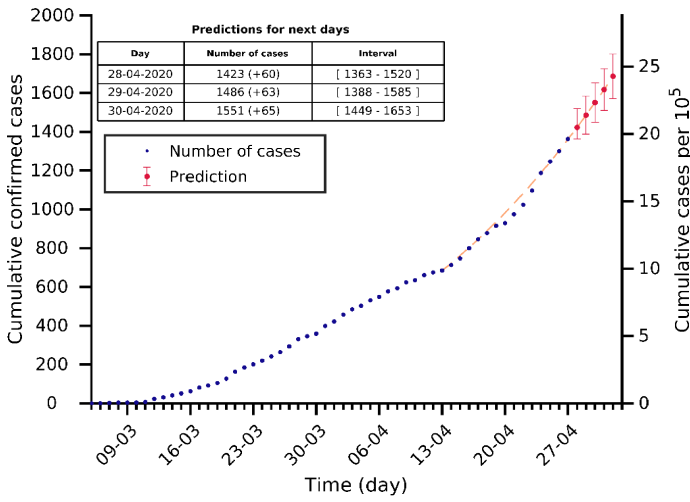
**Actual  $\rho_7 = 0.9$**



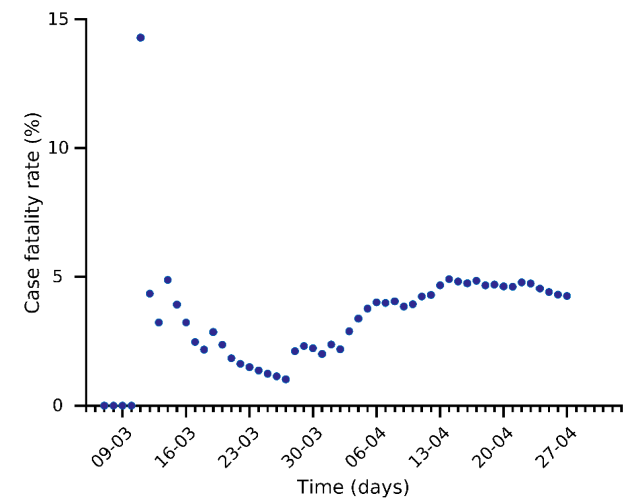
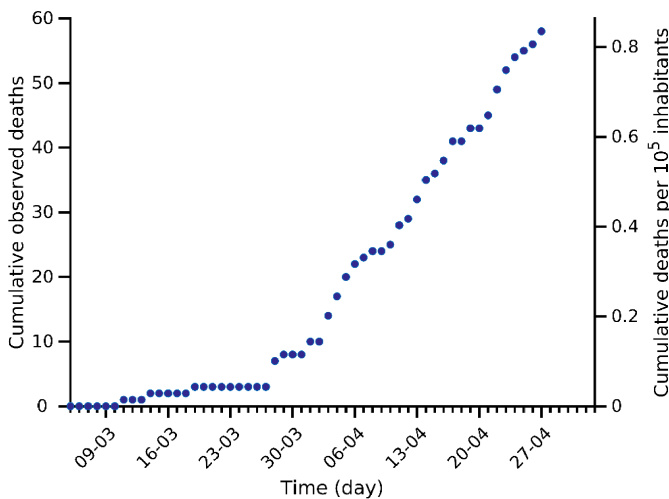
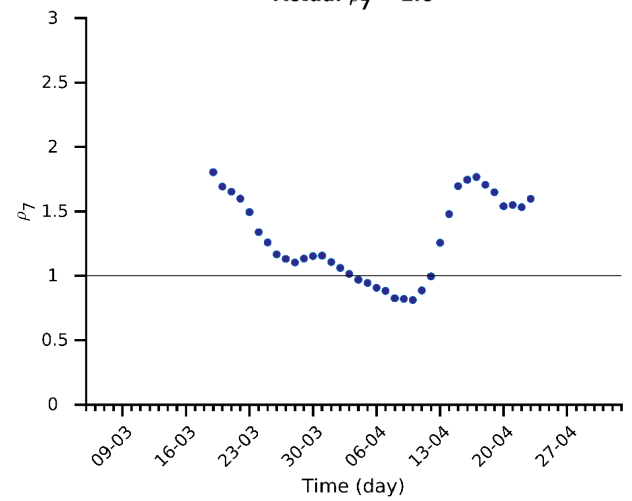
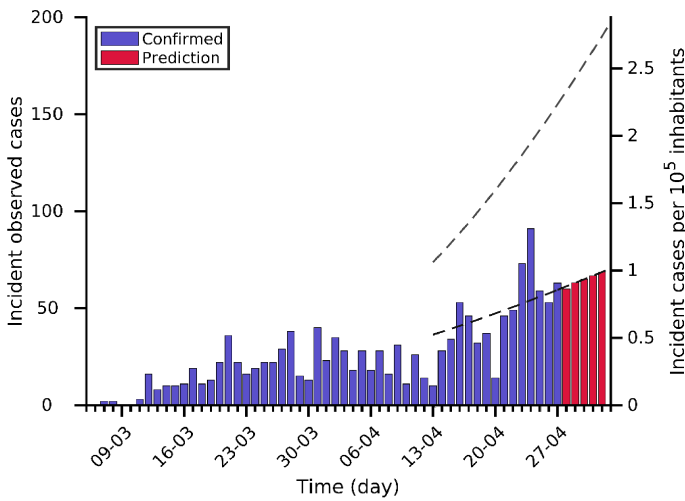
**Slovakia 27-04-2020. Population: 5.5M. Current cumulated incidence: 25/10<sup>5</sup>**



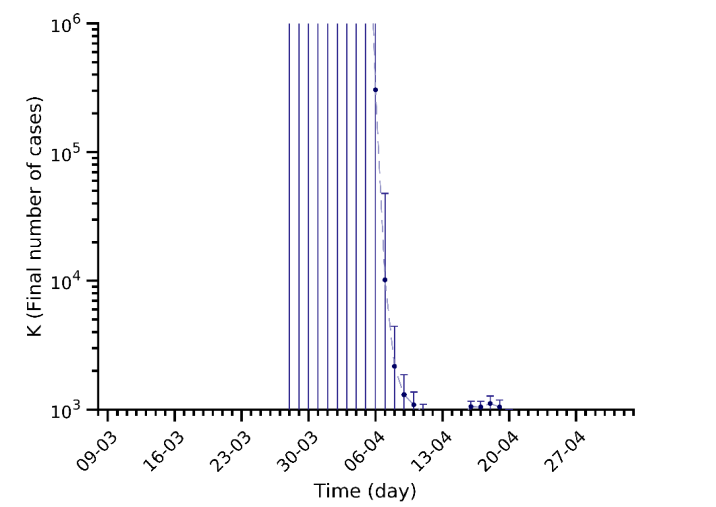
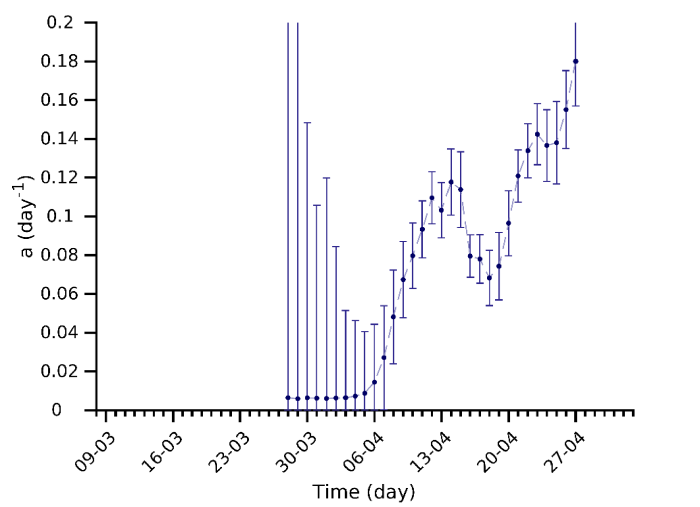
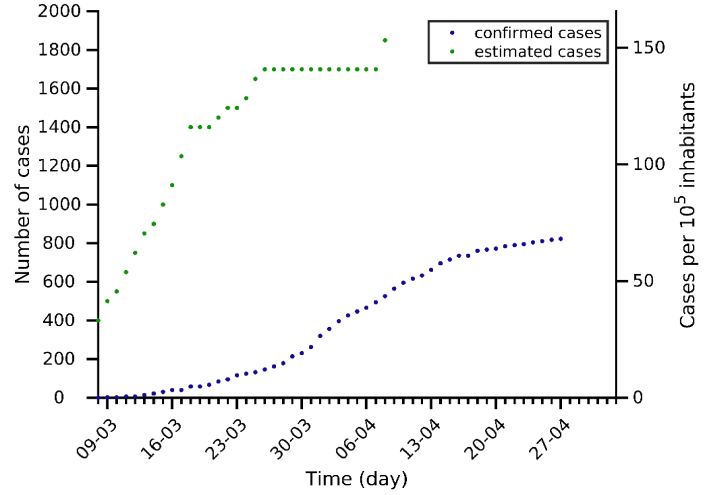
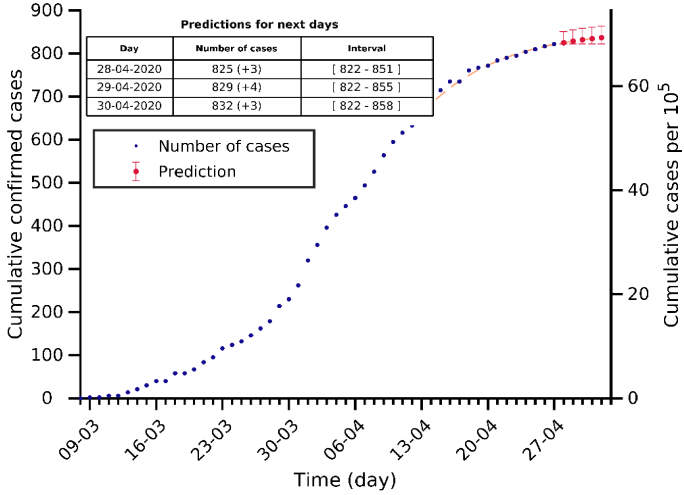
**Bulgaria 27-04-2020. Population: 6.9M. Current cumulated incidence: 20/10<sup>5</sup>**



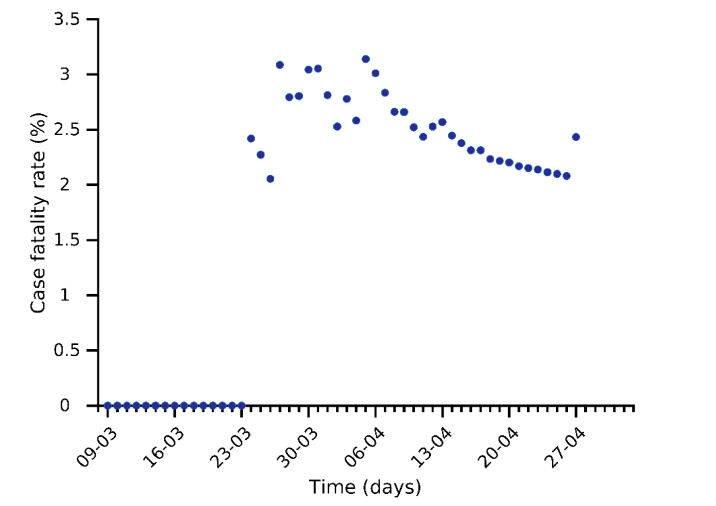
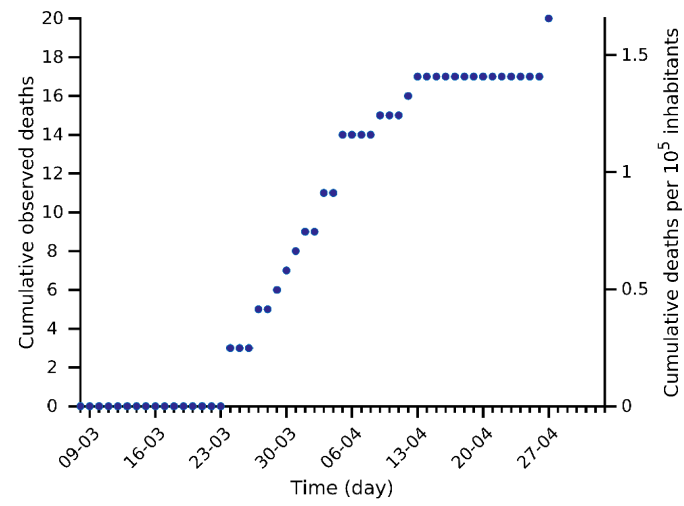
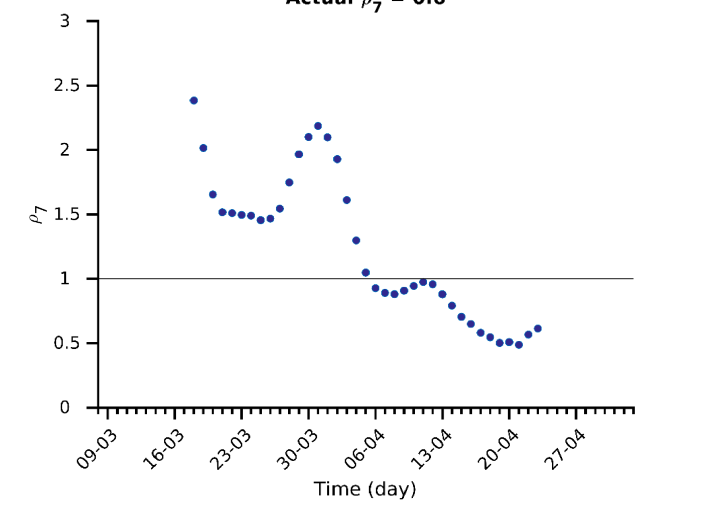
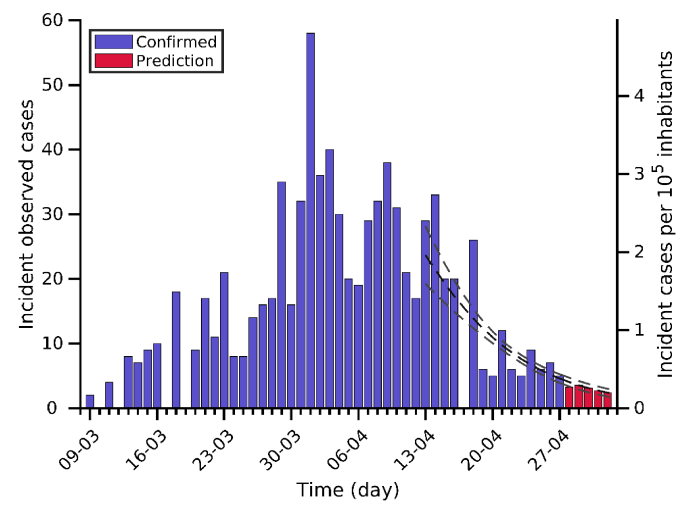
**Actual  $\rho_7 = 1.6$**



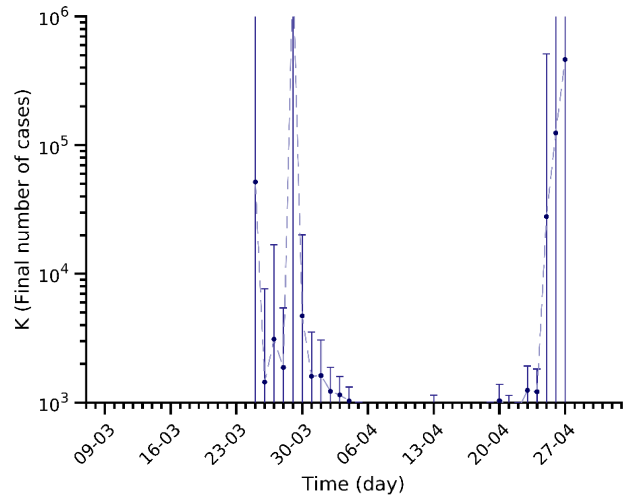
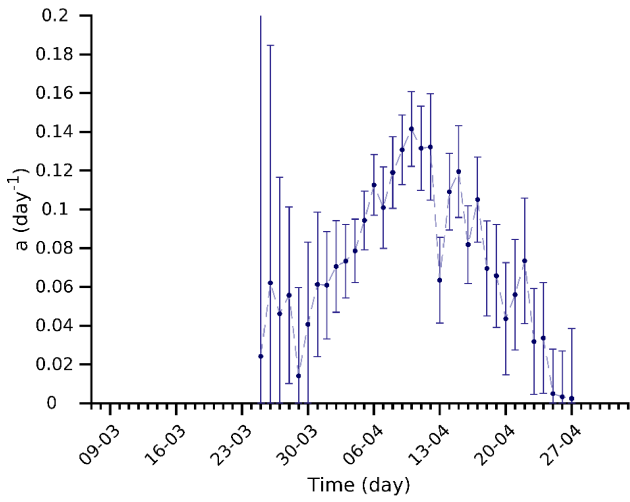
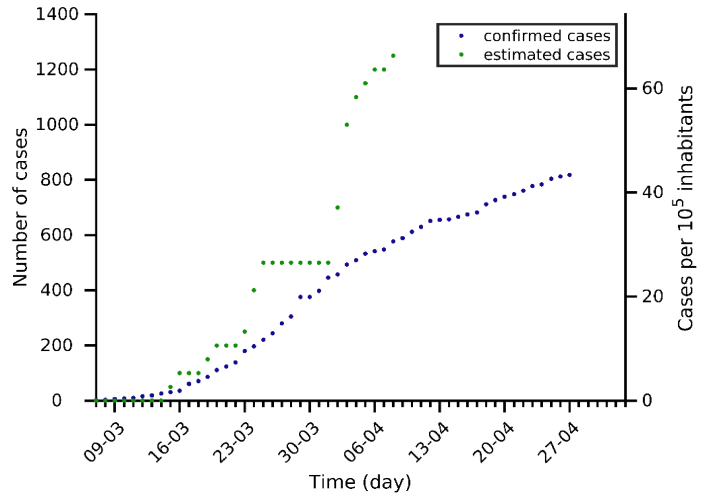
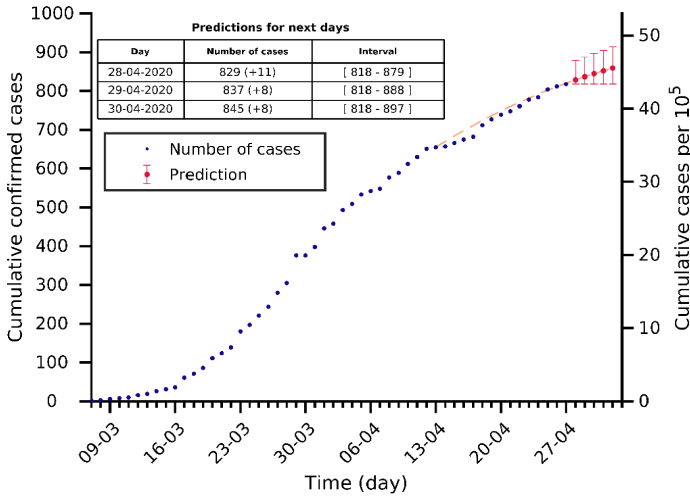
**Cyprus 27-04-2020. Population: 1.2M. Current cumulated incidence: 68/10<sup>5</sup>**



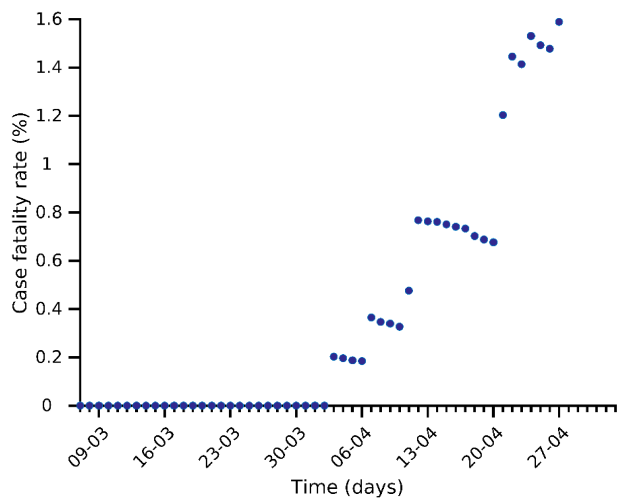
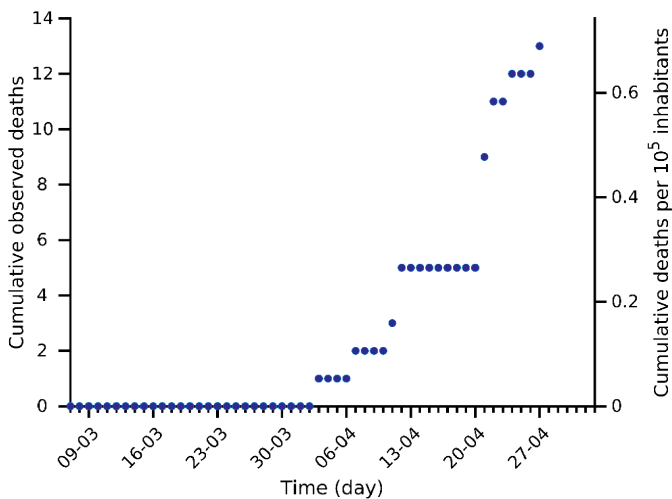
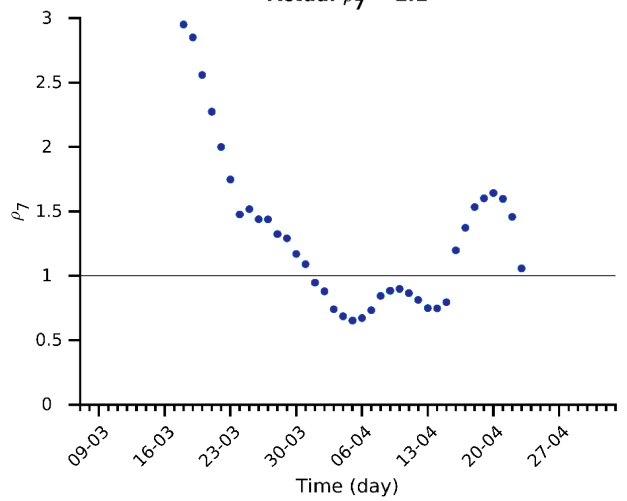
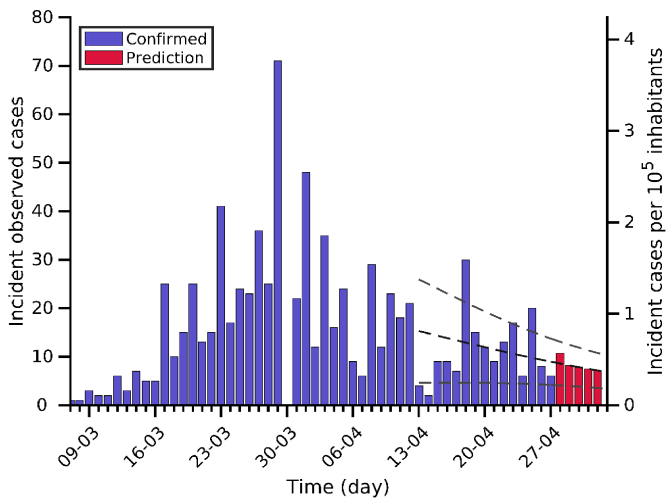
**Actual  $\rho_7 = 0.6$**



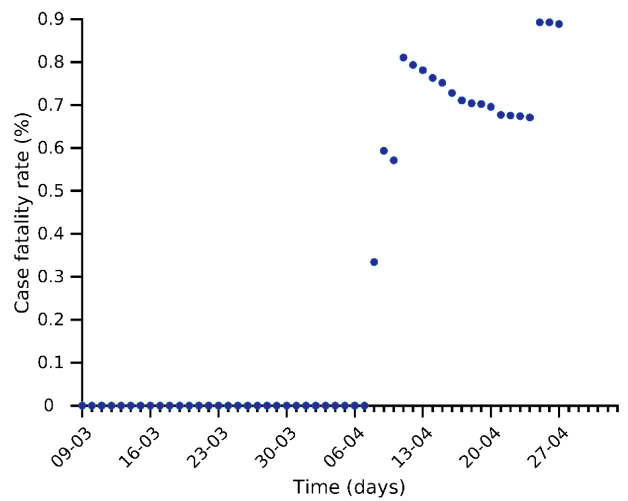
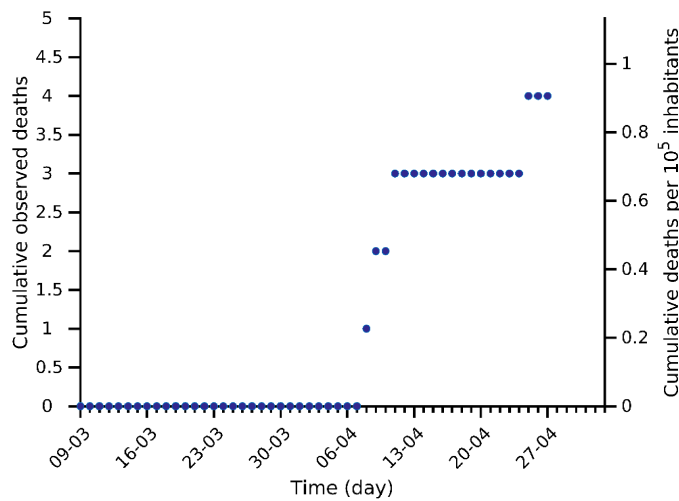
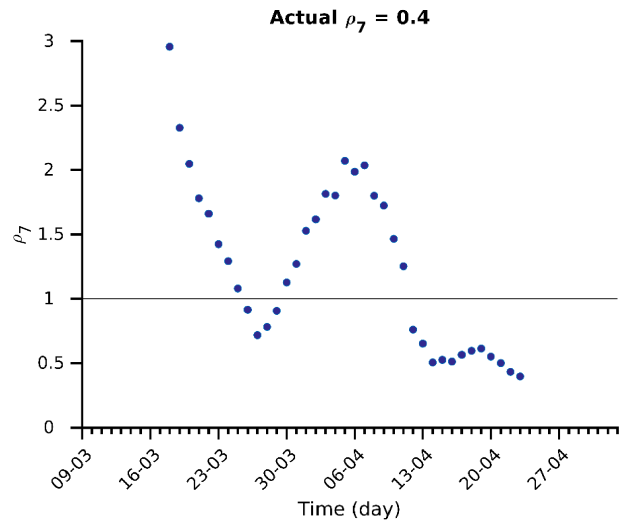
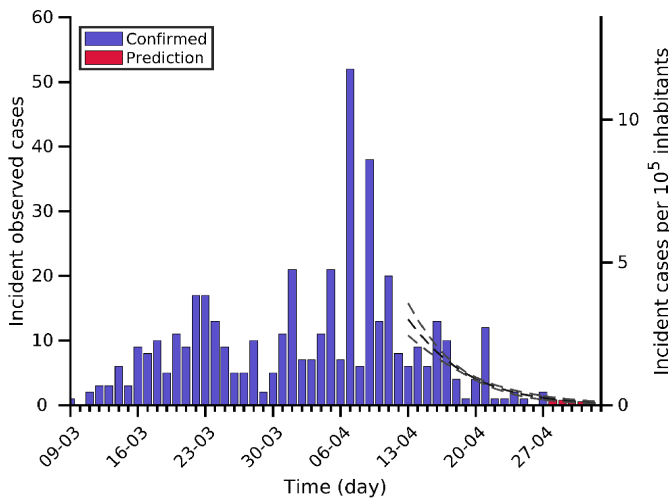
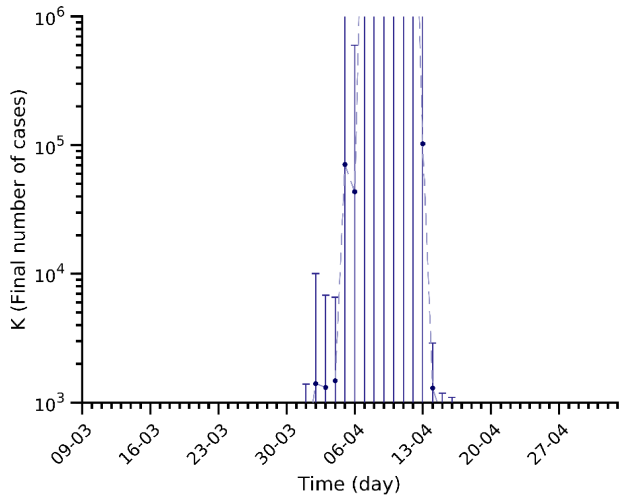
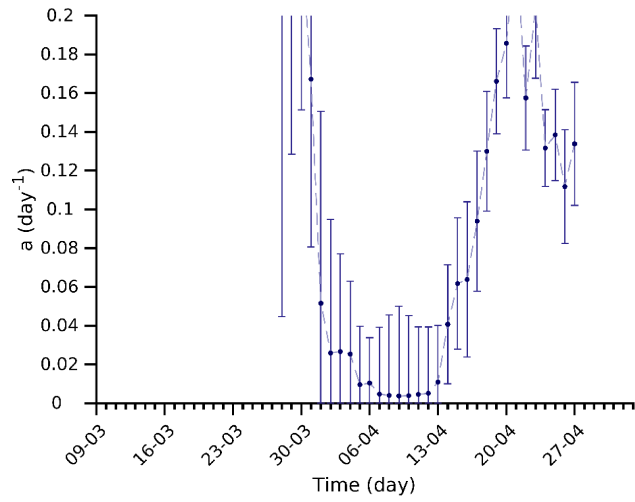
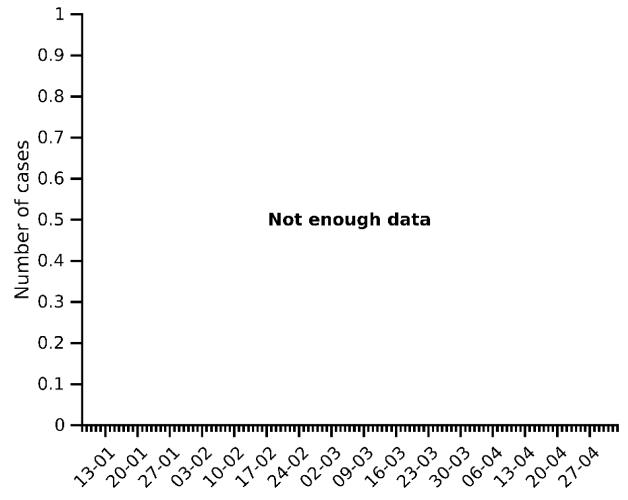
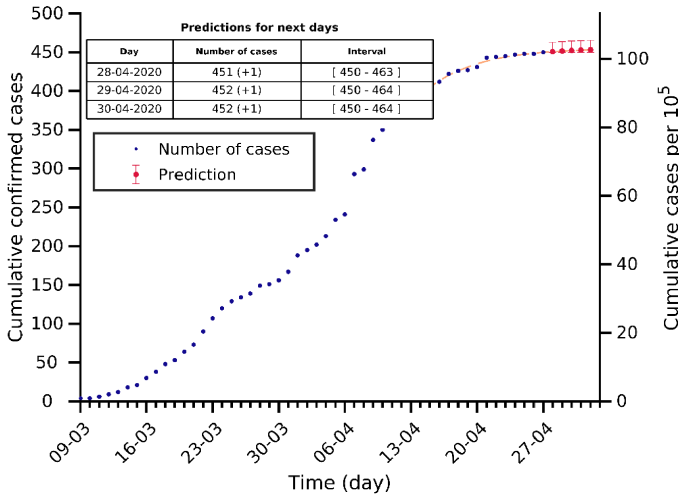
**Latvia 27-04-2020. Population: 1.9M. Current cumulated incidence: 43/10<sup>5</sup>**



**Actual  $\rho_7 = 1.1$**



**Malta 27-04-2020. Population: 0.4M. Current cumulated incidence: 102/10<sup>5</sup>**

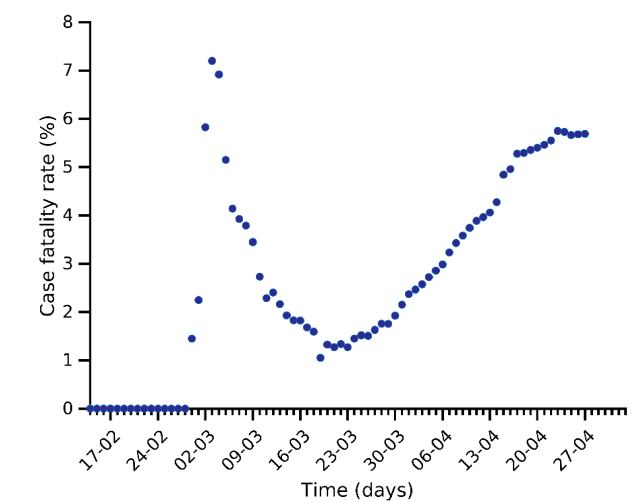
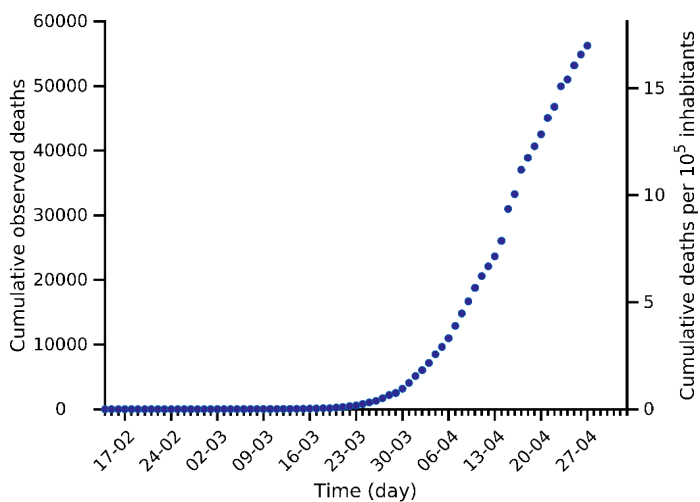
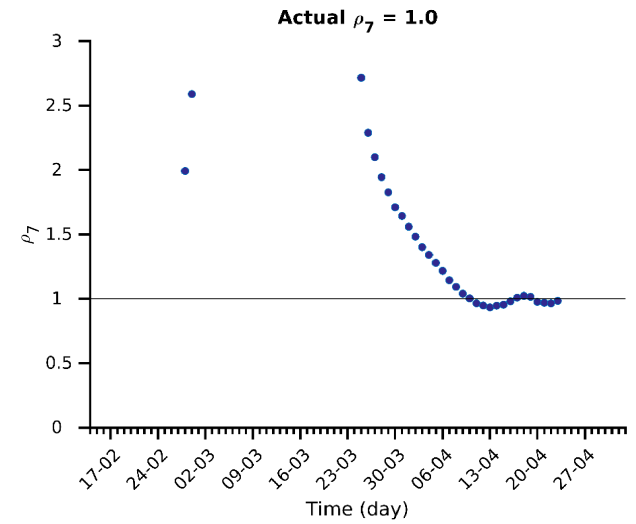
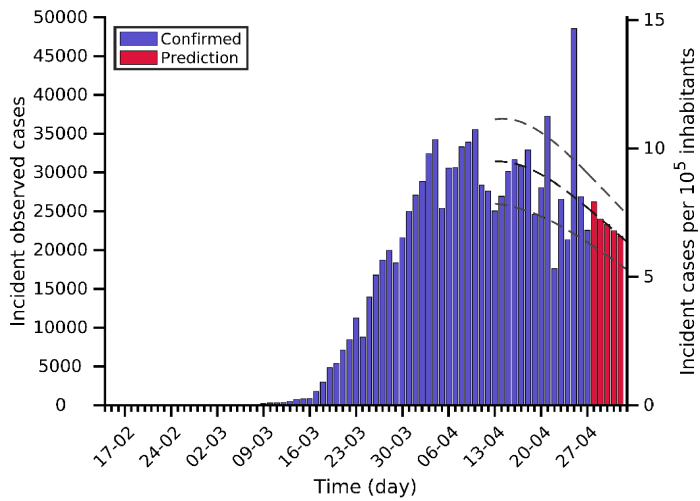
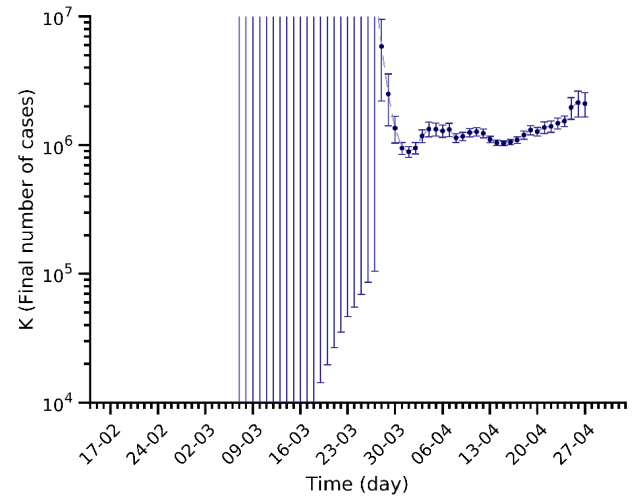
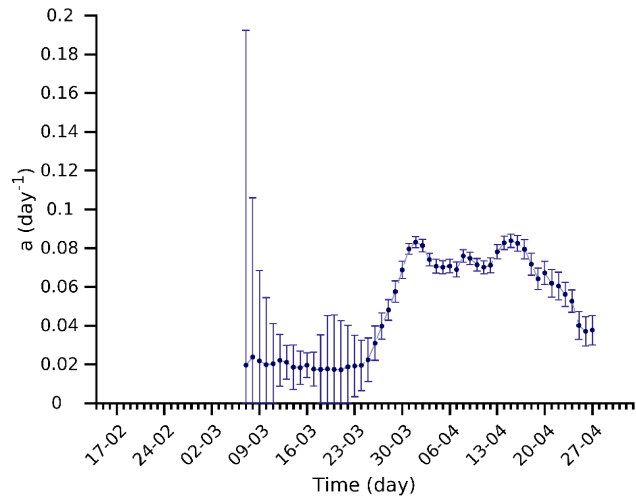
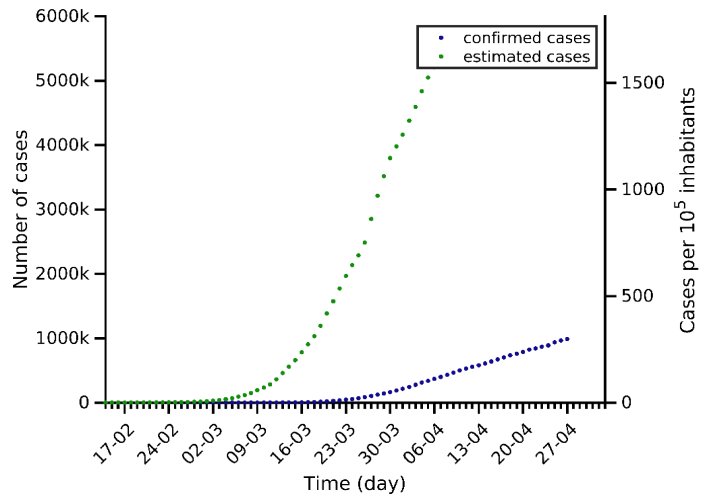
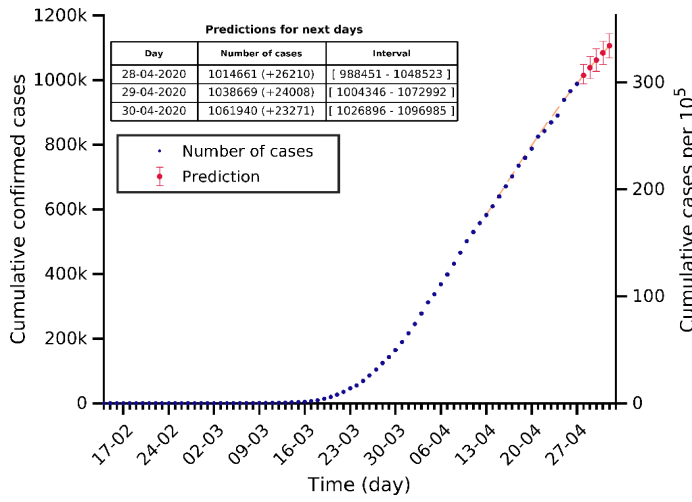


## **(2) Analysis and prediction of COVID-19 for other countries**

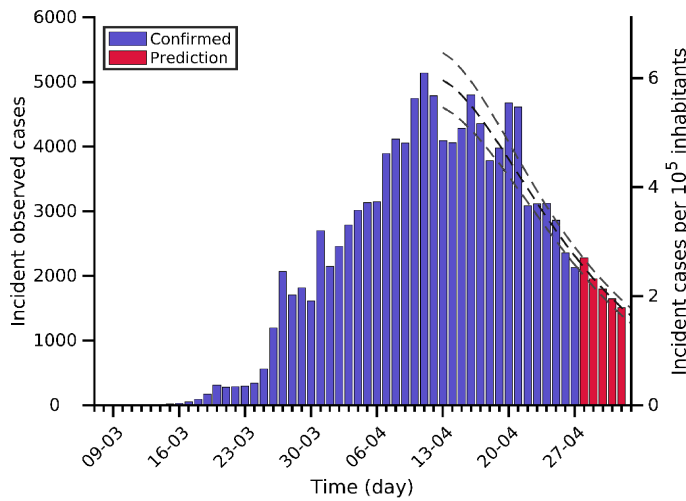
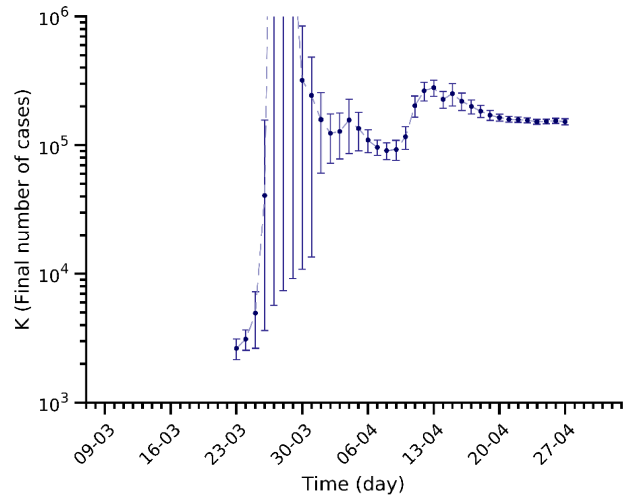
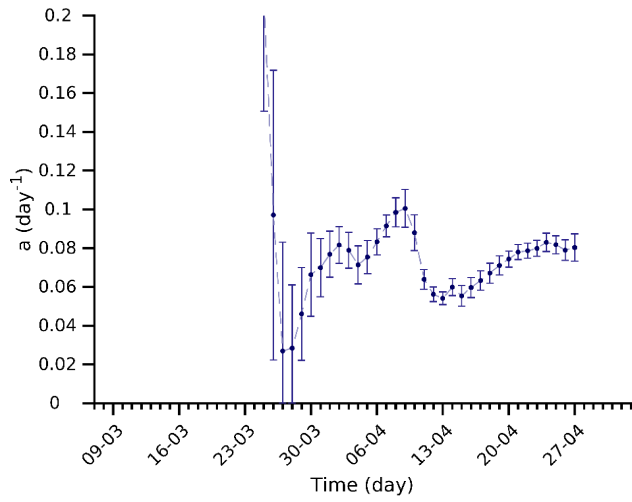
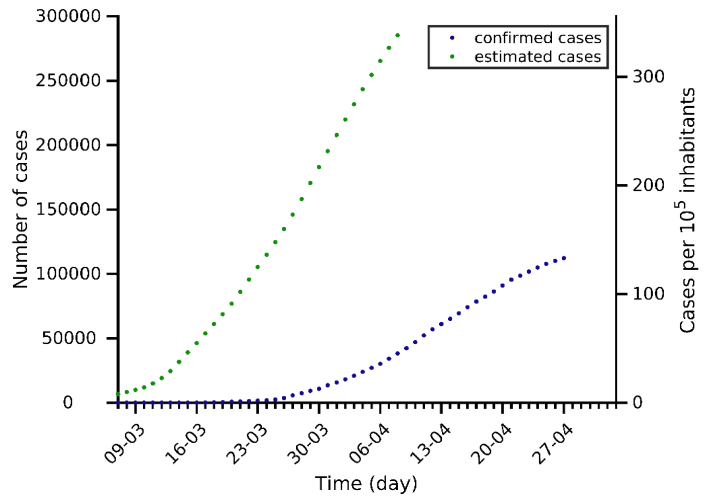
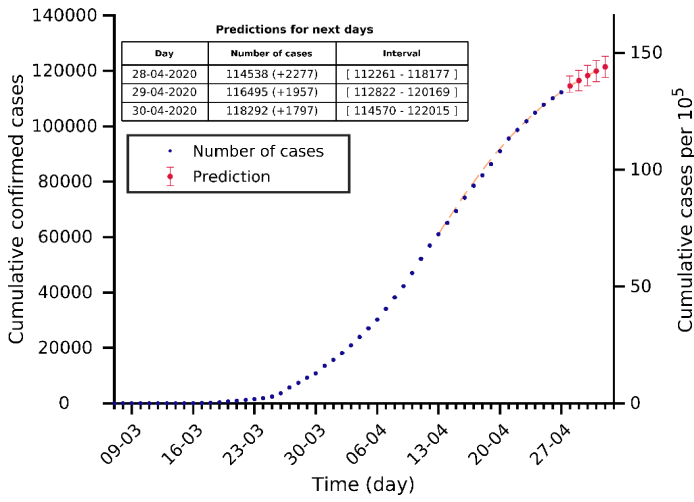
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>



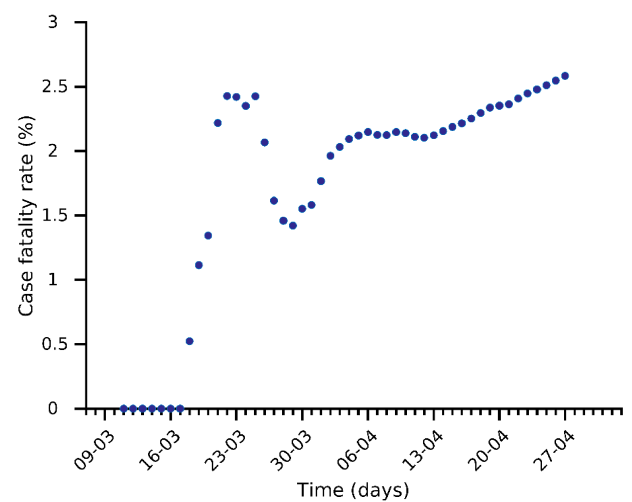
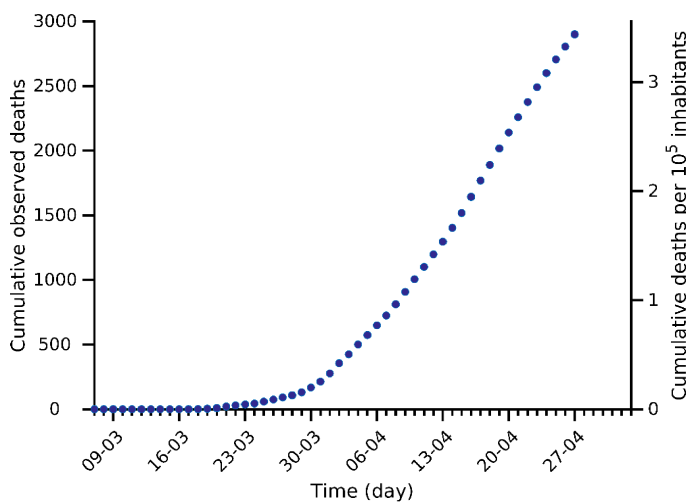
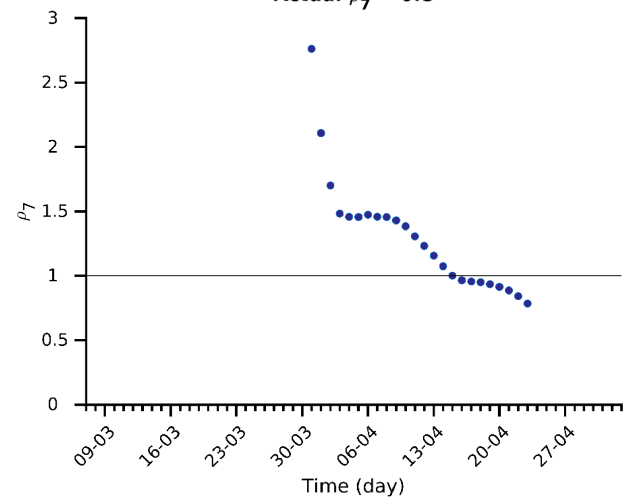
**USA 27-04-2020. Population: 331.0M. Current cumulated incidence: 299/10<sup>5</sup>**



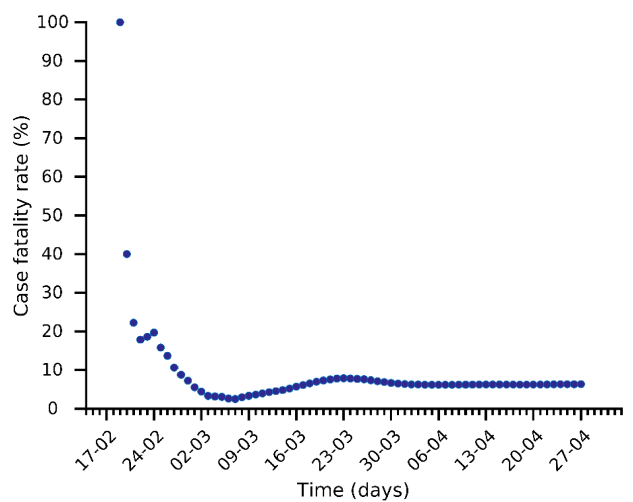
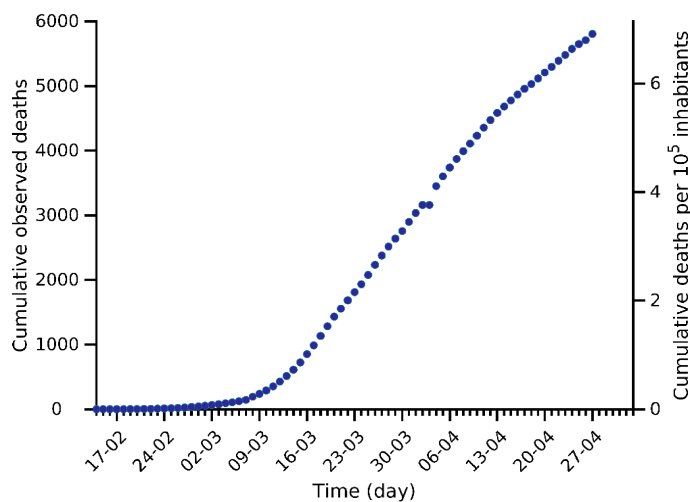
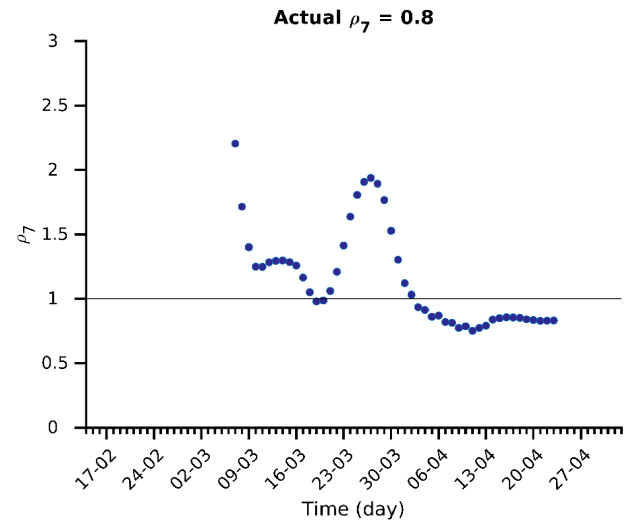
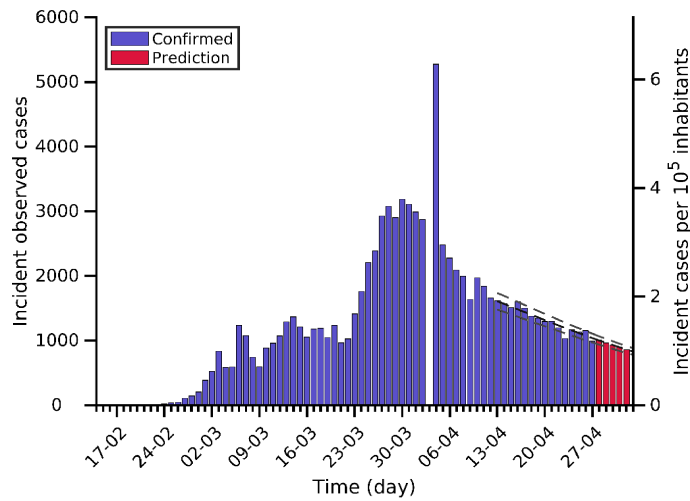
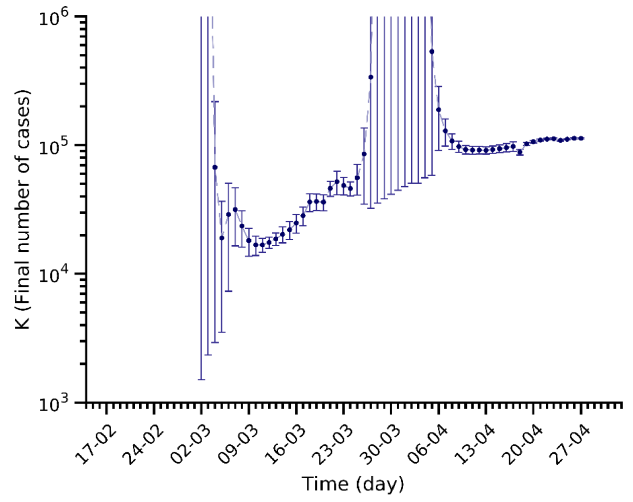
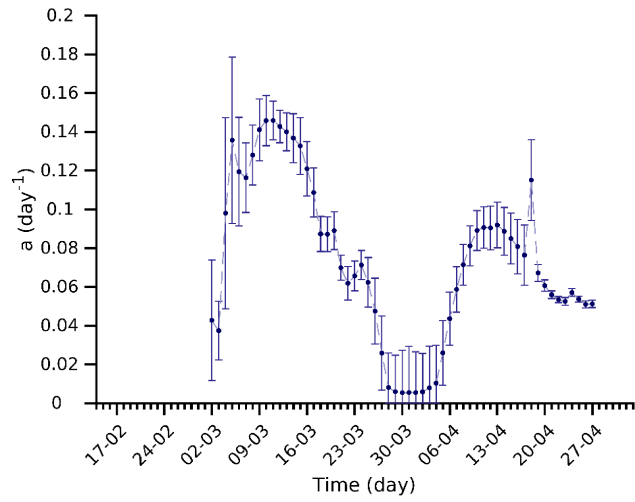
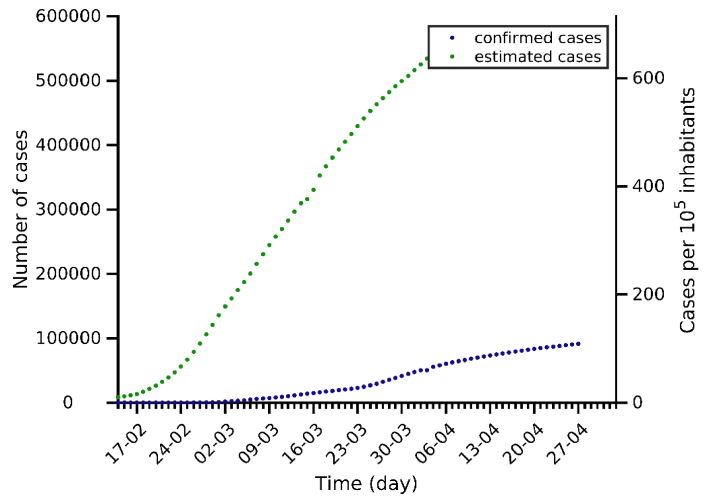
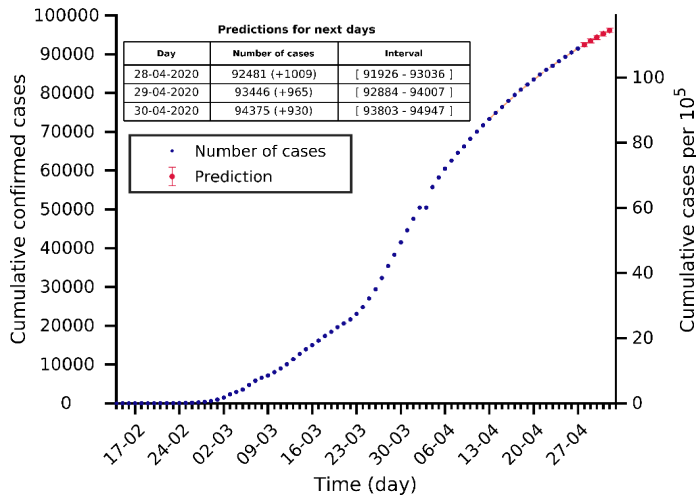
Turkey 27-04-2020. Population: 84.3M. Current cumulated incidence: 133/10<sup>5</sup>



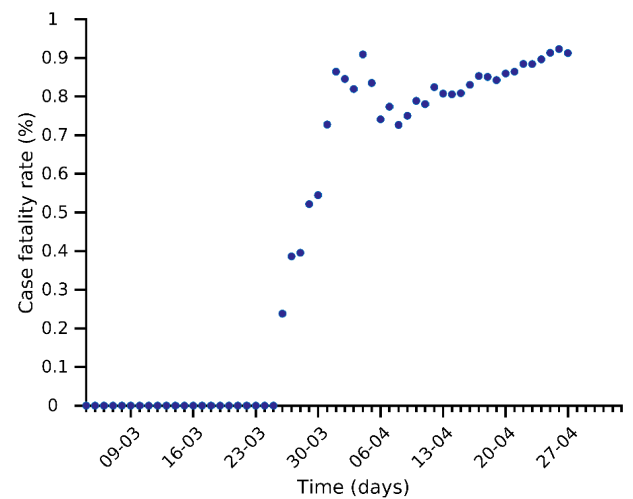
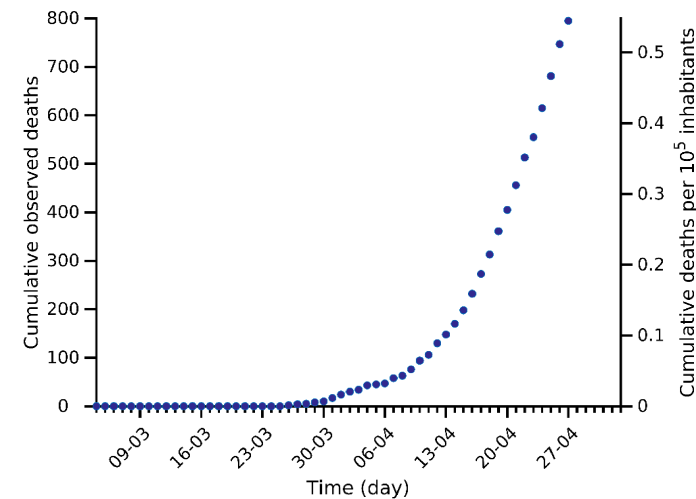
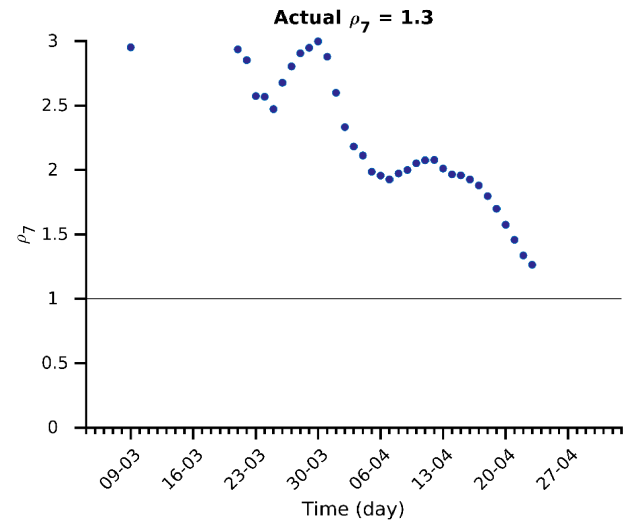
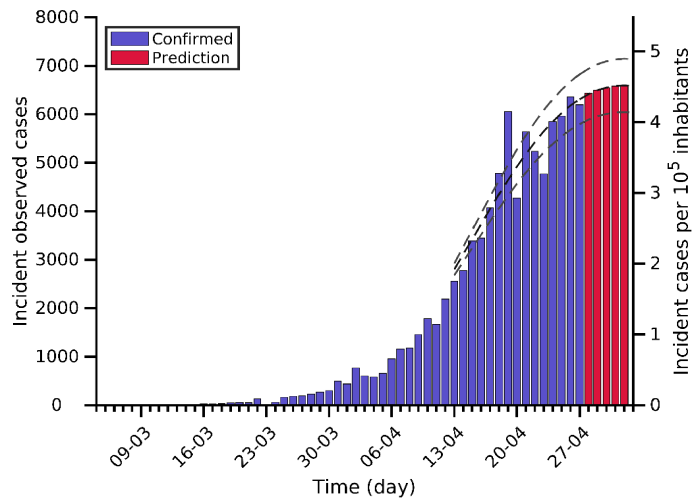
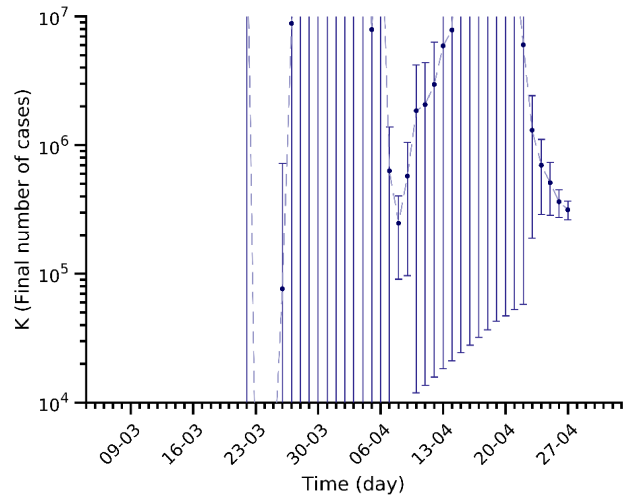
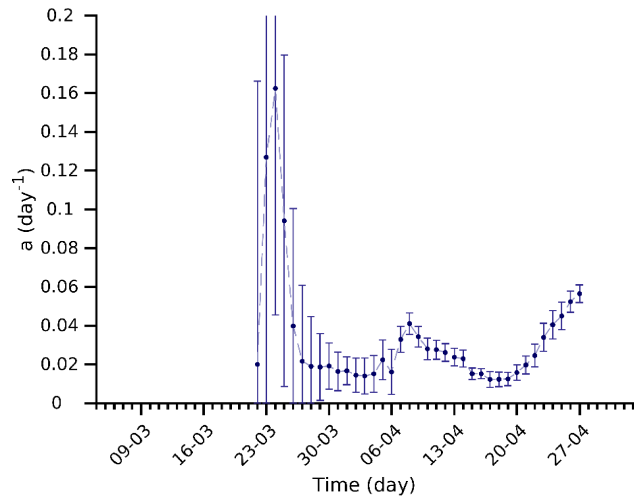
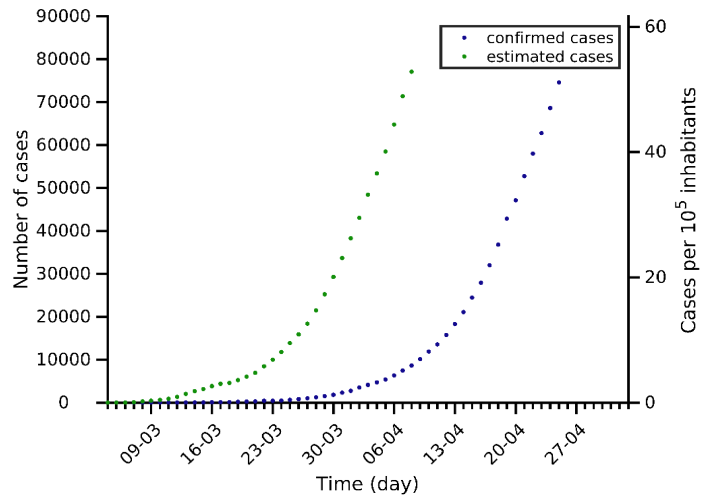
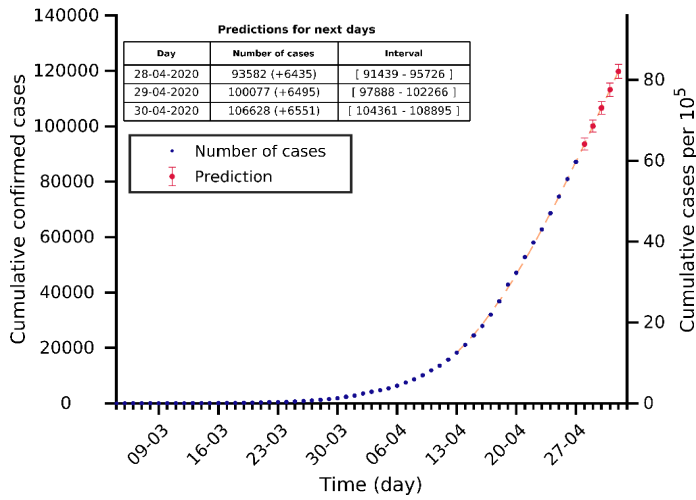
**Actual  $\rho_7 = 0.8$**



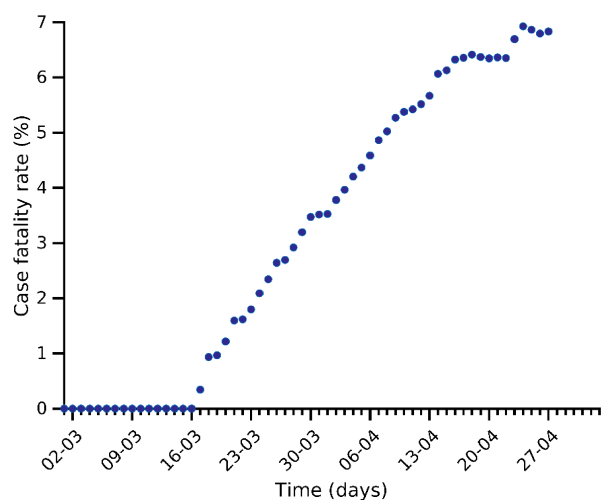
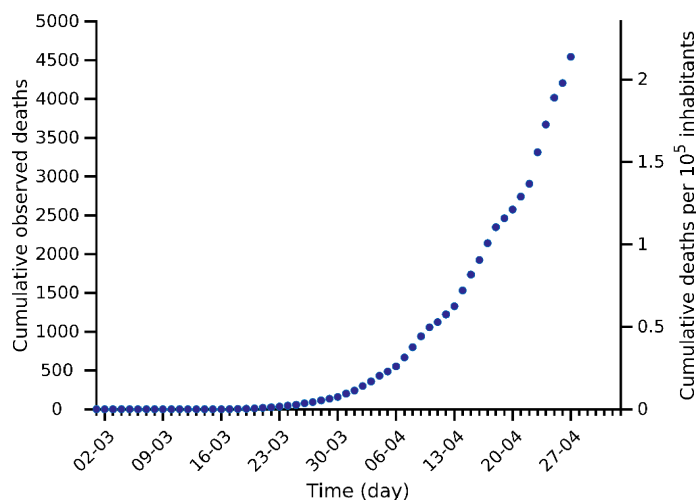
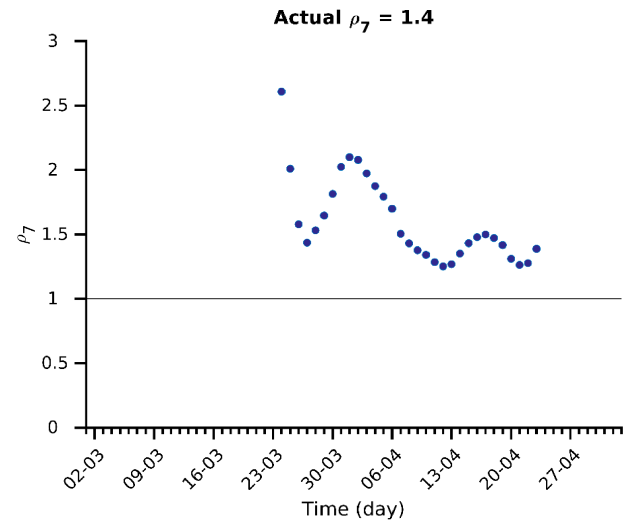
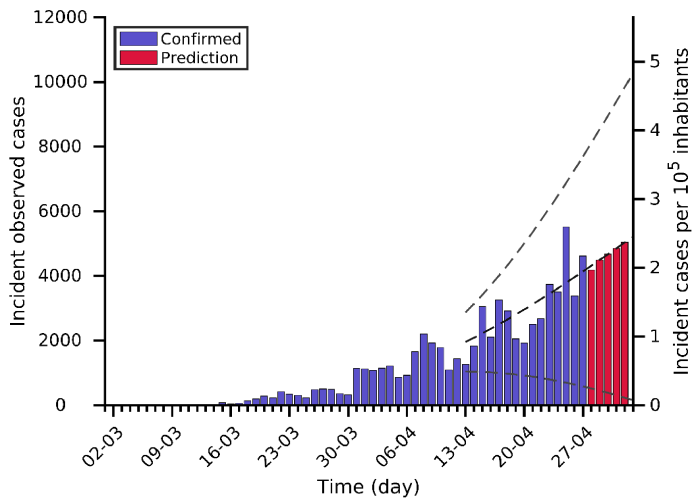
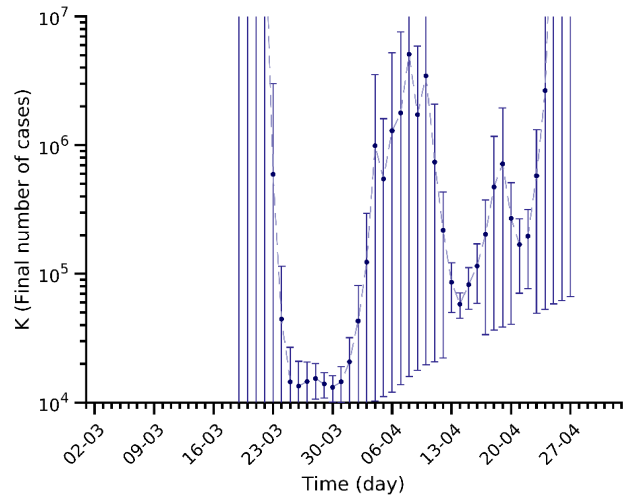
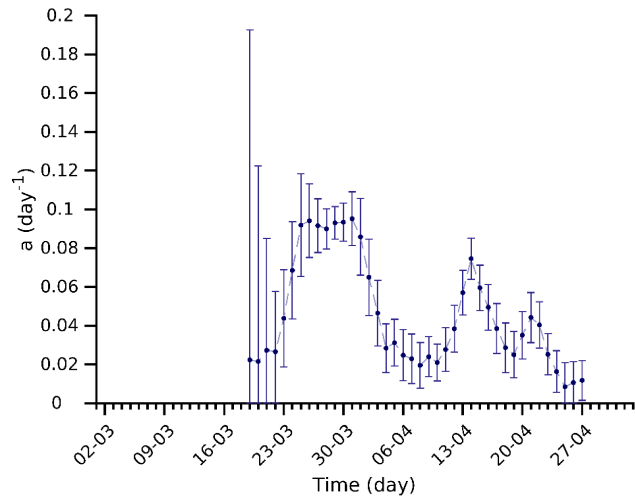
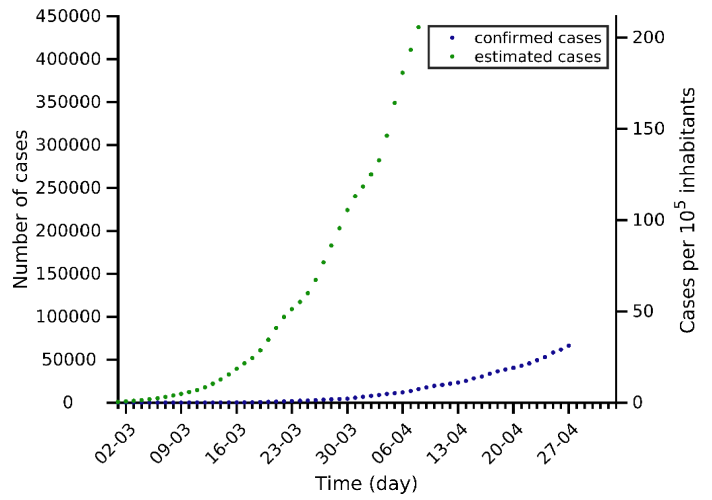
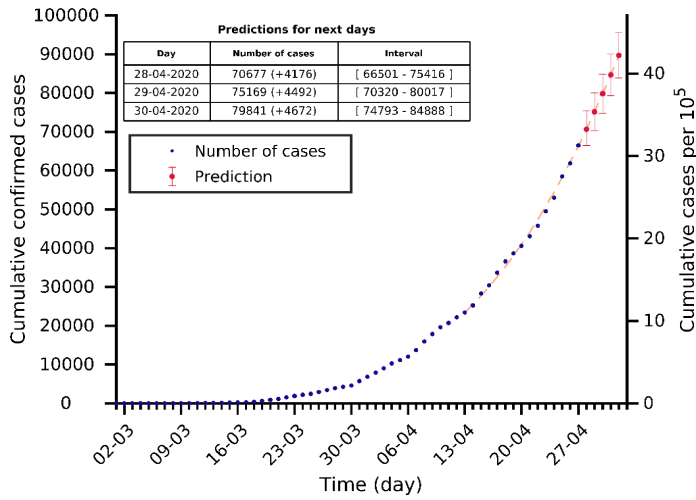
**Iran 27-04-2020. Population: 84.0M. Current cumulated incidence: 109/10<sup>5</sup>**



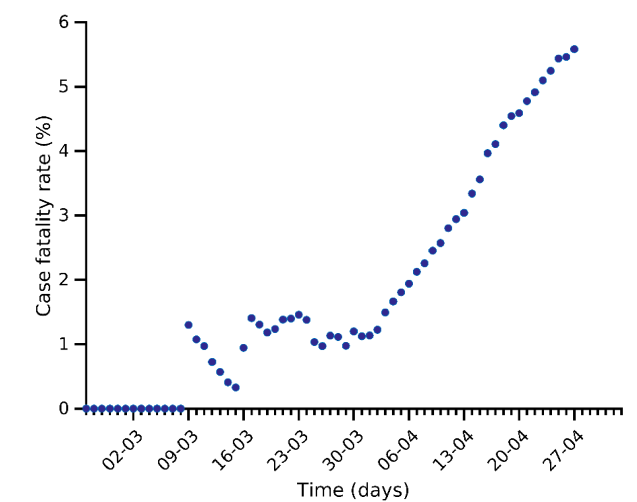
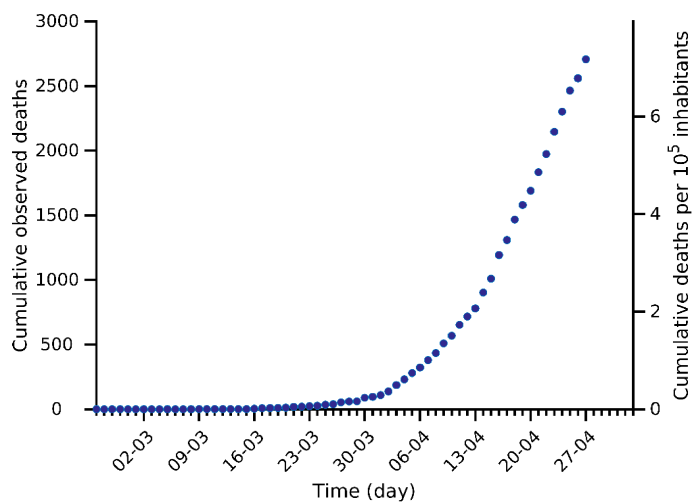
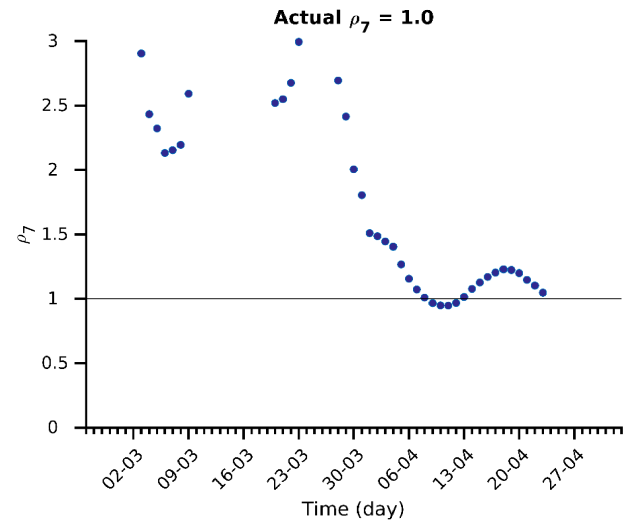
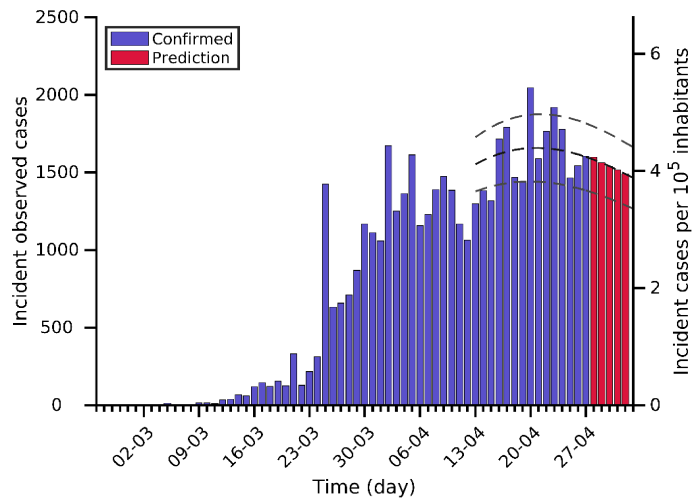
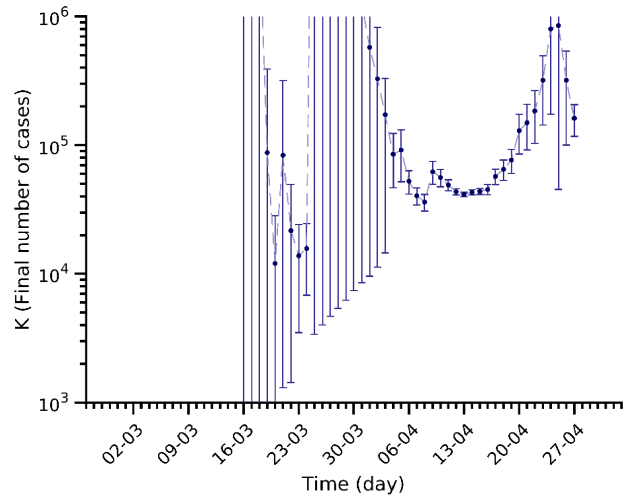
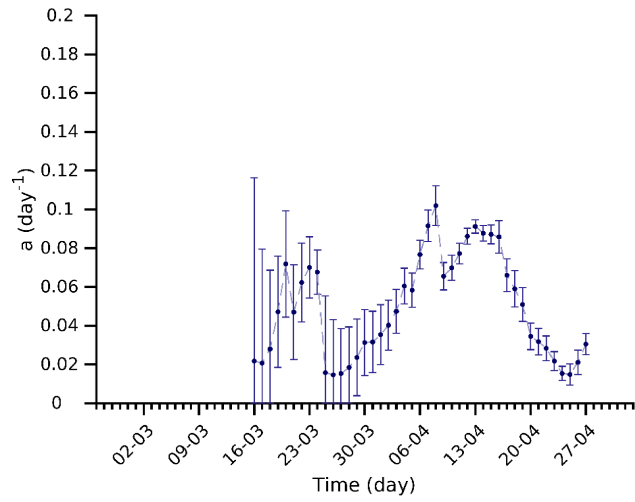
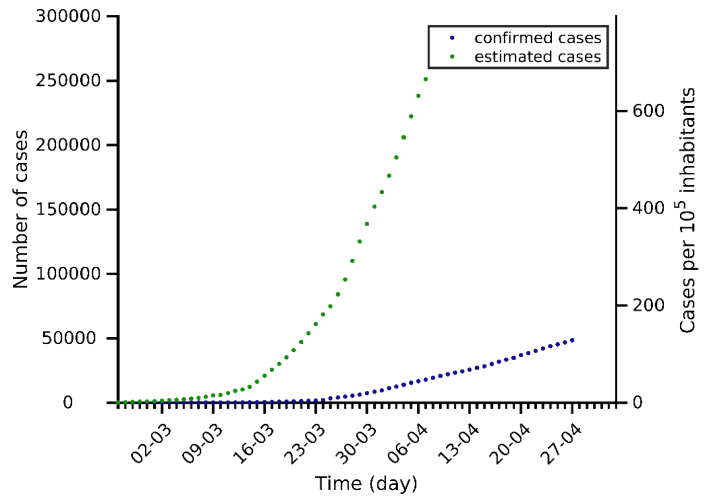
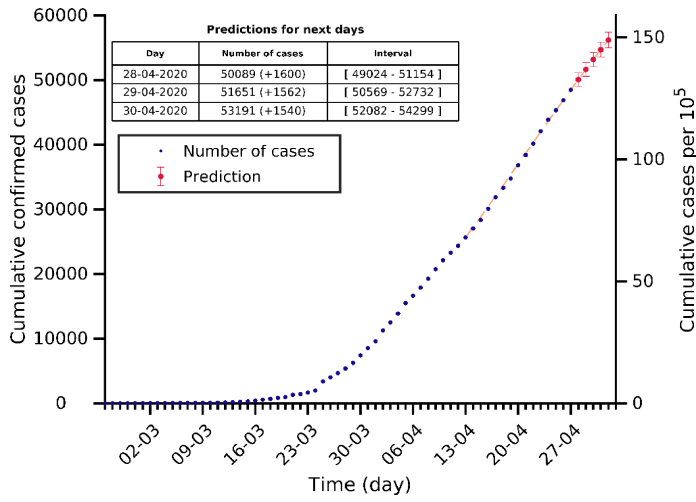
**Russia 27-04-2020. Population: 145.9M. Current cumulated incidence: 60/10<sup>5</sup>**



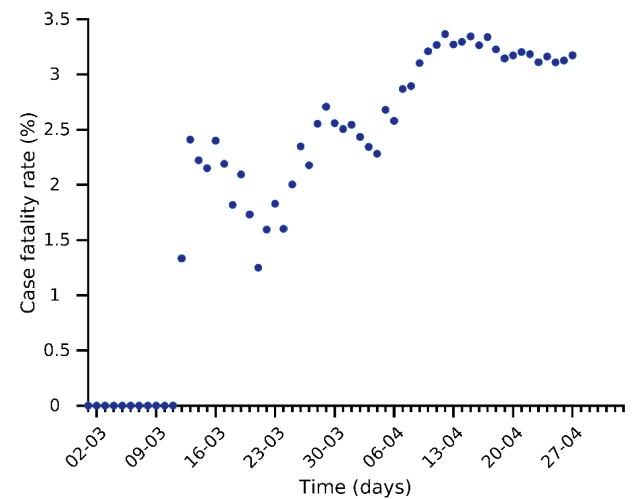
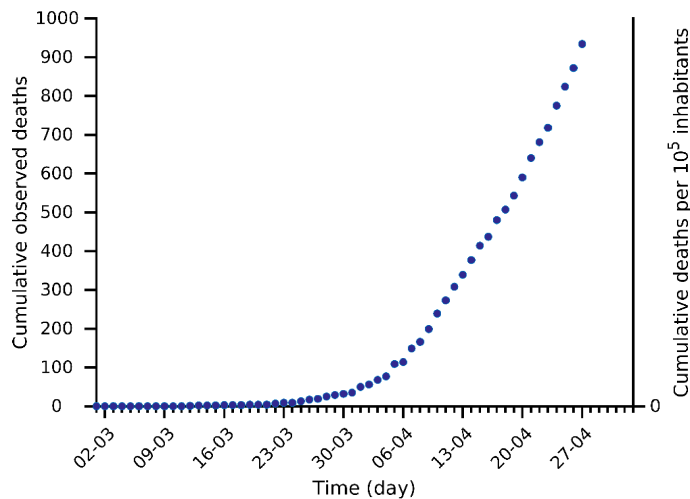
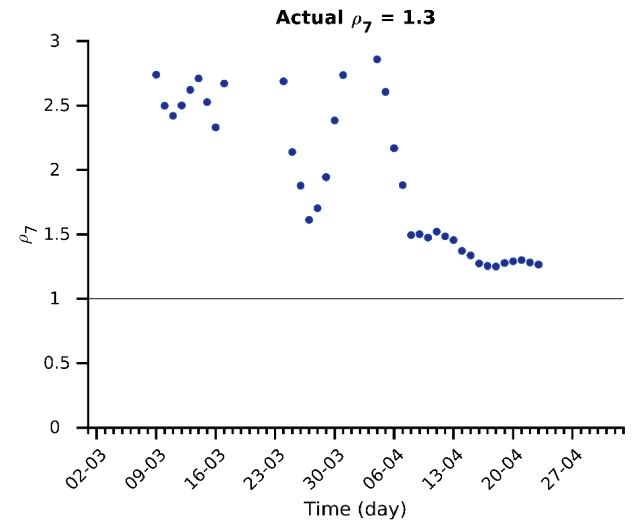
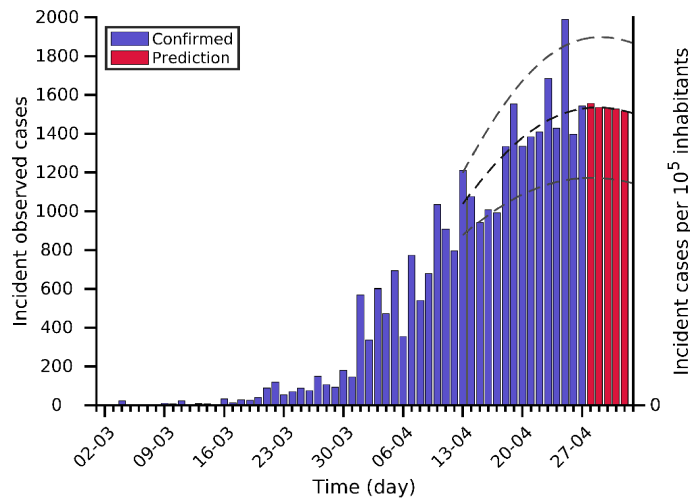
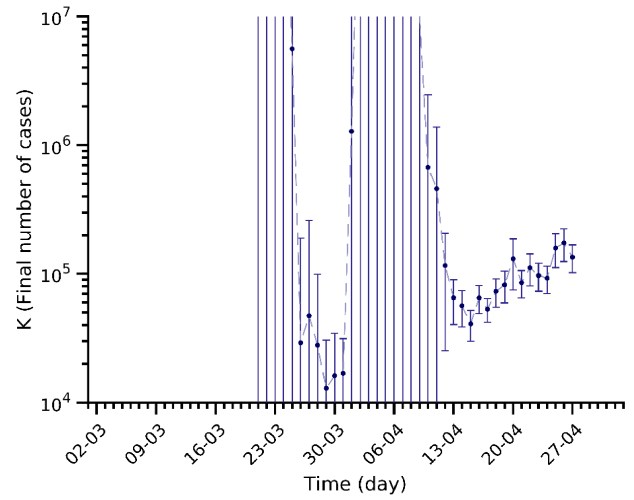
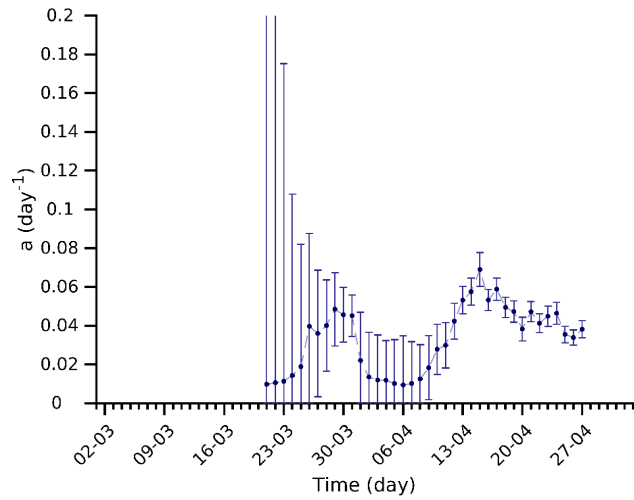
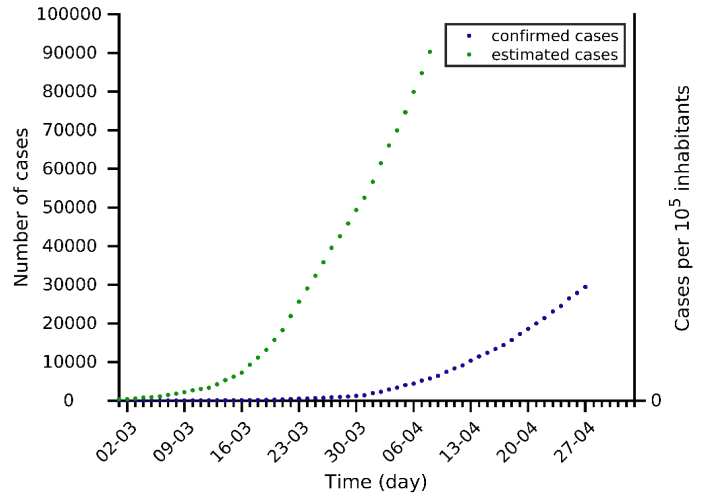
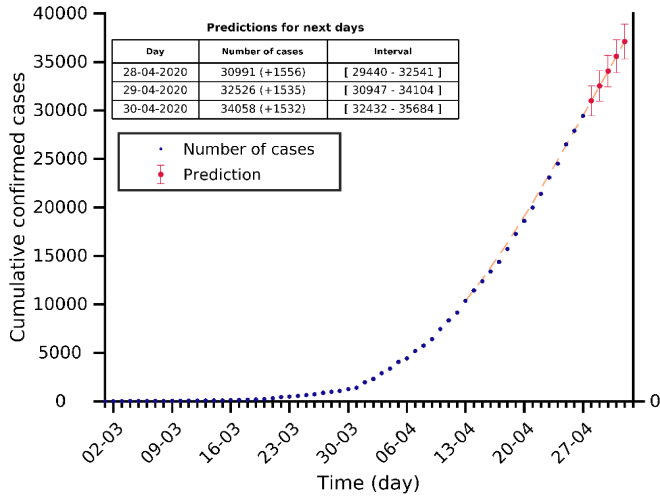
**Brazil 27-04-2020. Population: 212.6M. Current cumulated incidence: 31/10<sup>5</sup>**



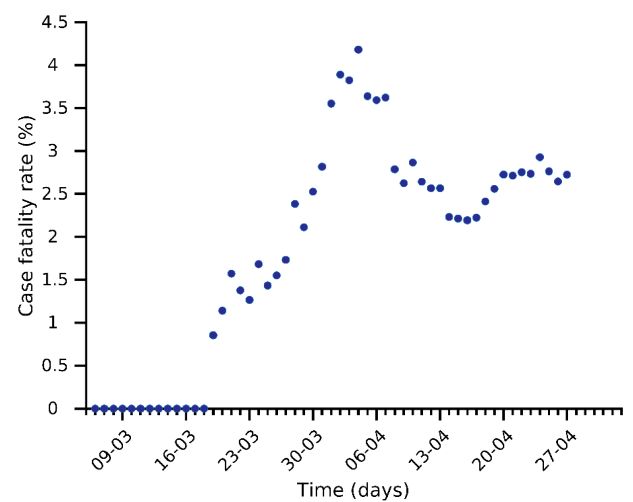
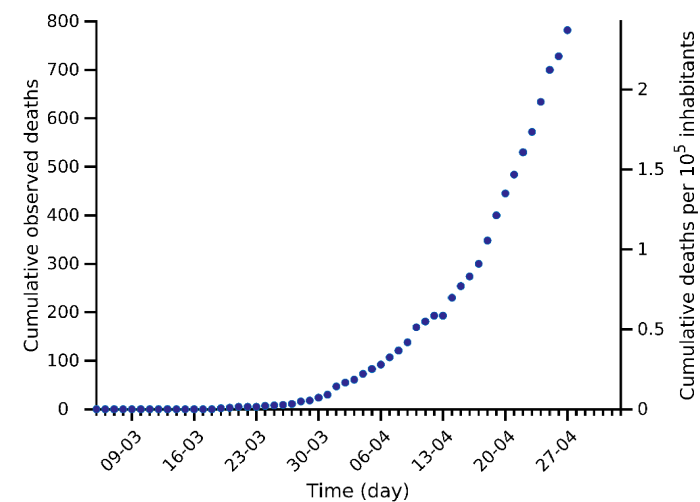
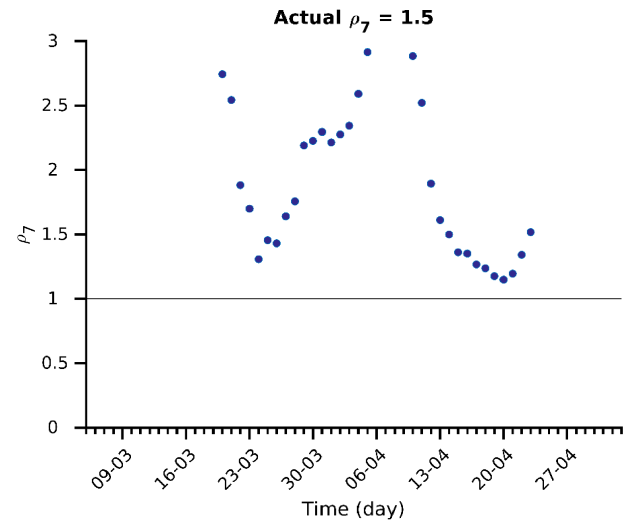
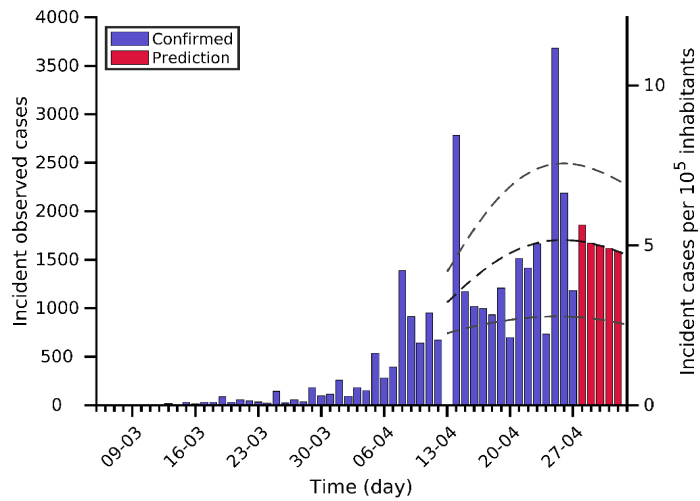
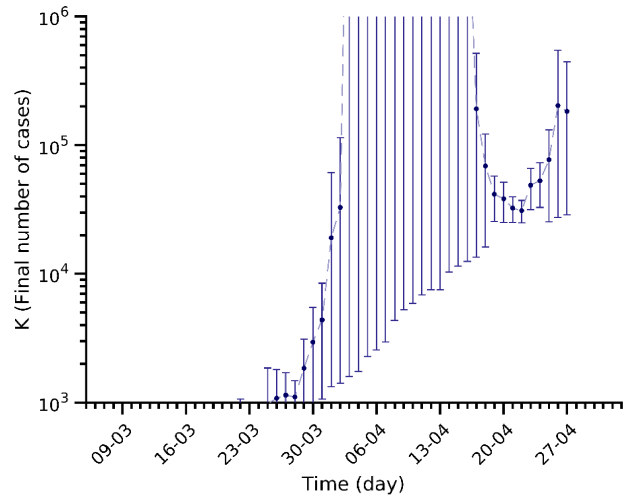
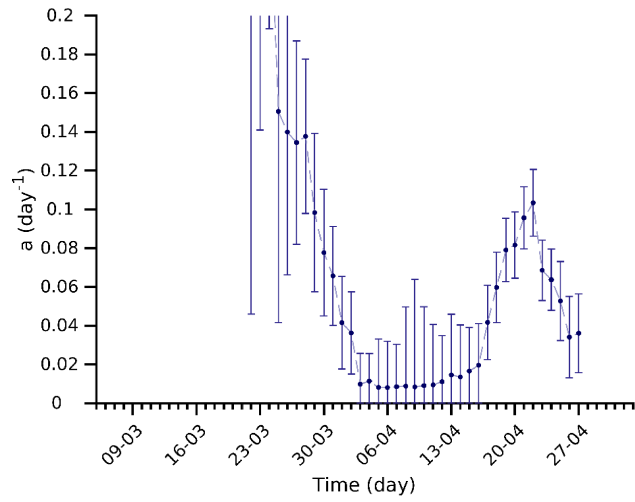
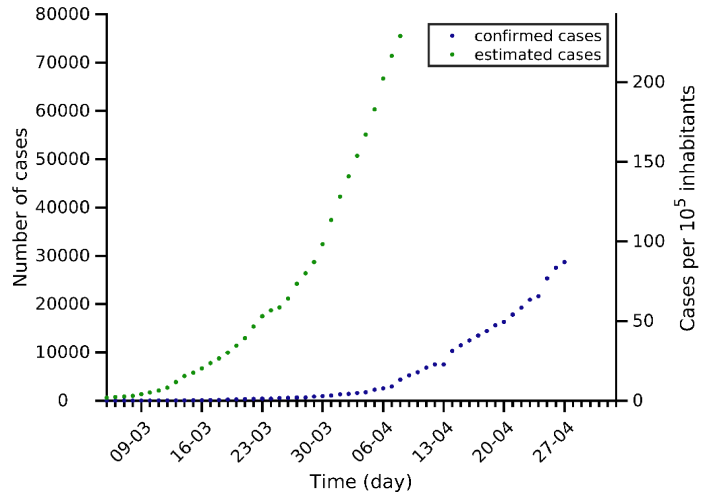
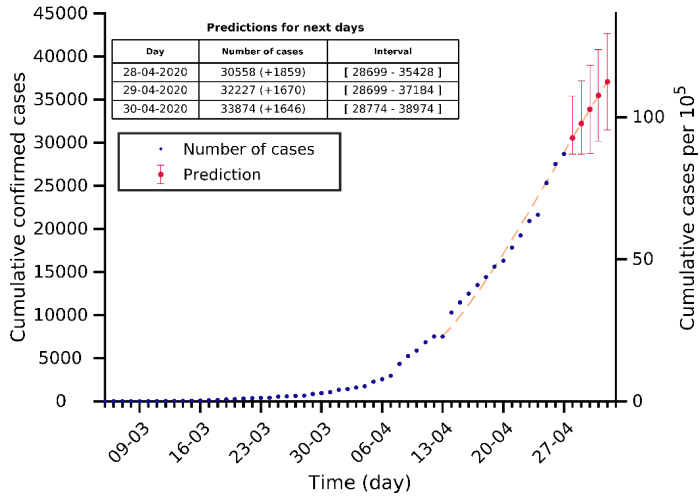
**Canada 27-04-2020. Population: 37.7M. Current cumulated incidence: 128/10<sup>5</sup>**



**India 27-04-2020. Population: 1353000.0M. Current cumulated incidence: 0/10<sup>5</sup>**

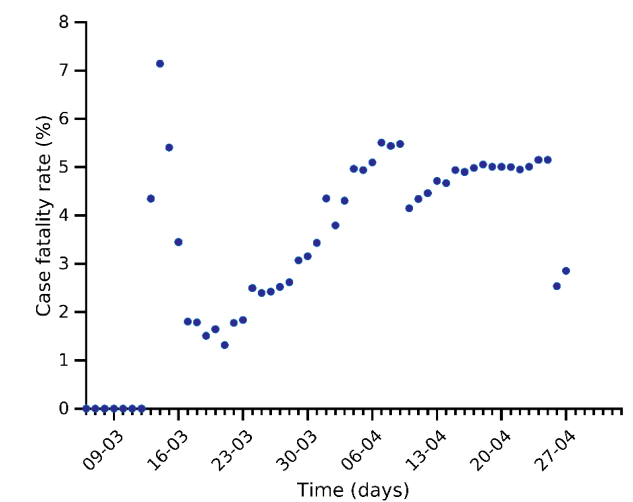
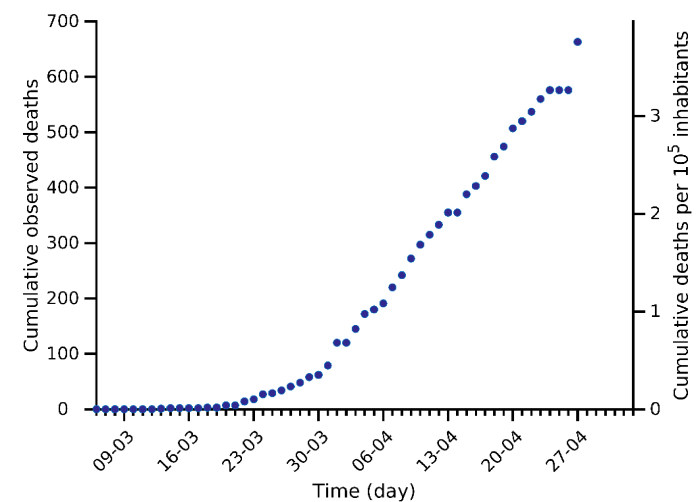
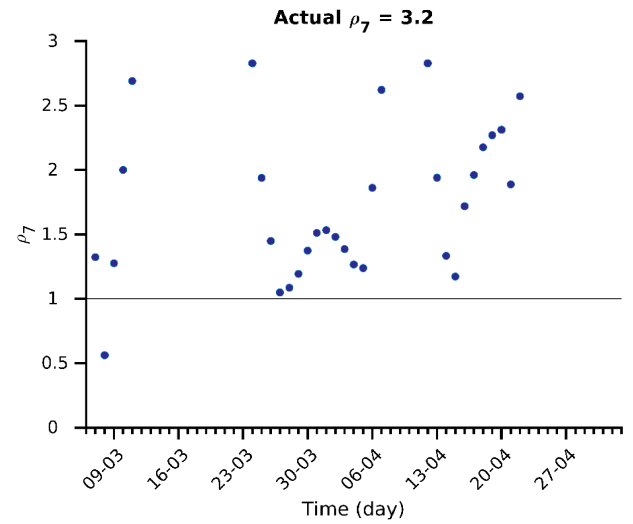
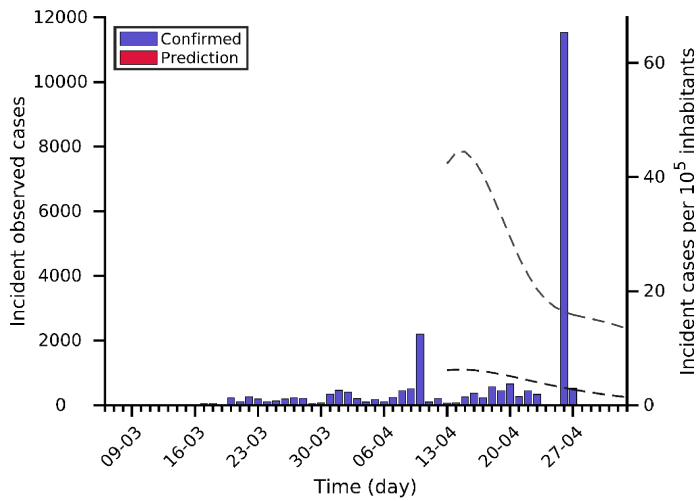
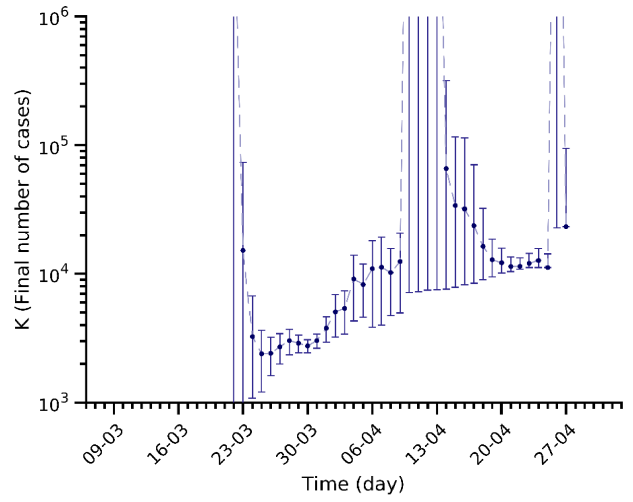
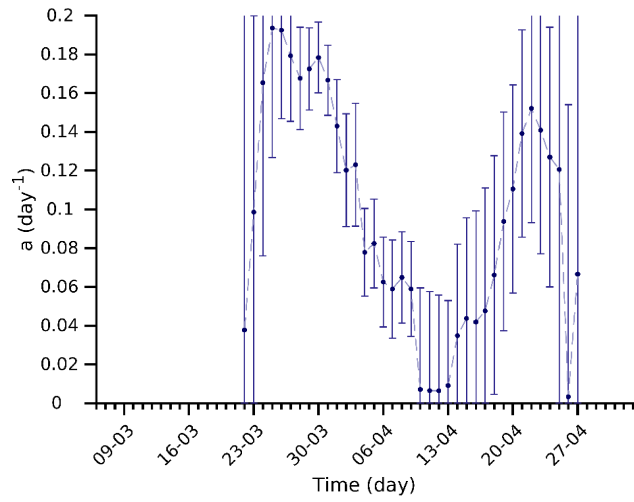
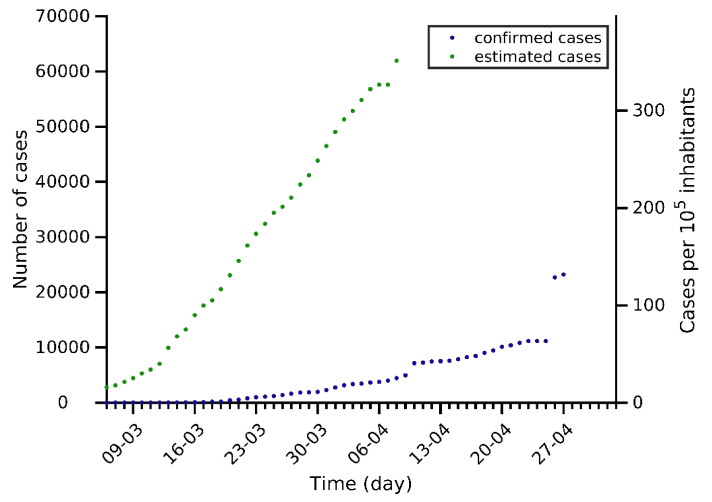
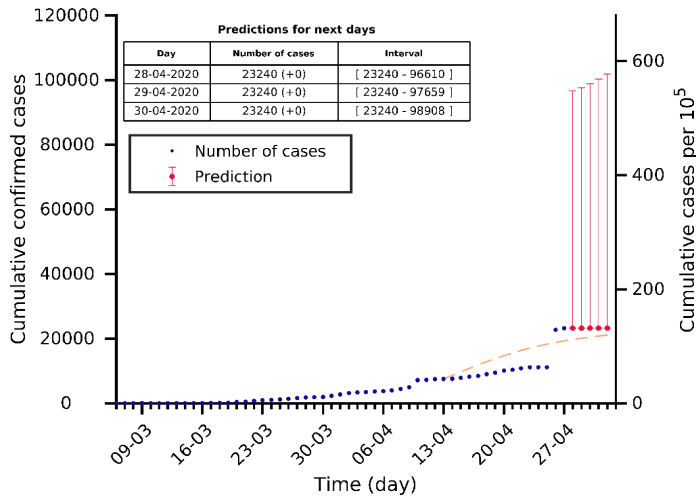


**Peru 27-04-2020. Population: 33.0M. Current cumulated incidence: 87/10<sup>5</sup>**

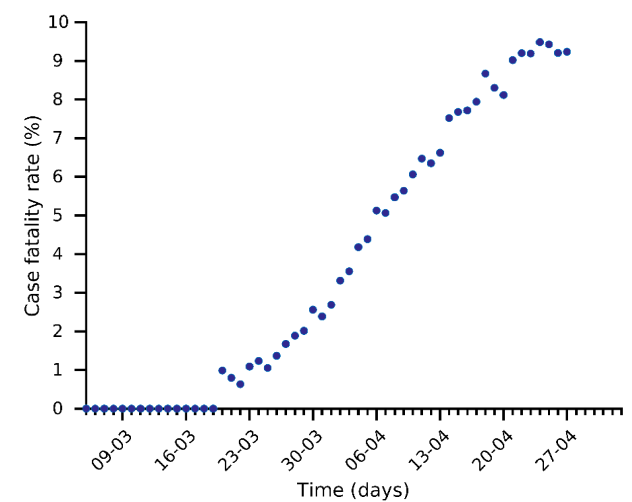
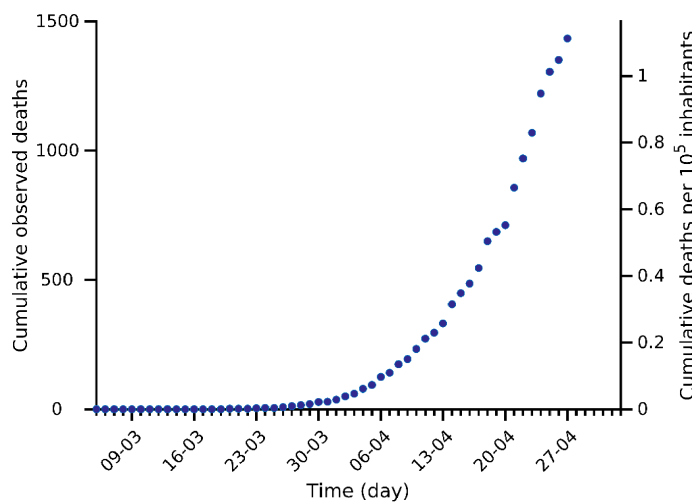
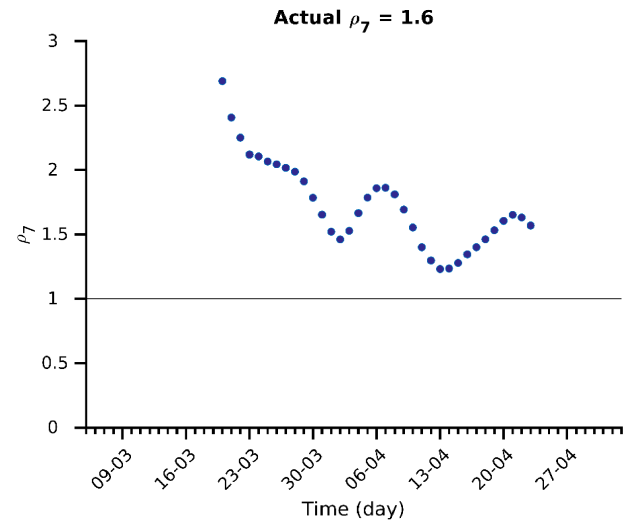
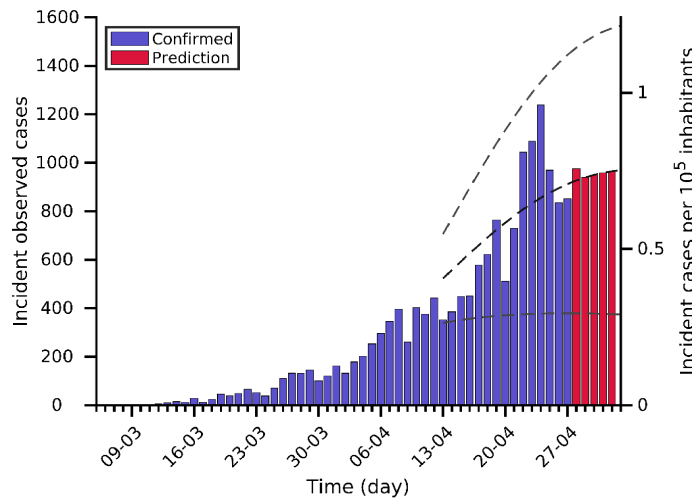
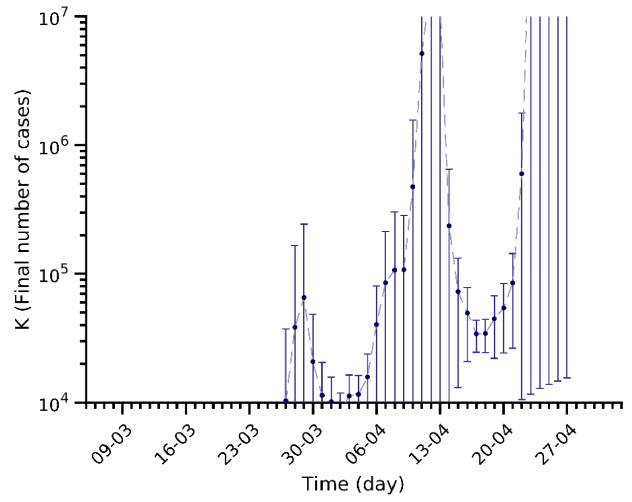
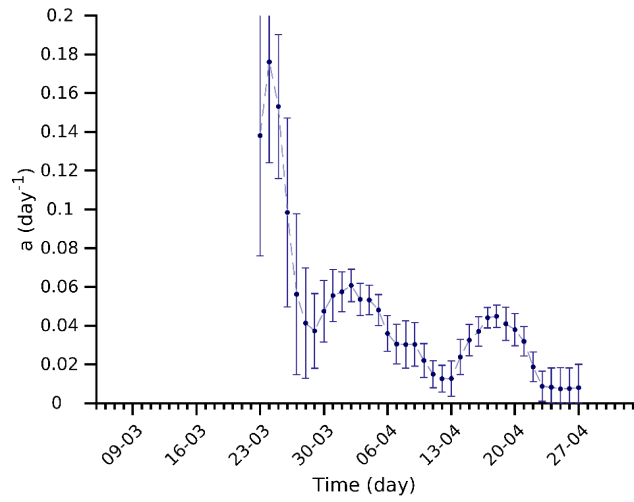
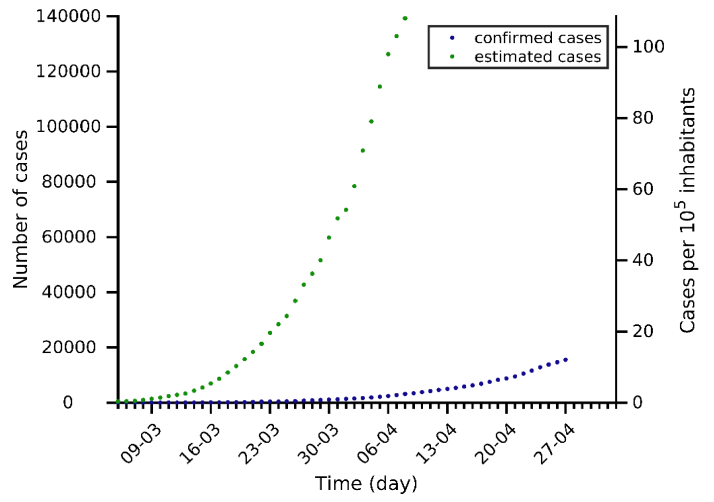
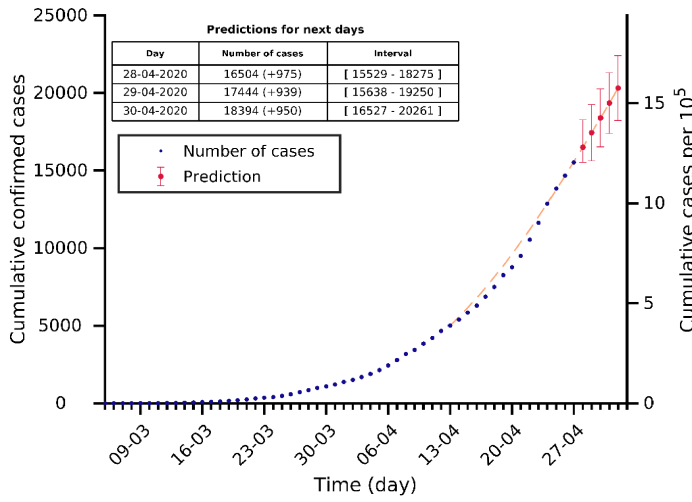




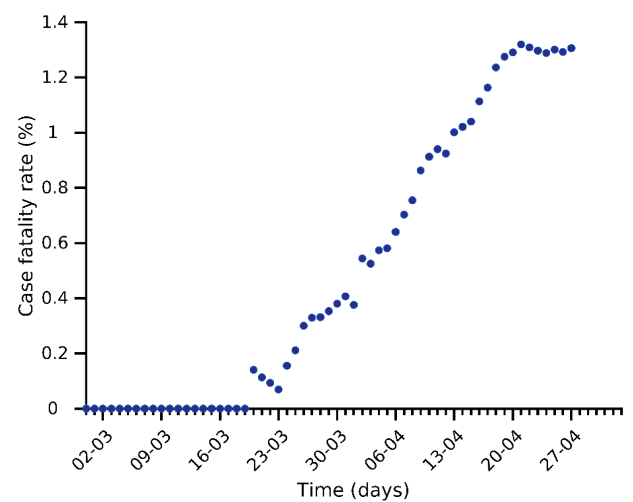
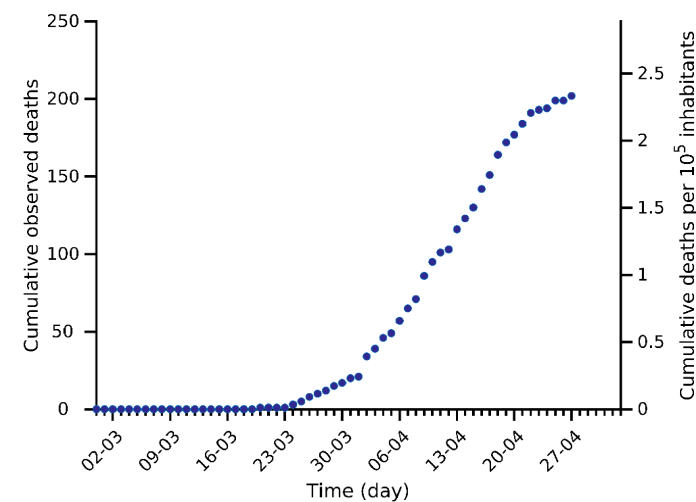
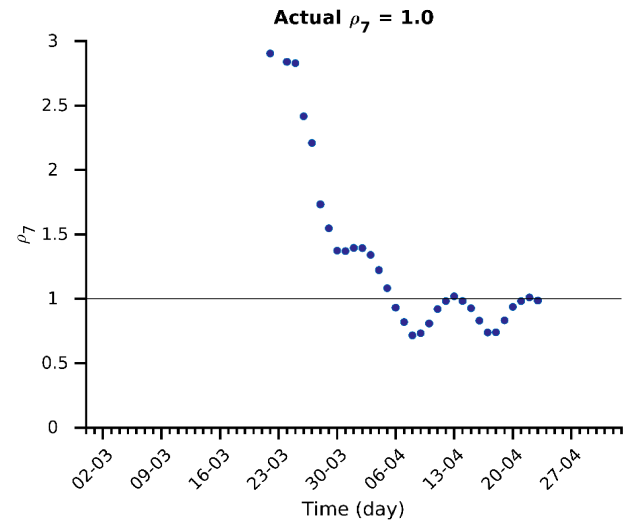
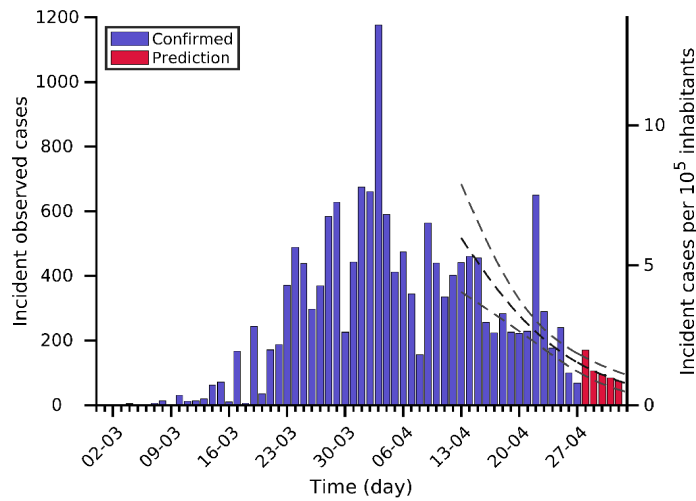
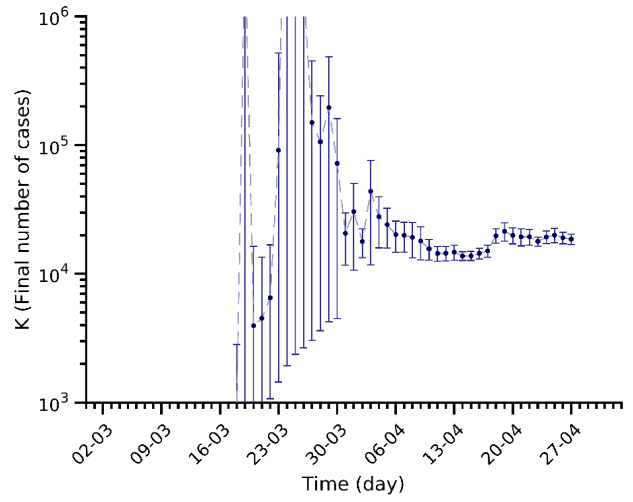
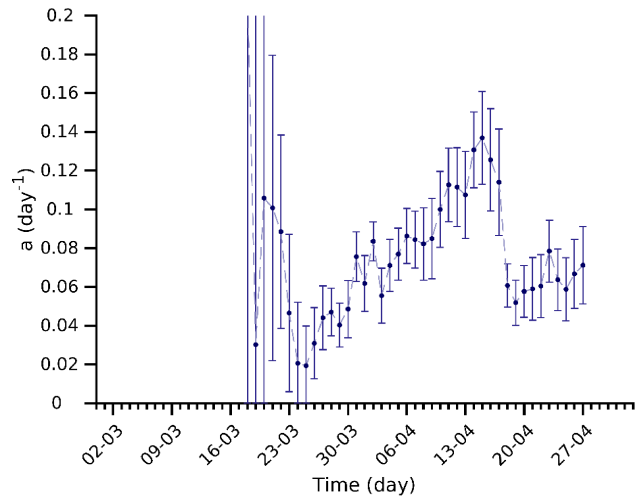
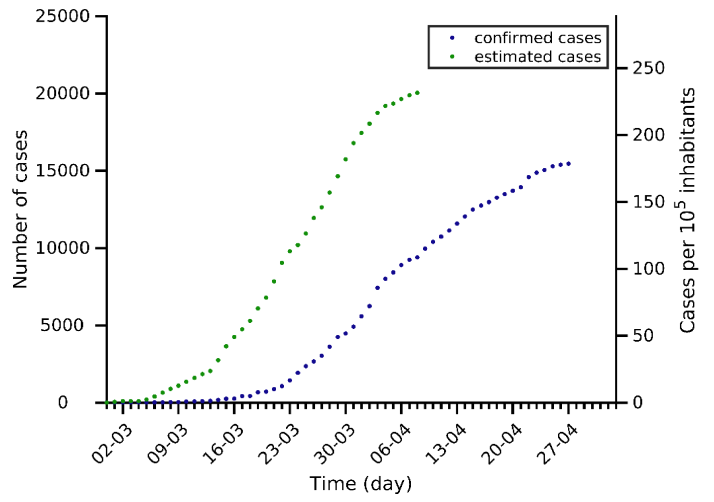
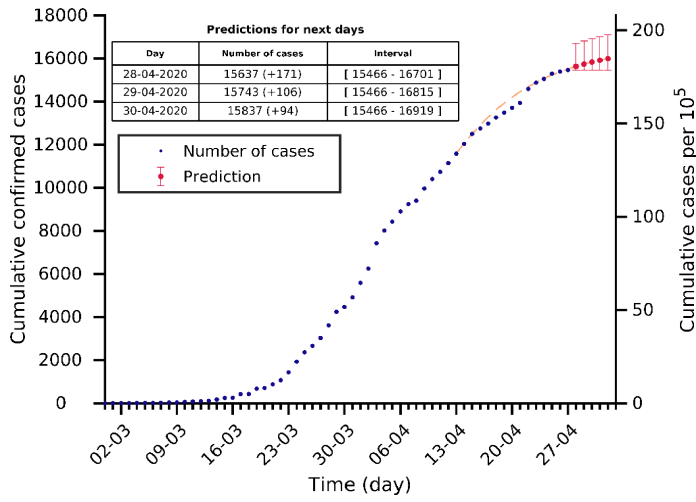
**Ecuador 27-04-2020. Population: 17.6M. Current cumulated incidence: 132/10<sup>5</sup>**



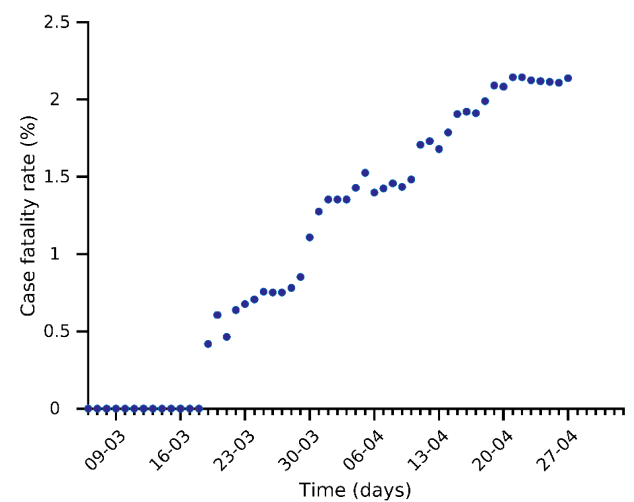
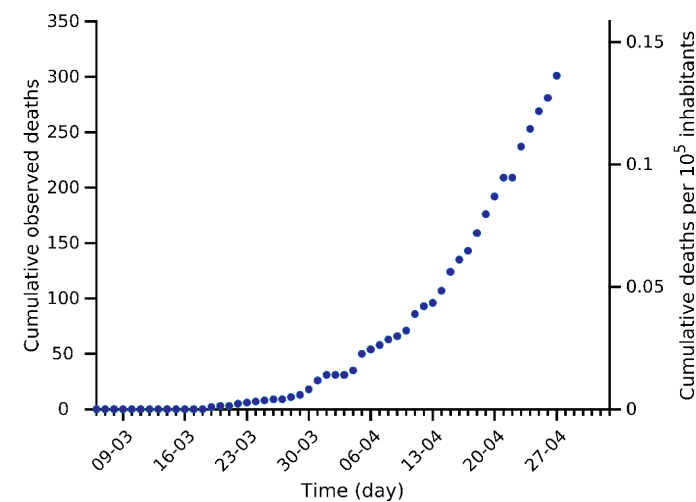
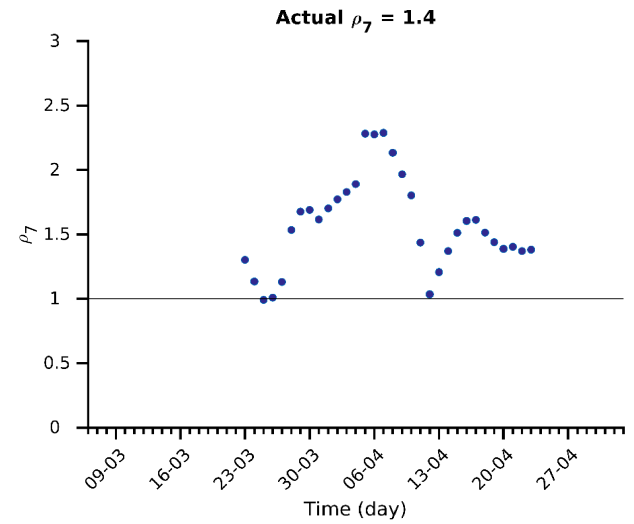
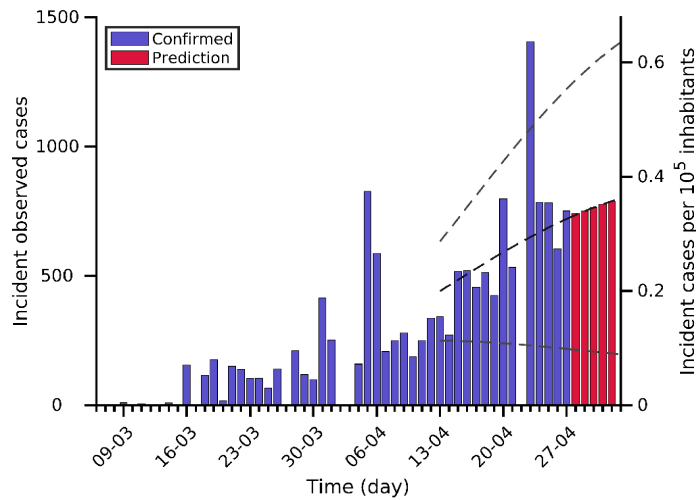
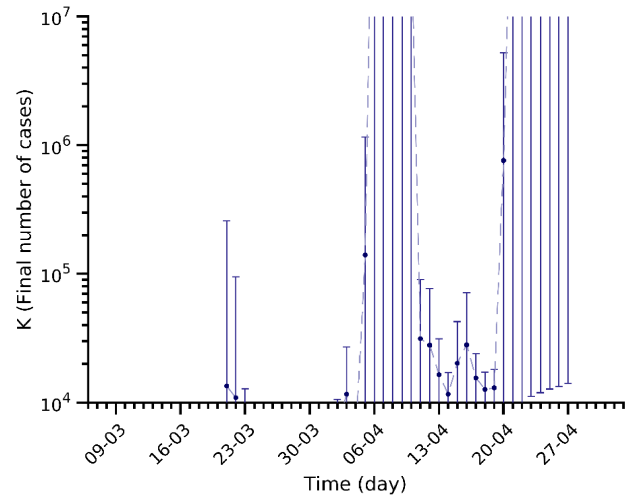
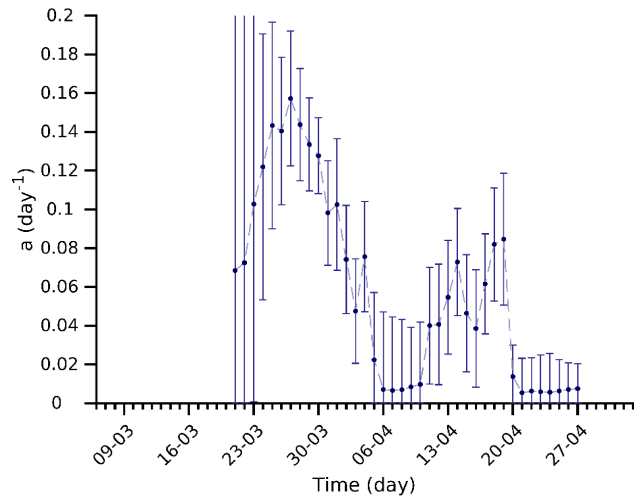
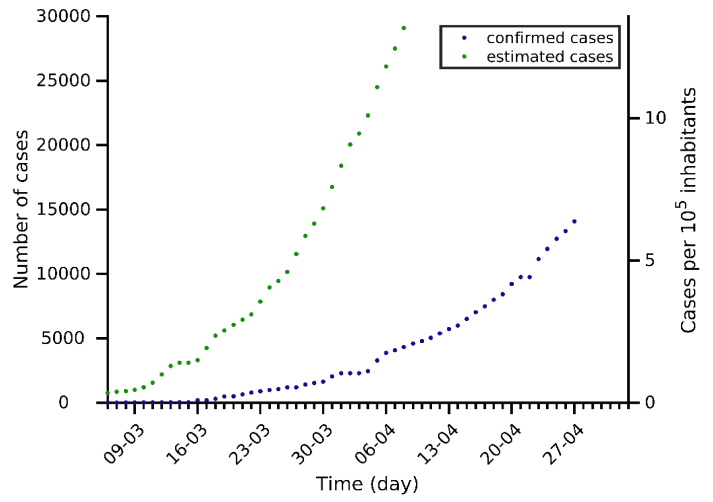
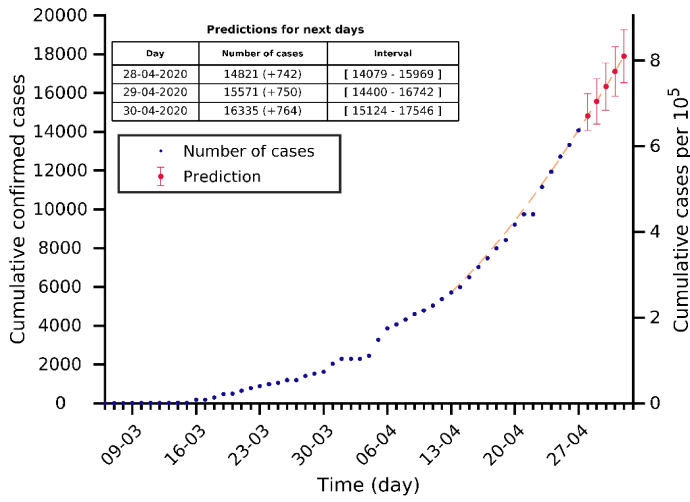
**Mexico 27-04-2020. Population: 128.9M. Current cumulated incidence: 12/10<sup>5</sup>**



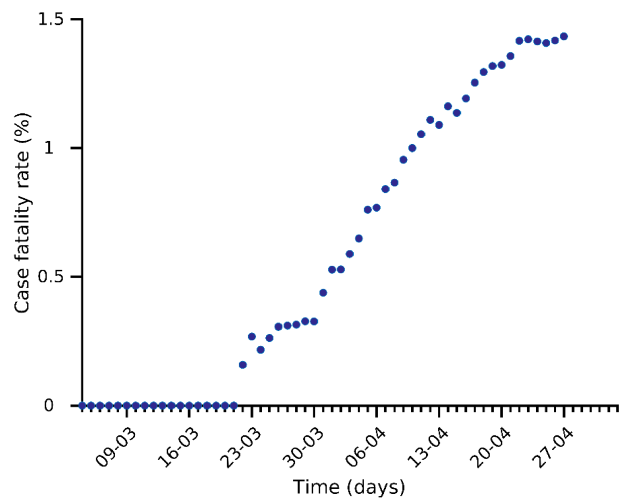
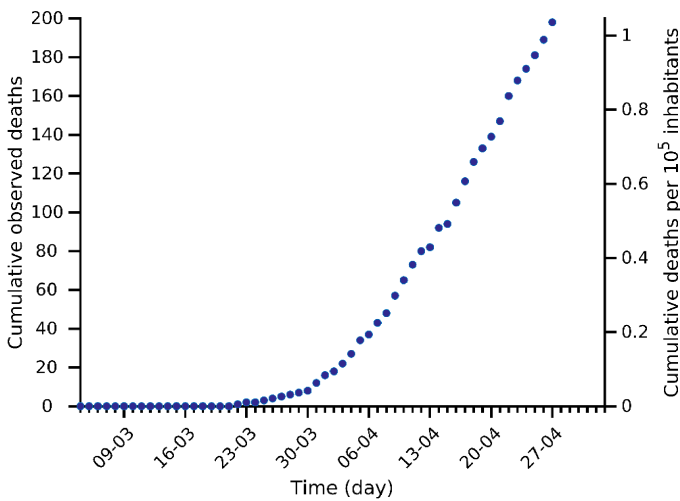
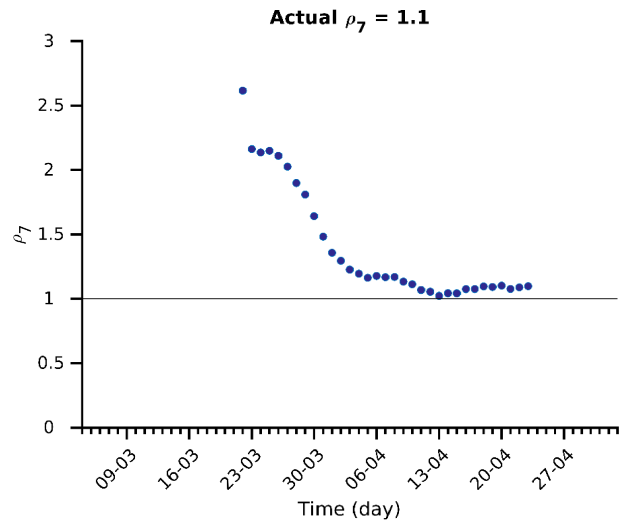
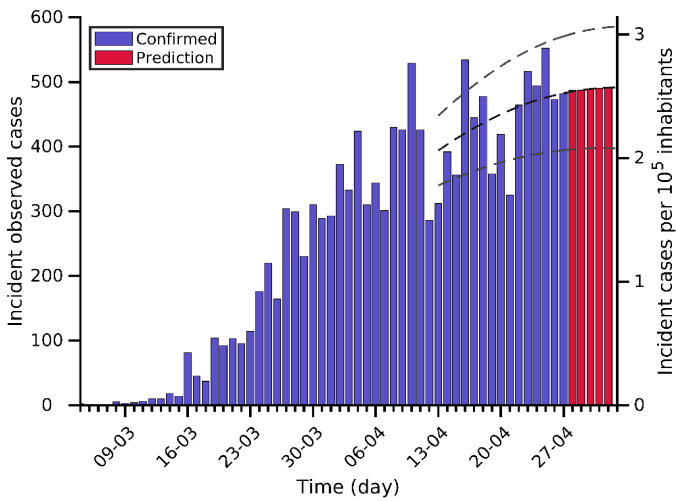
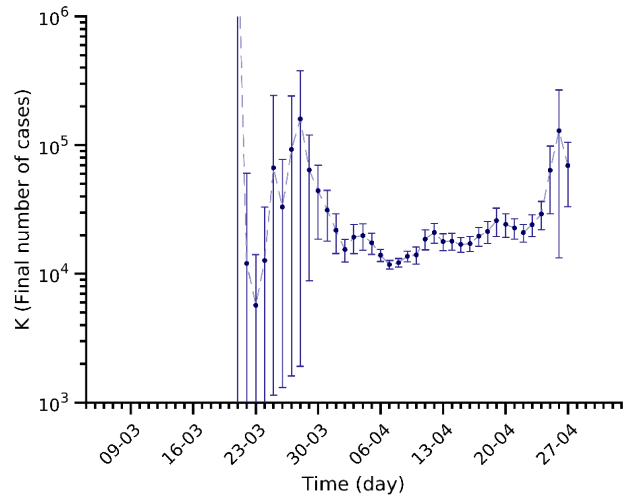
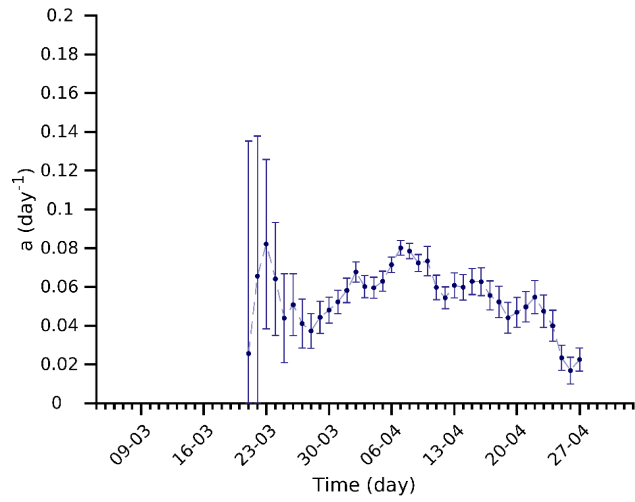
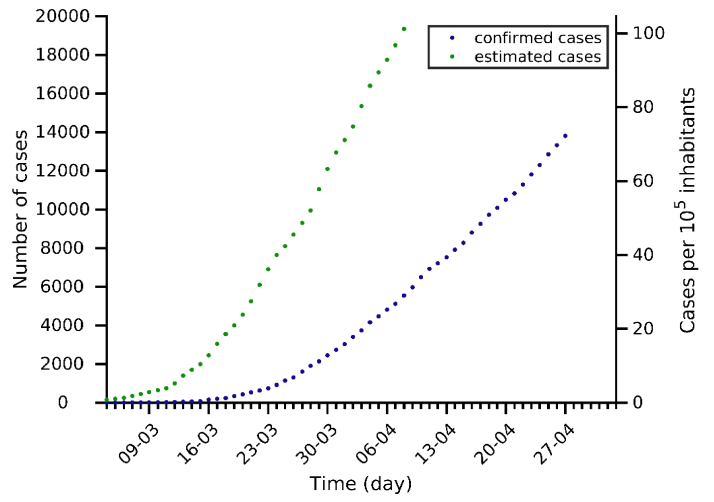
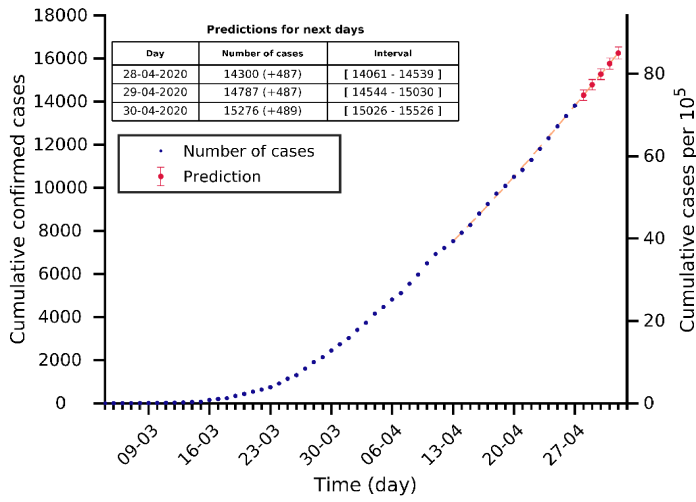
**Israel 27-04-2020. Population: 8.7M. Current cumulated incidence: 179/10<sup>5</sup>**



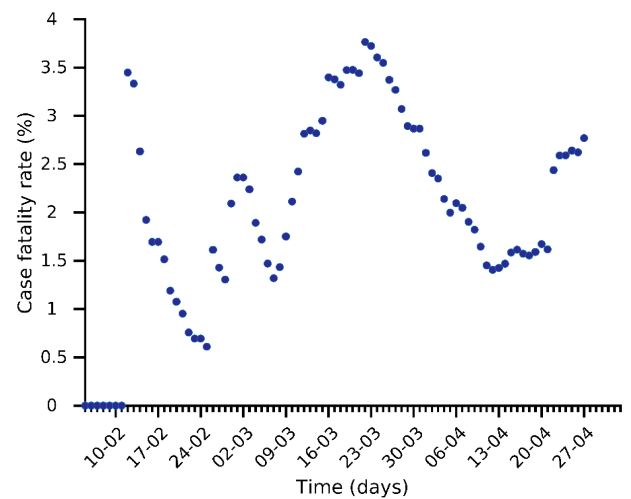
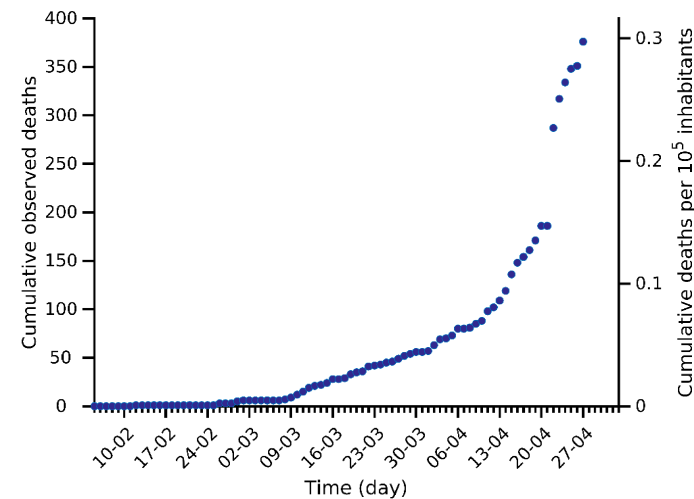
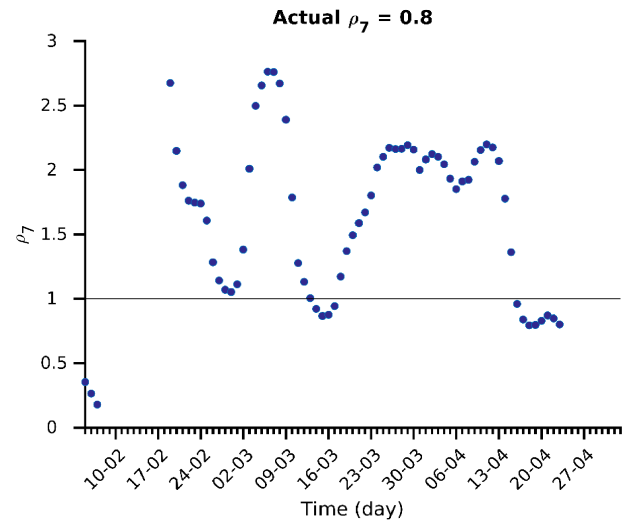
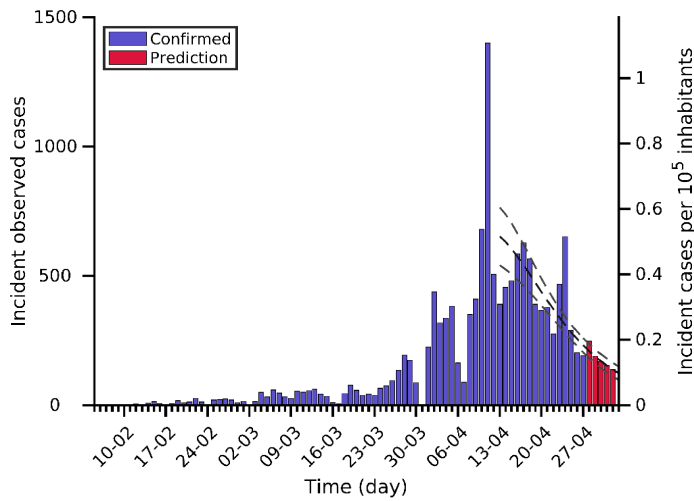
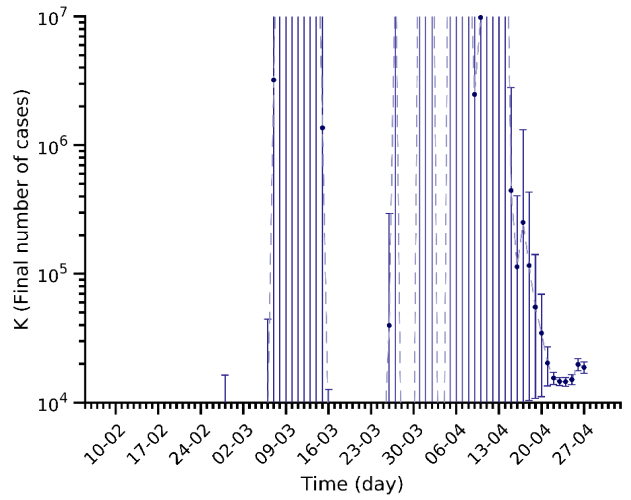
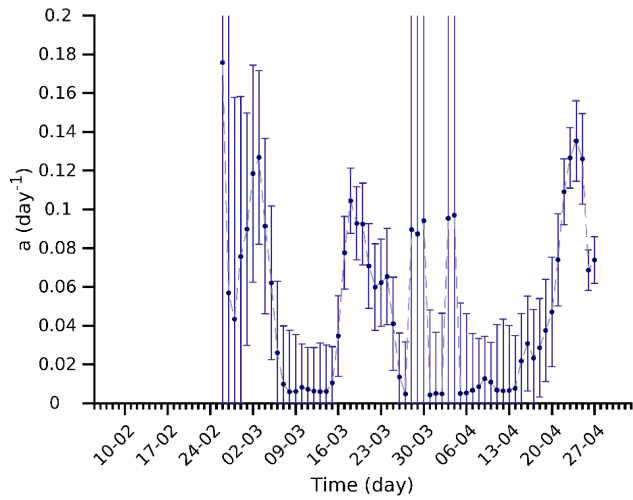
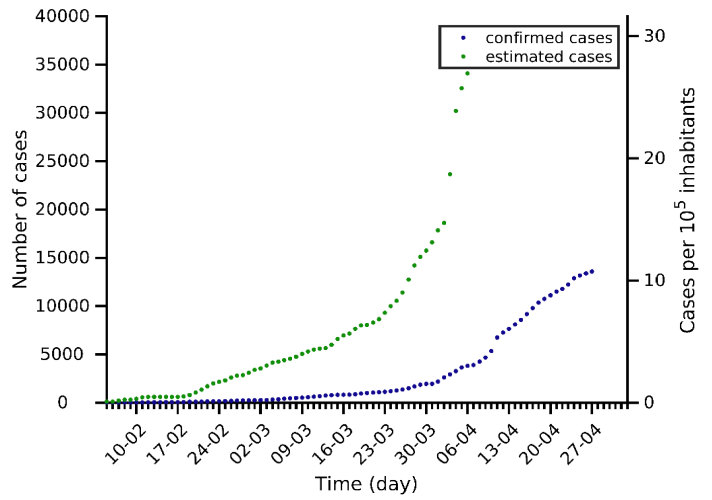
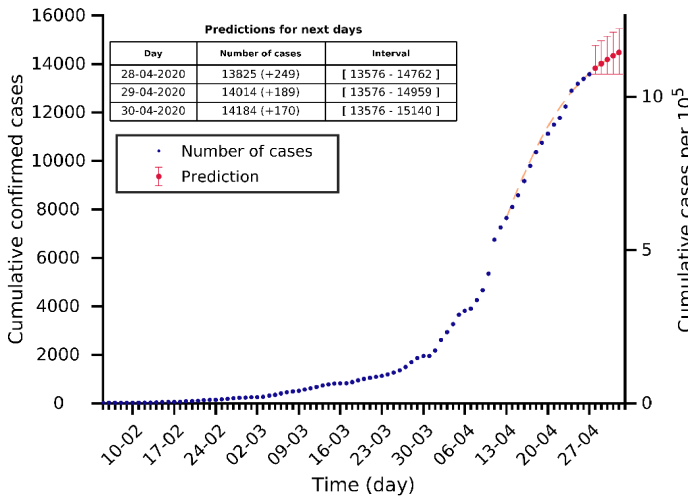
**Pakistan 27-04-2020. Population: 220.9M. Current cumulated incidence: 6/10<sup>5</sup>**



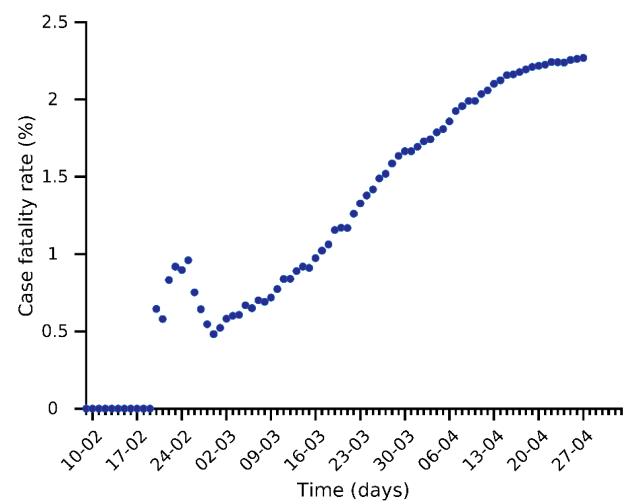
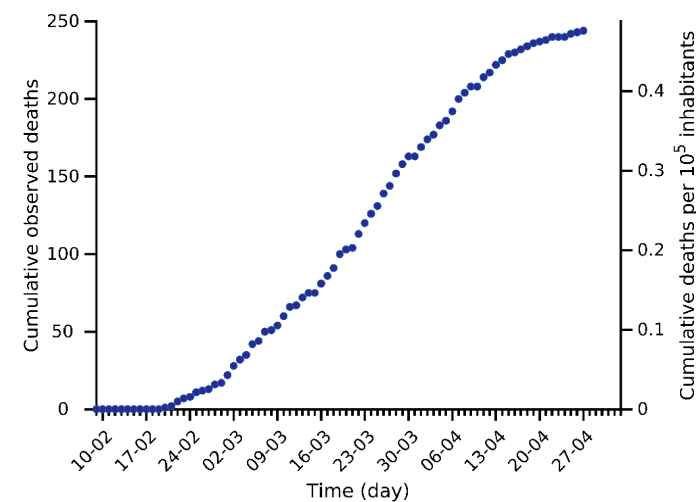
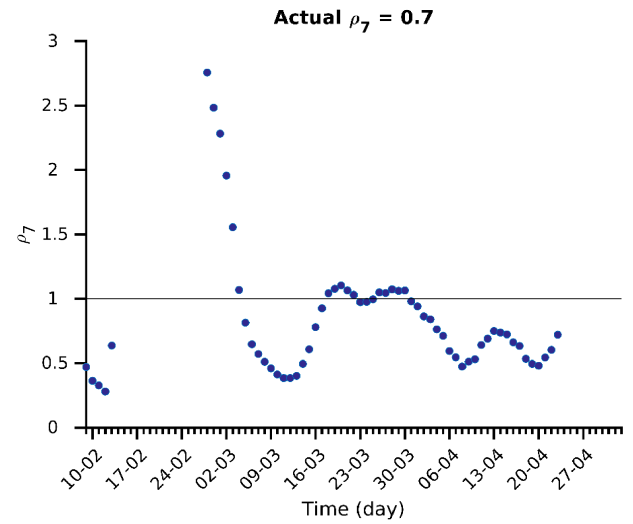
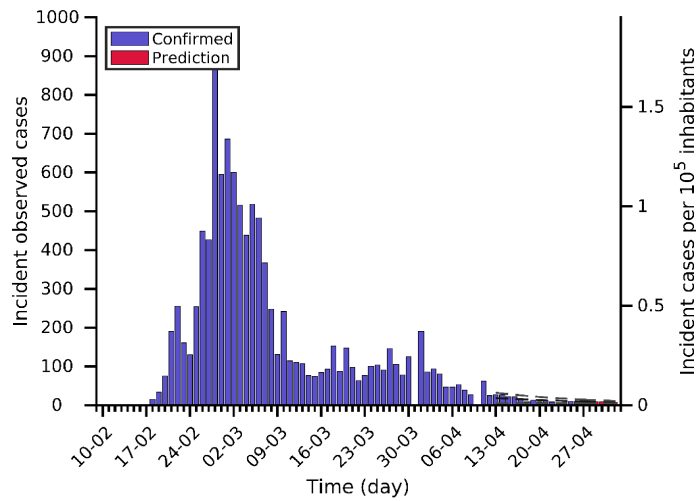
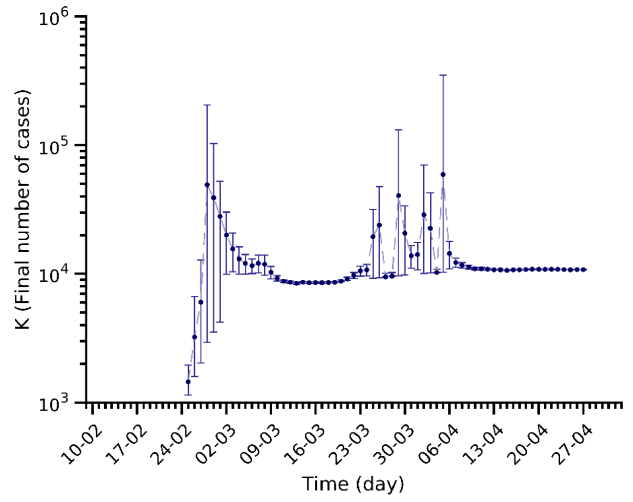
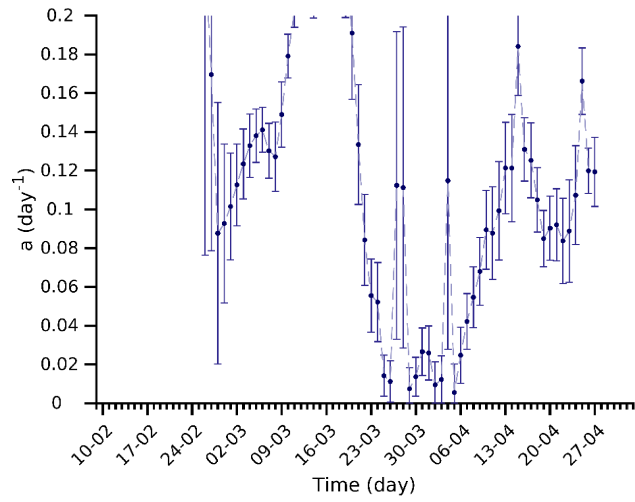
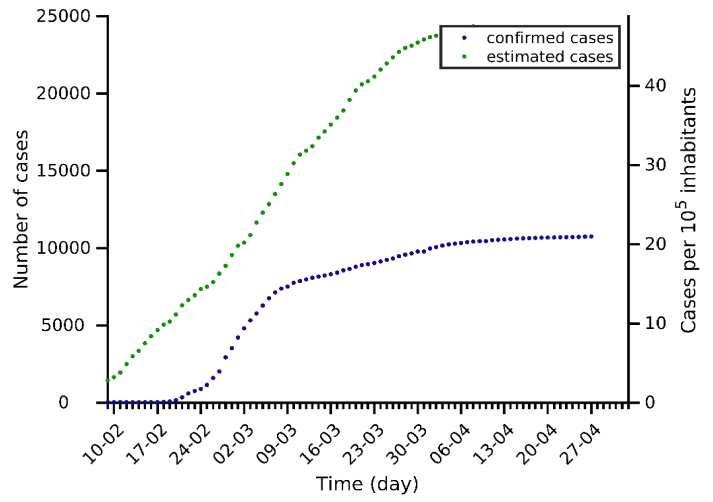
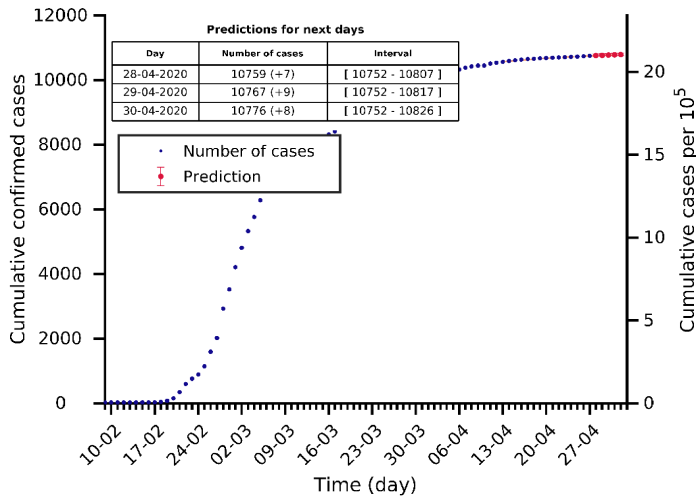
**Chile 27-04-2020. Population: 19.1M. Current cumulated incidence: 72/10<sup>5</sup>**



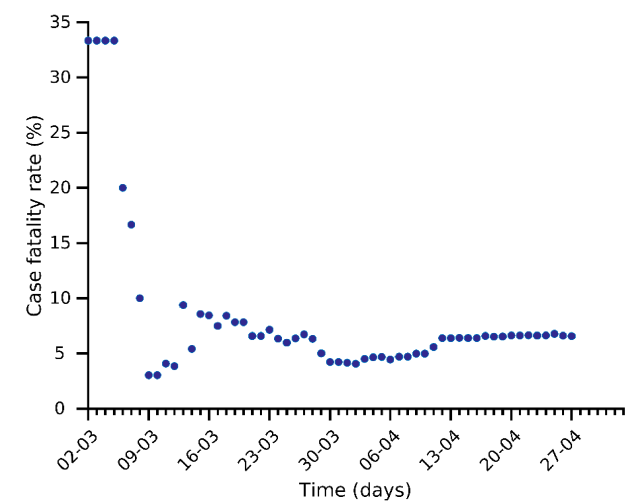
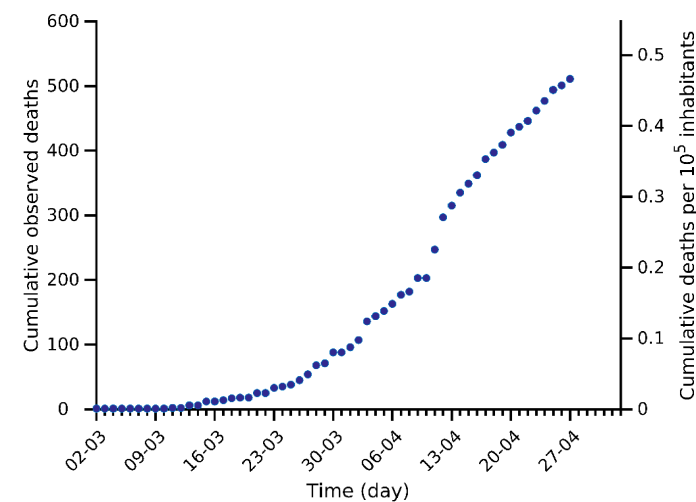
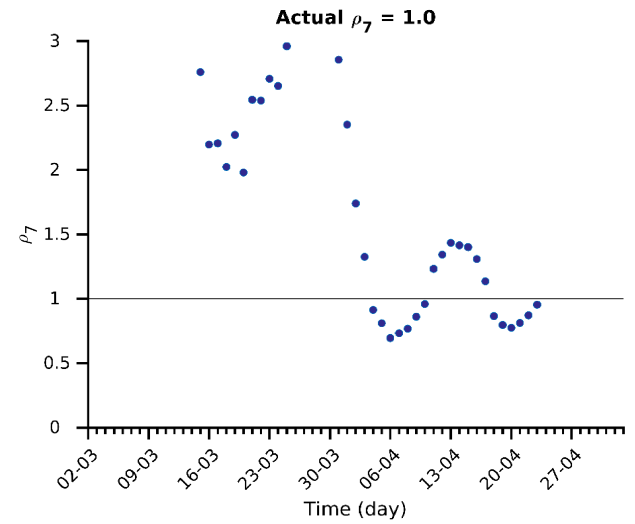
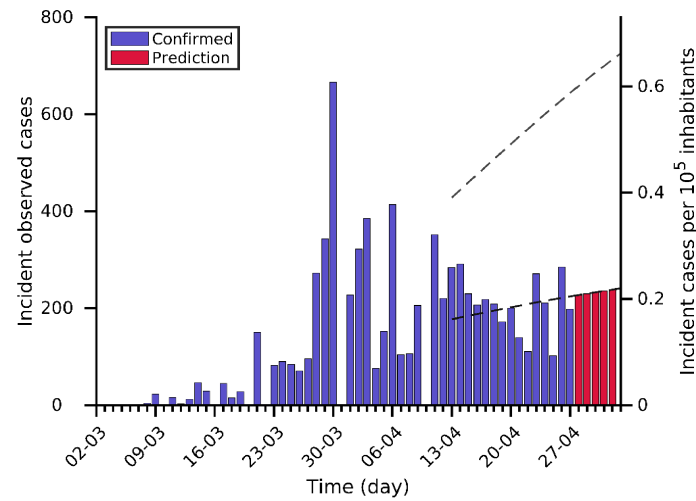
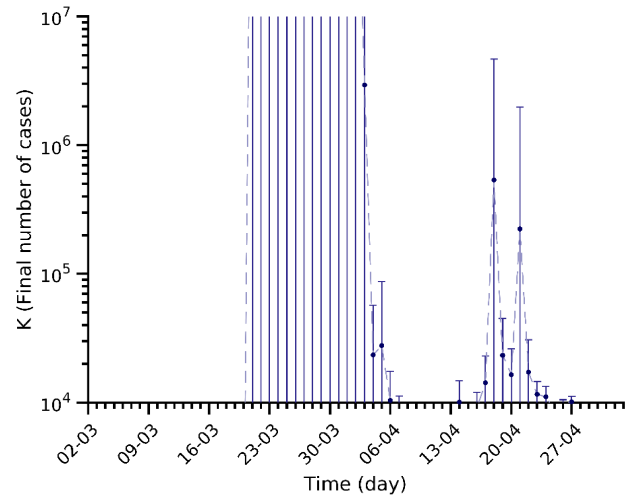
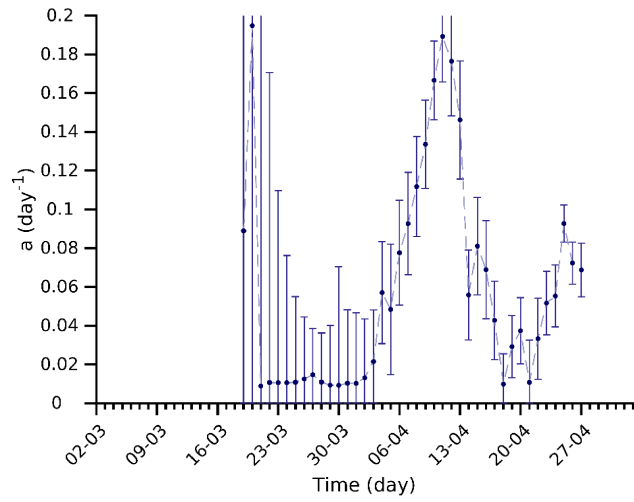
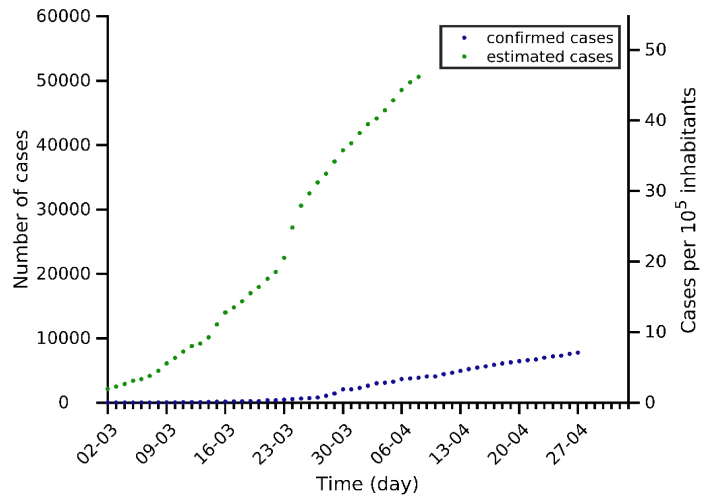
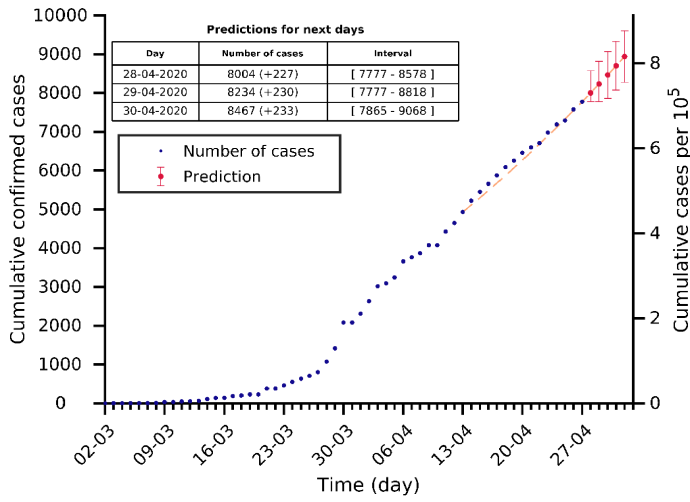
**Japan 27-04-2020. Population: 126.5M. Current cumulated incidence: 11/10<sup>5</sup>**



**South Korea 27-04-2020. Population: 51.3M. Current cumulated incidence: 21/10<sup>5</sup>**

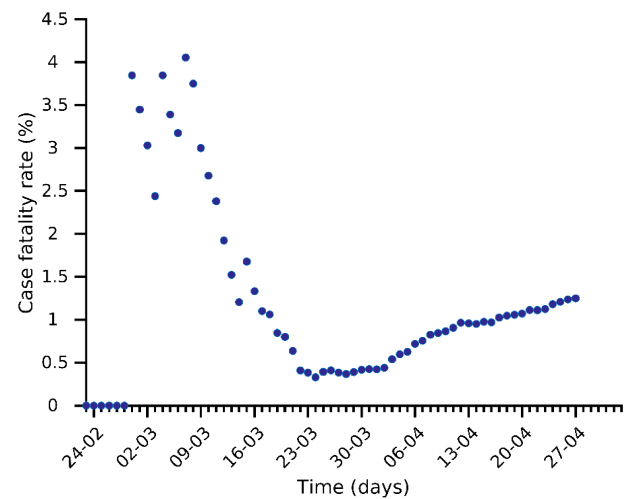
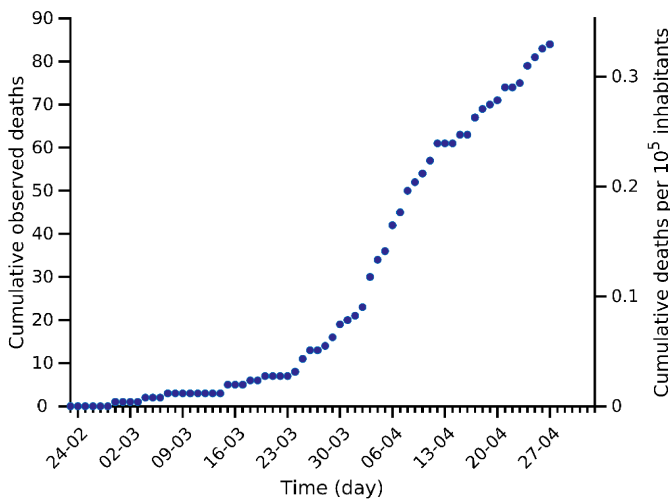
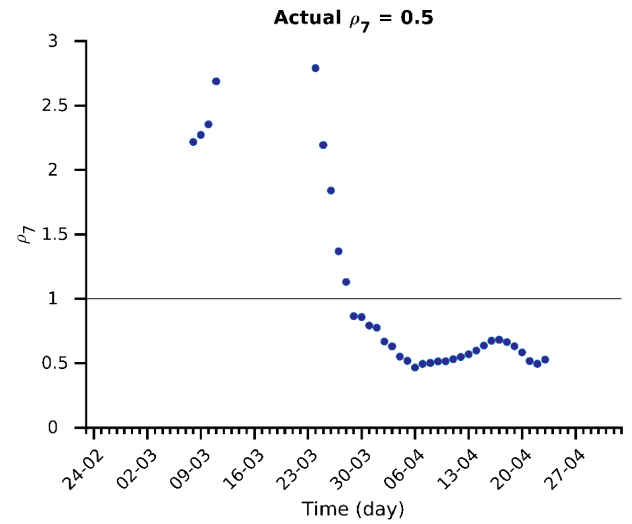
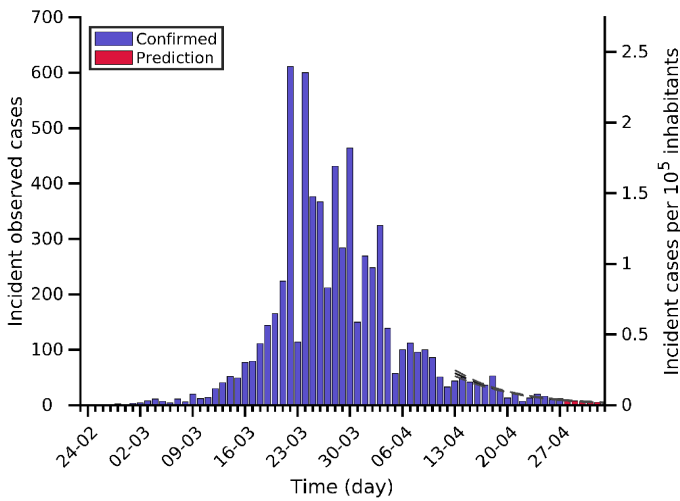
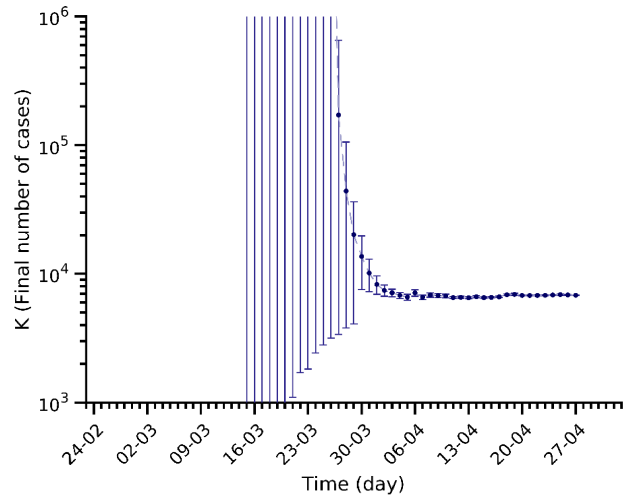
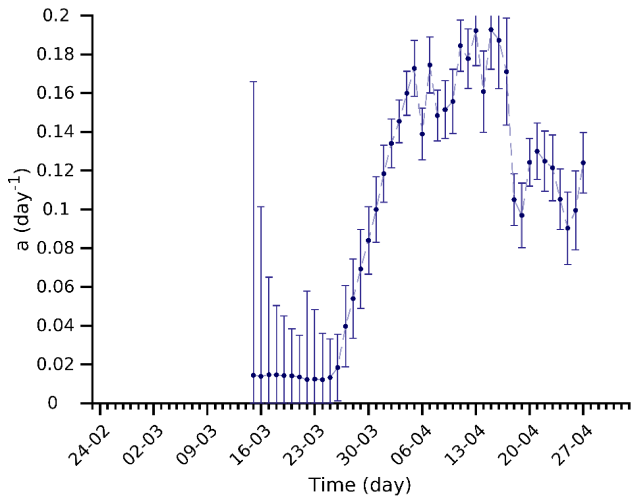
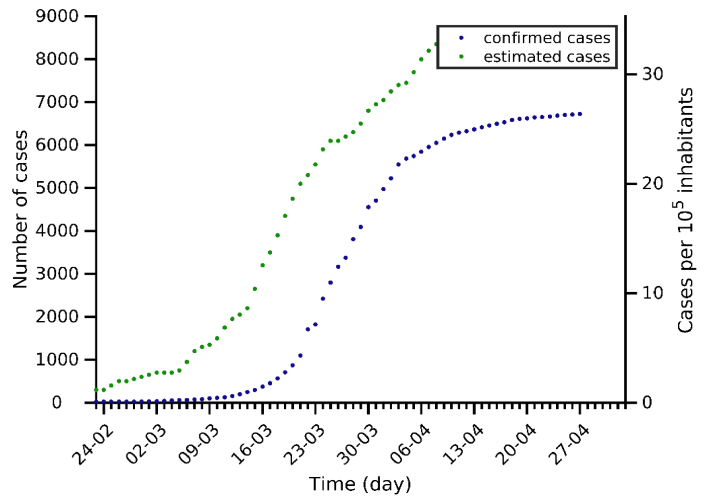
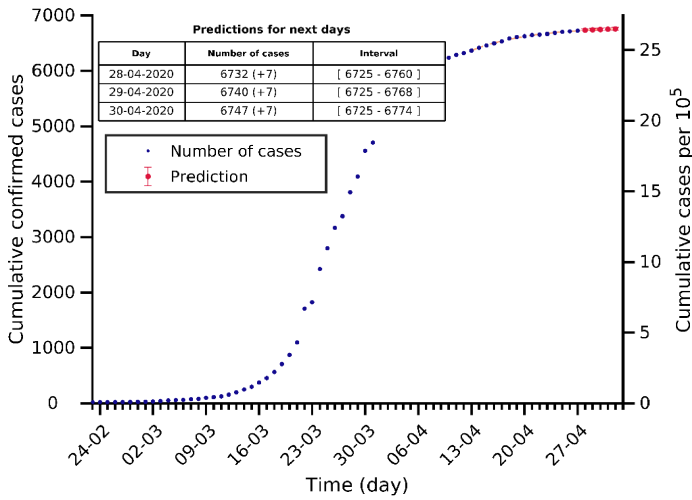


**Philippines 27-04-2020. Population: 109.6M. Current cumulated incidence: 7/10<sup>5</sup>**

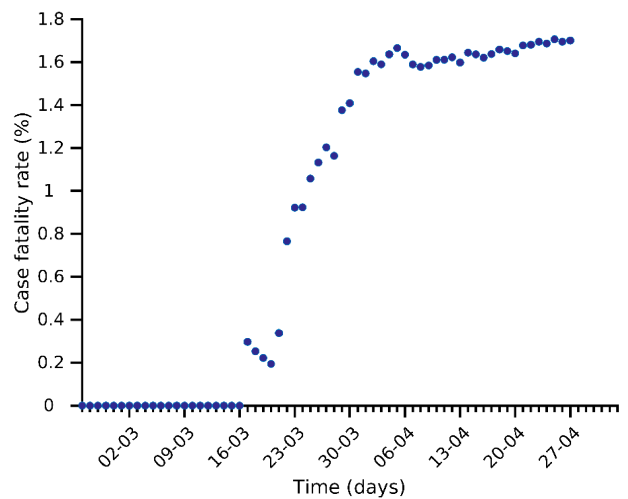
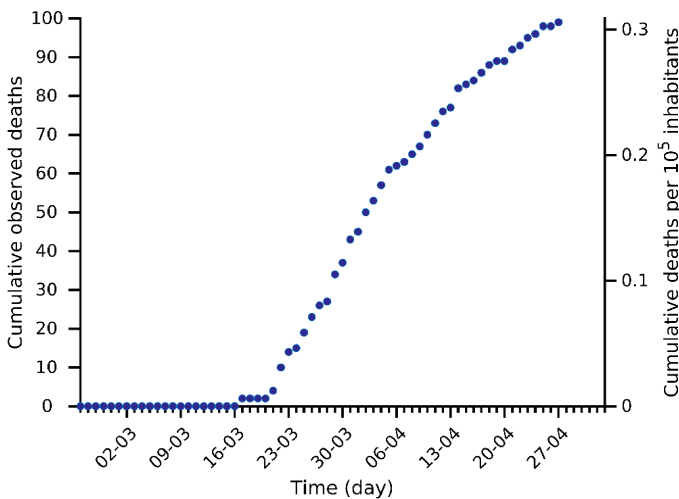
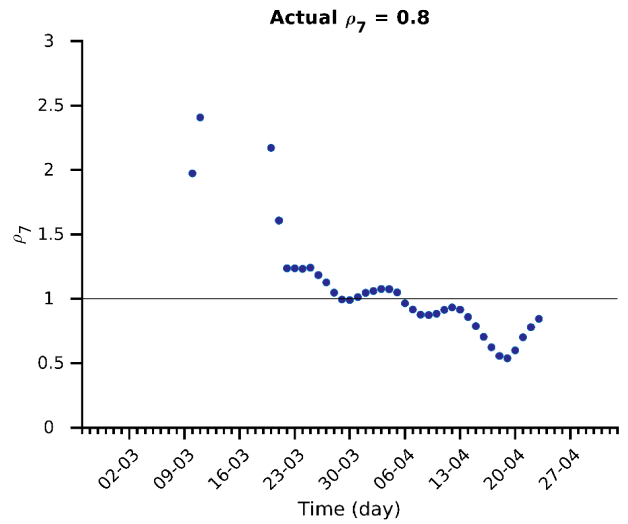
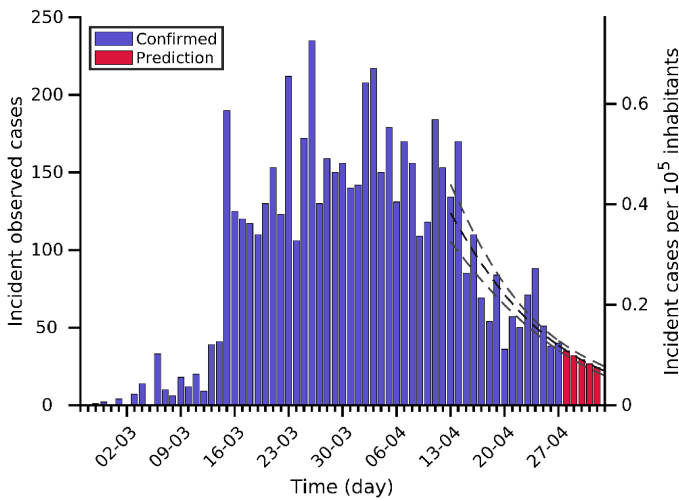
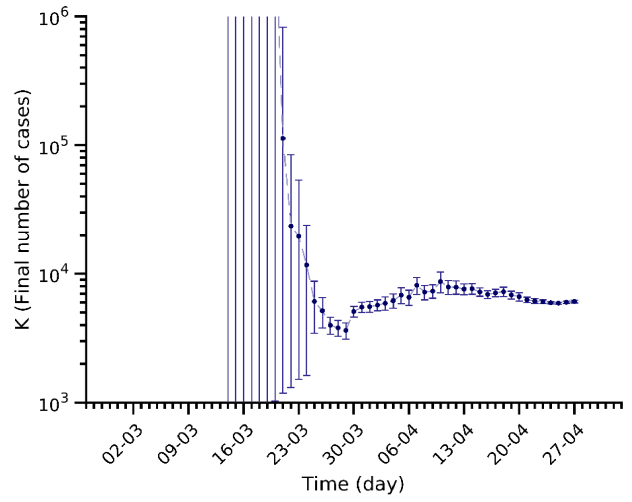
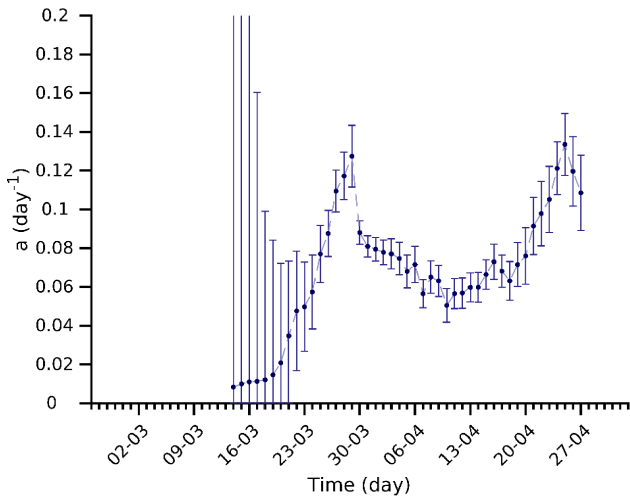
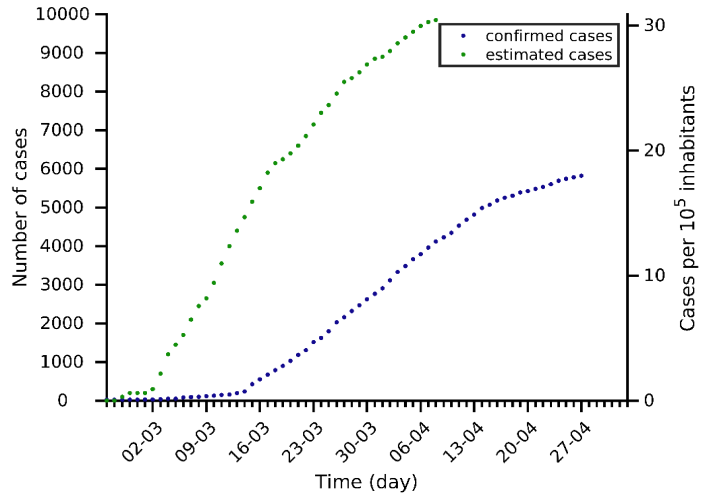
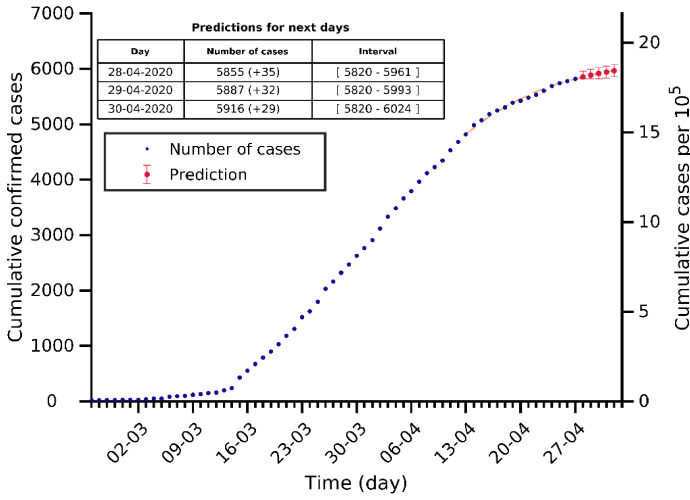




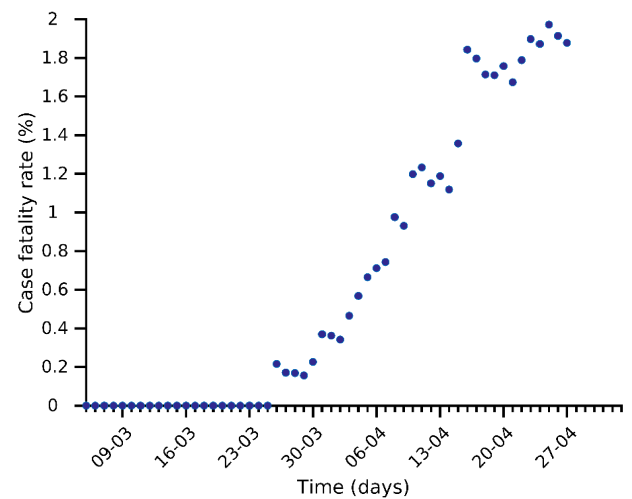
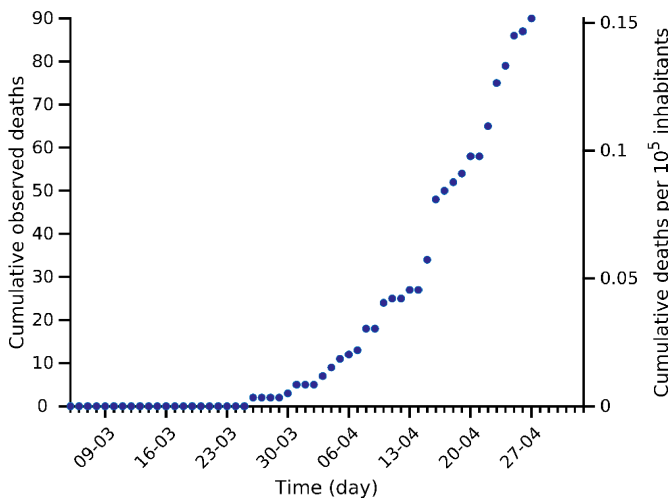
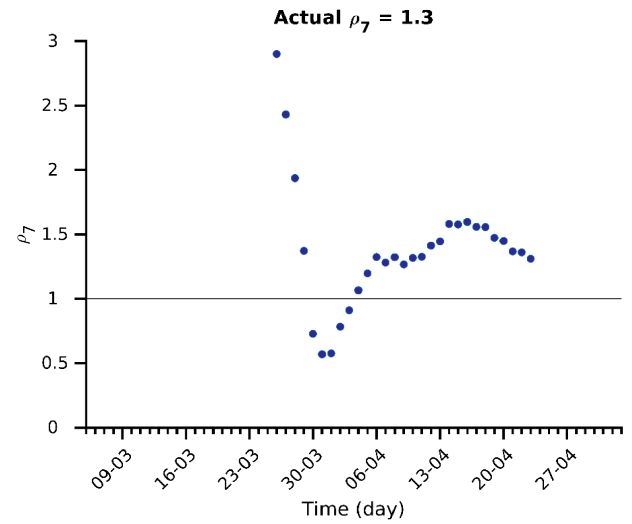
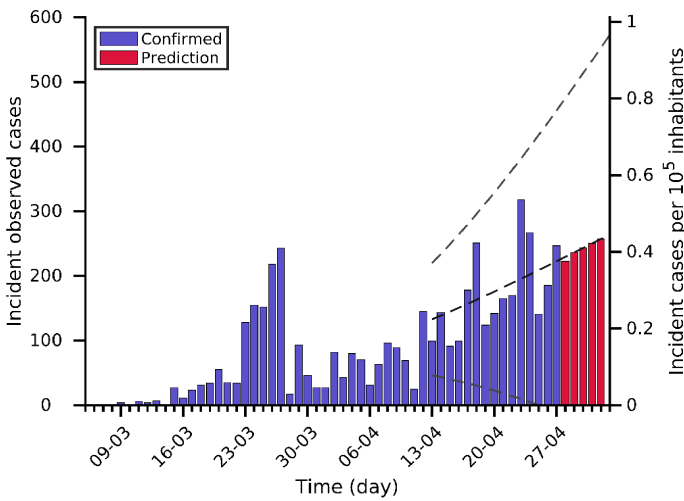
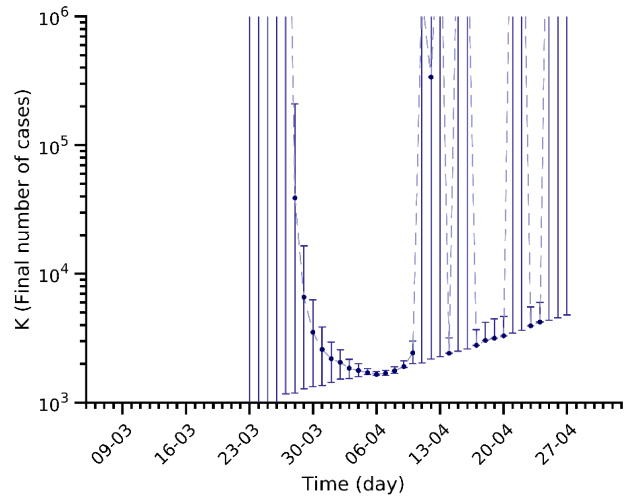
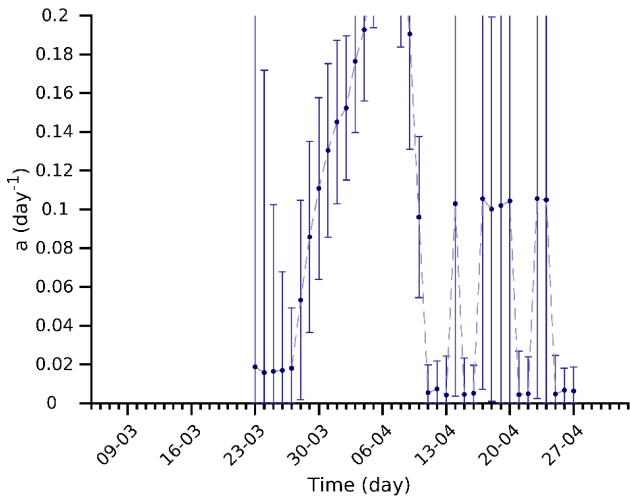
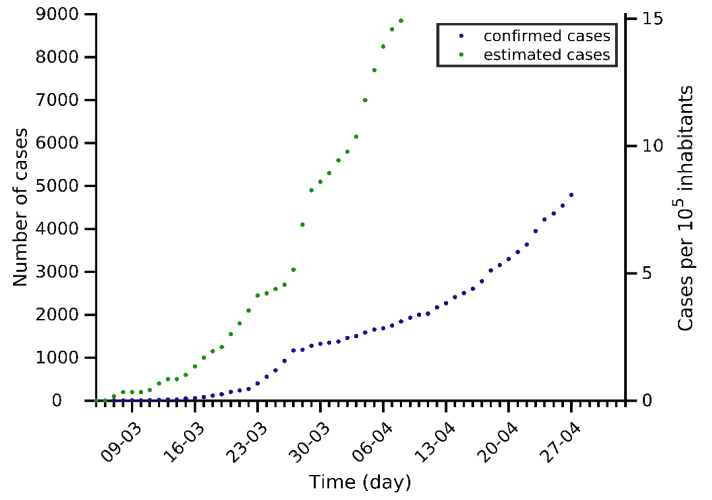
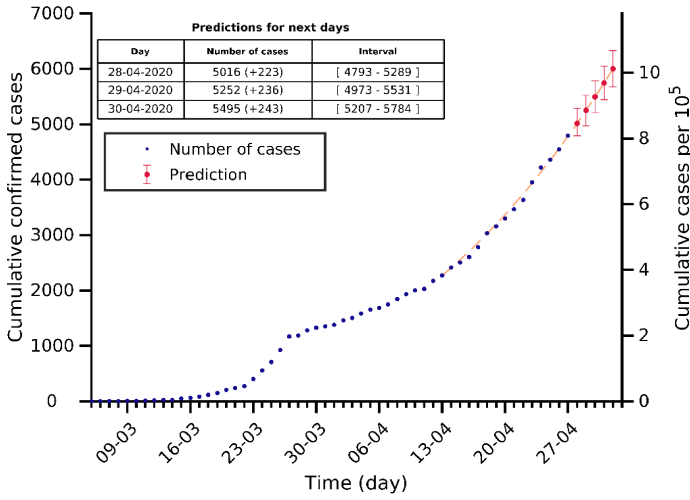
**Australia 27-04-2020. Population: 25.5M. Current cumulated incidence: 26/10<sup>5</sup>**



**Malaysia 27-04-2020. Population: 32.4M. Current cumulated incidence: 18/10<sup>5</sup>**



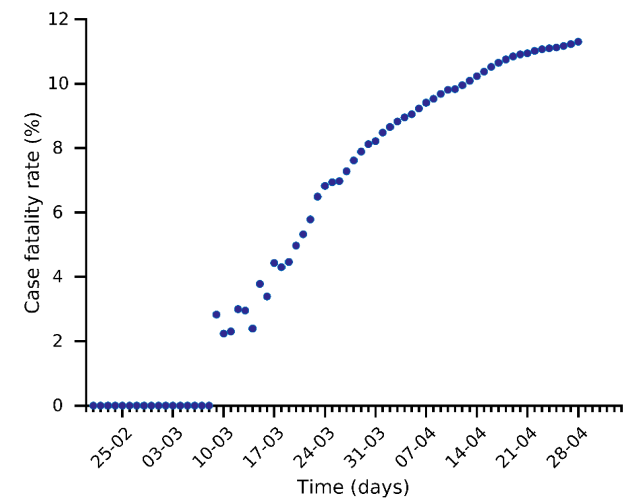
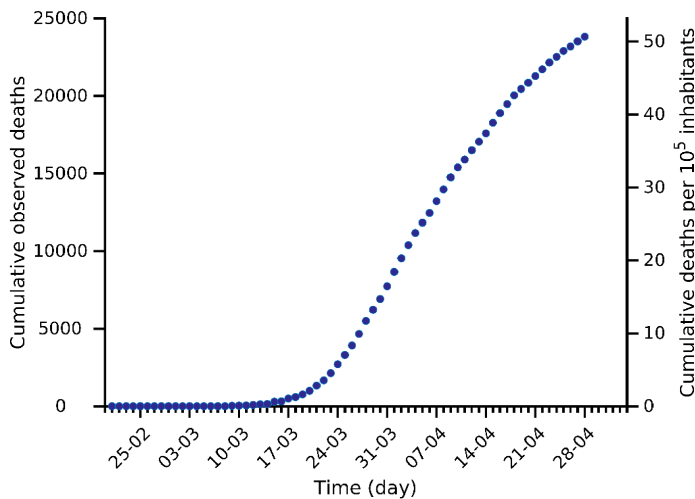
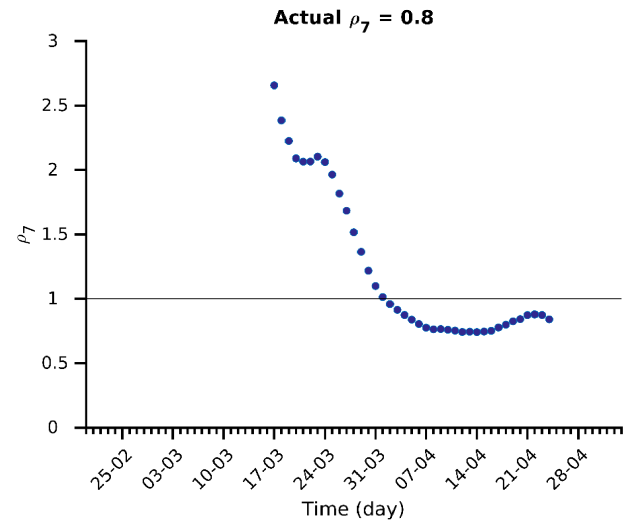
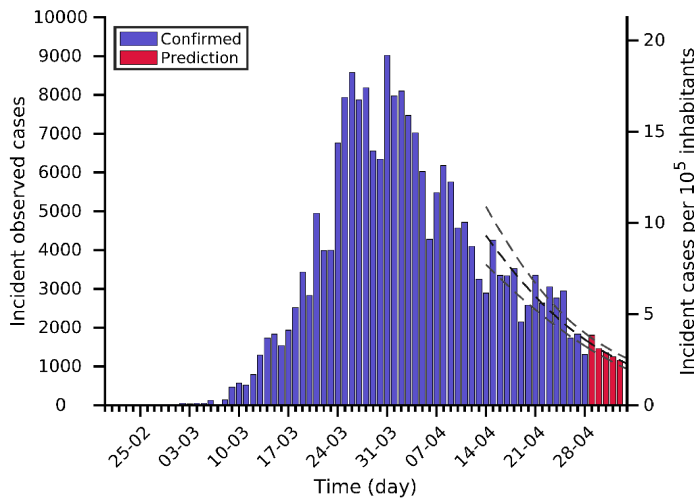
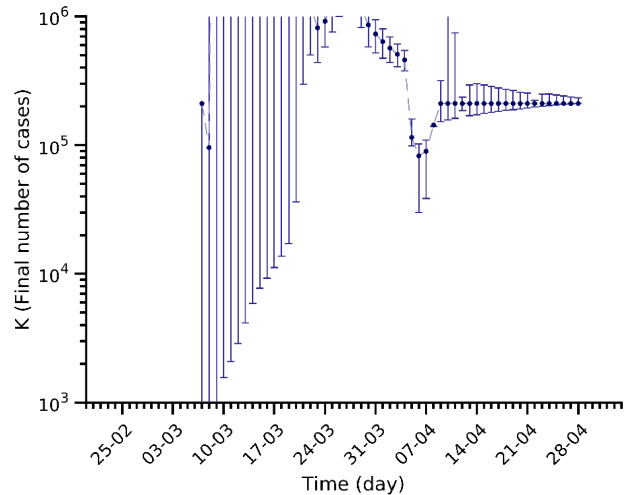
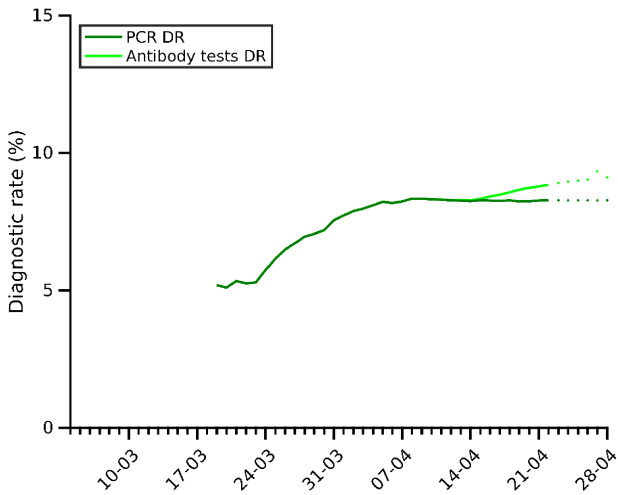
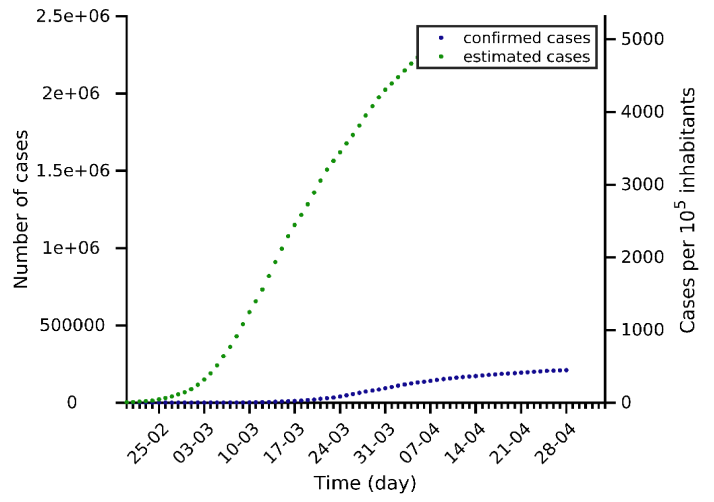
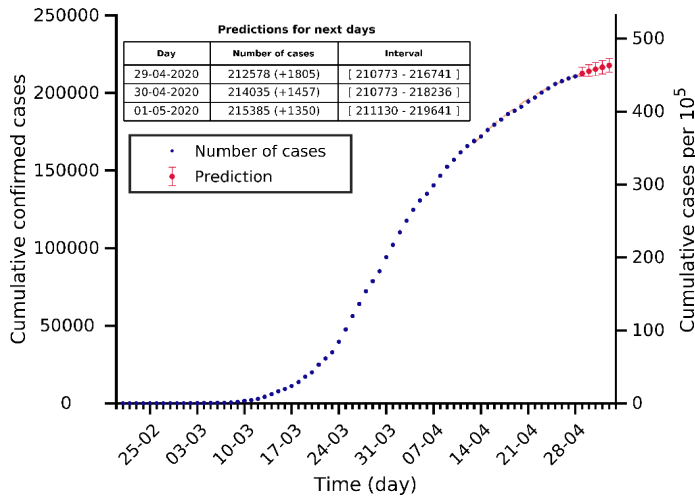
**South Africa 27-04-2020. Population: 59.3M. Current cumulated incidence: 8/10<sup>5</sup>**



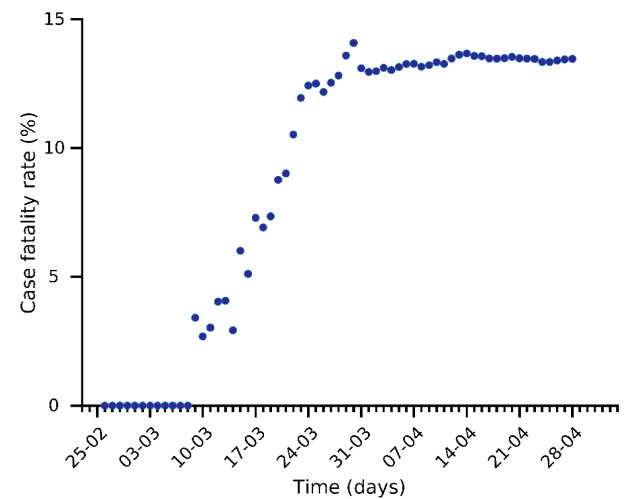
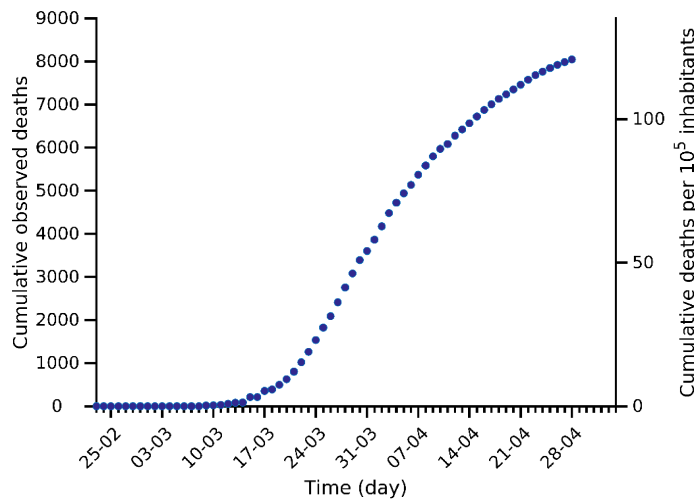
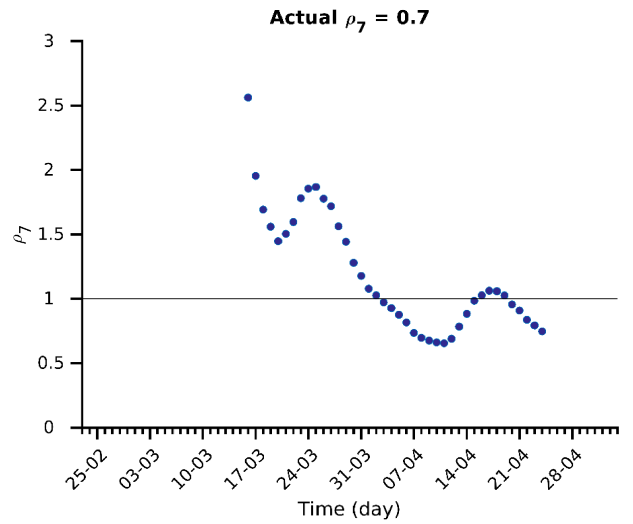
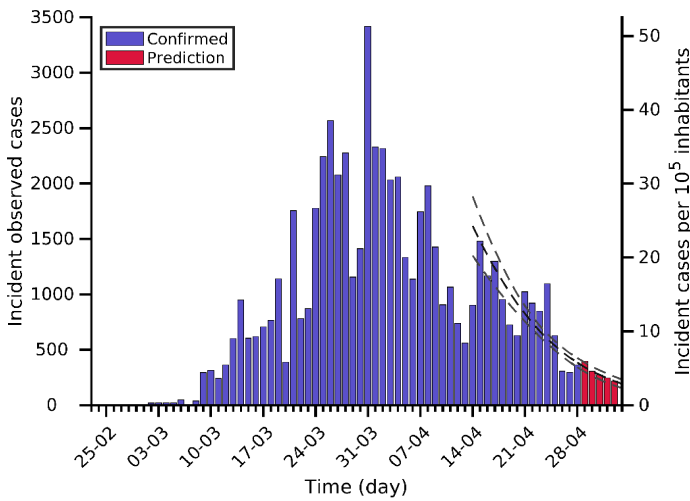
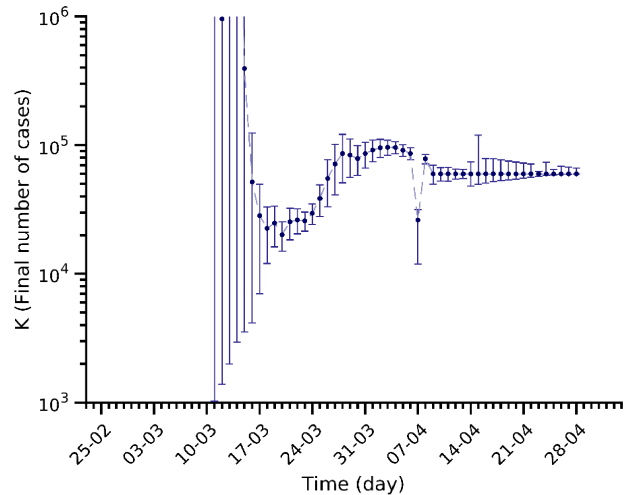
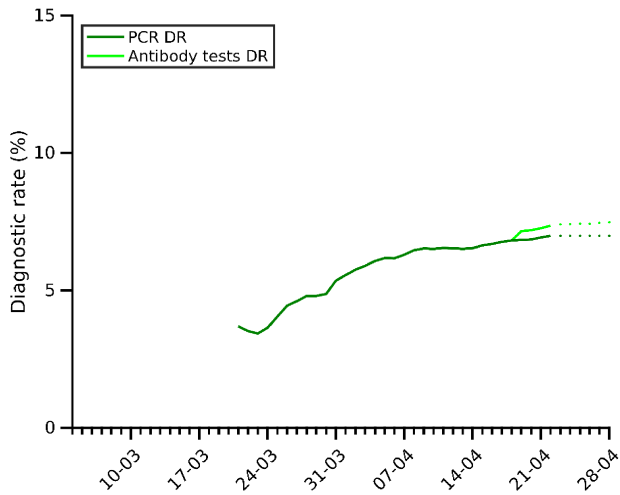
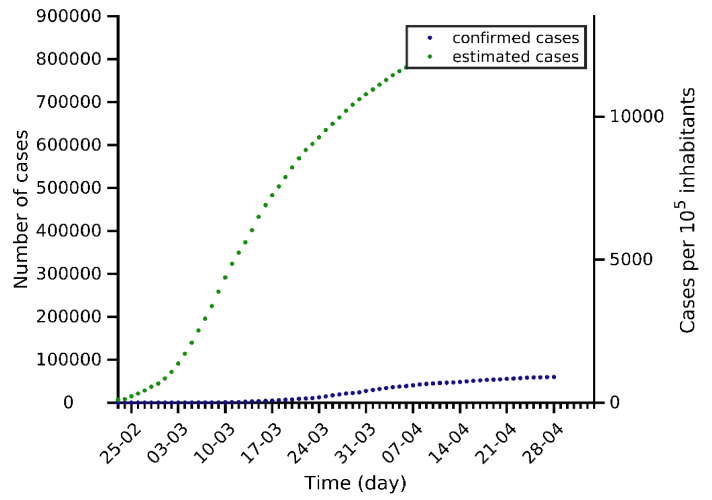
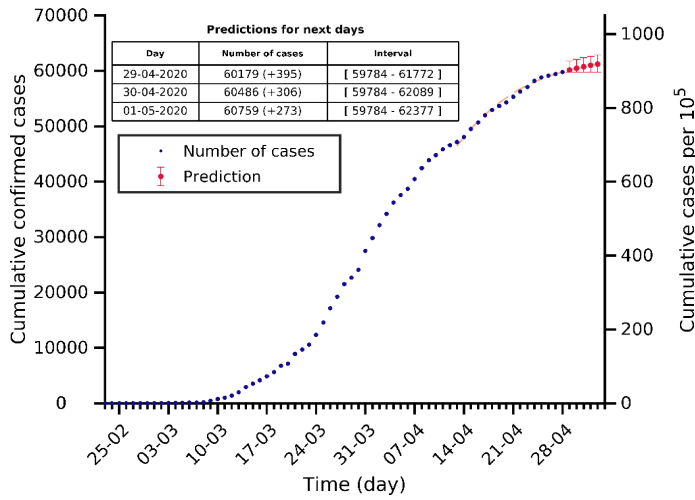
### **(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities**

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and <https://covid19.isciii.es/>

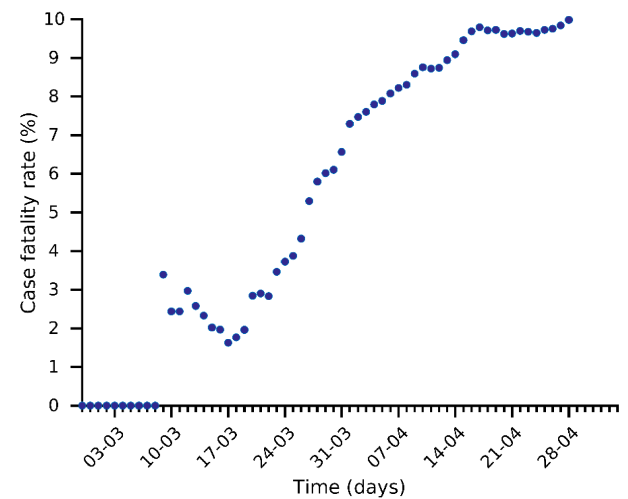
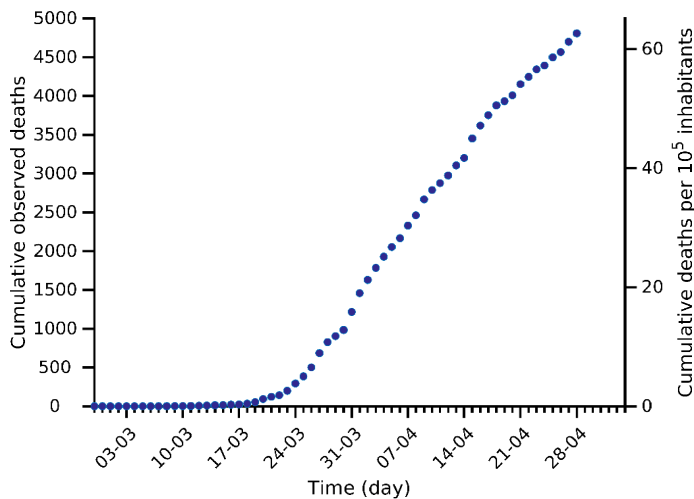
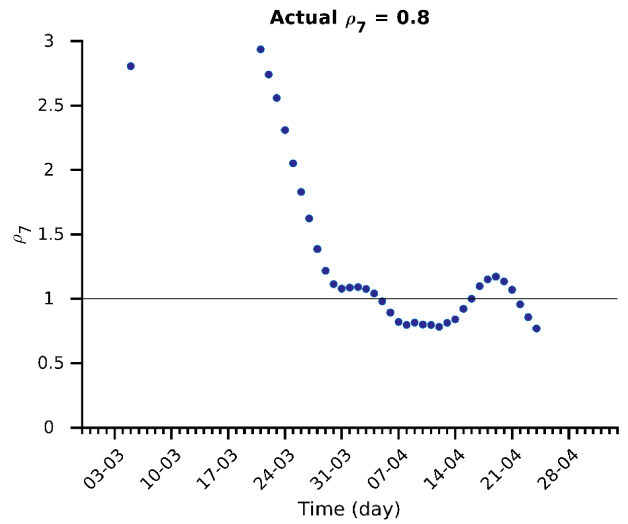
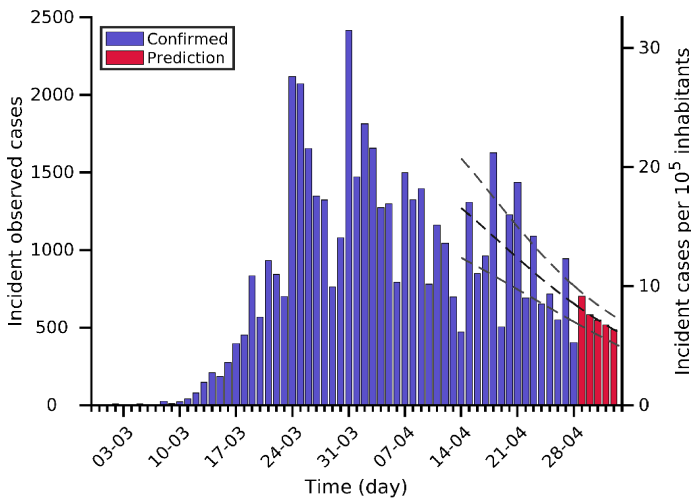
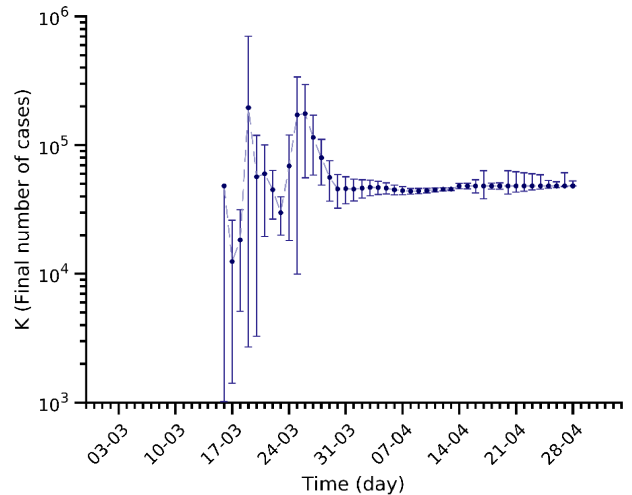
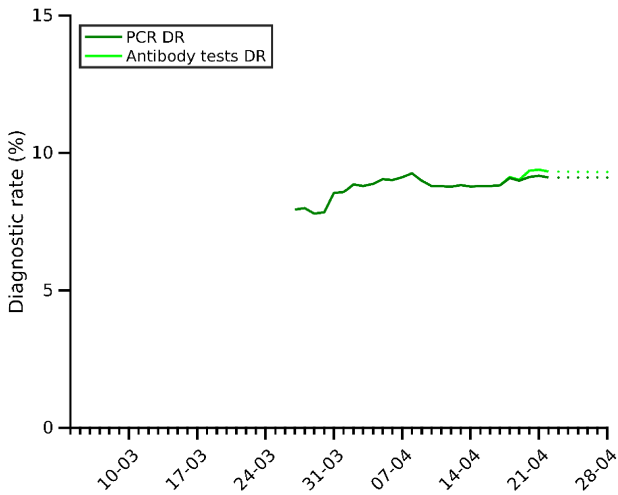
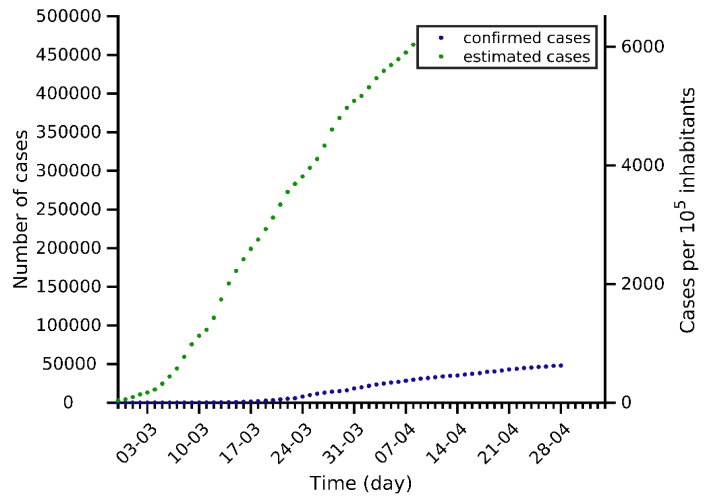
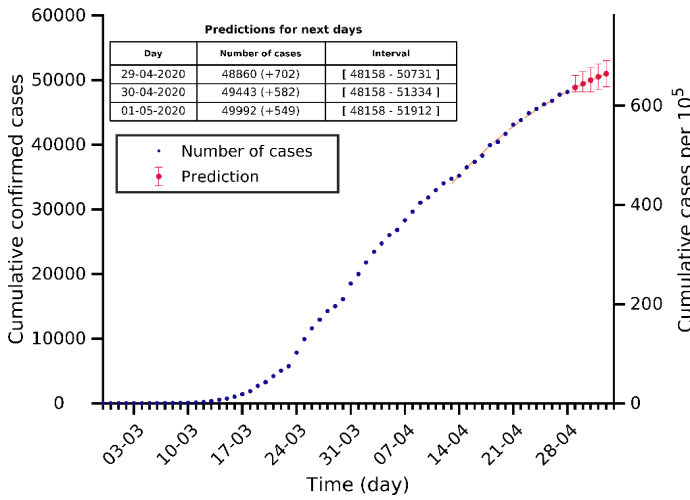
**Spain 28-04-2020. Population: 47.0M. Current cumulated incidence: 448/10<sup>5</sup>**



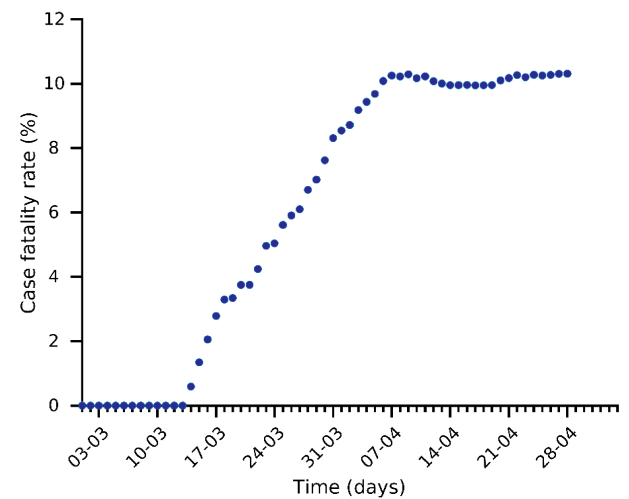
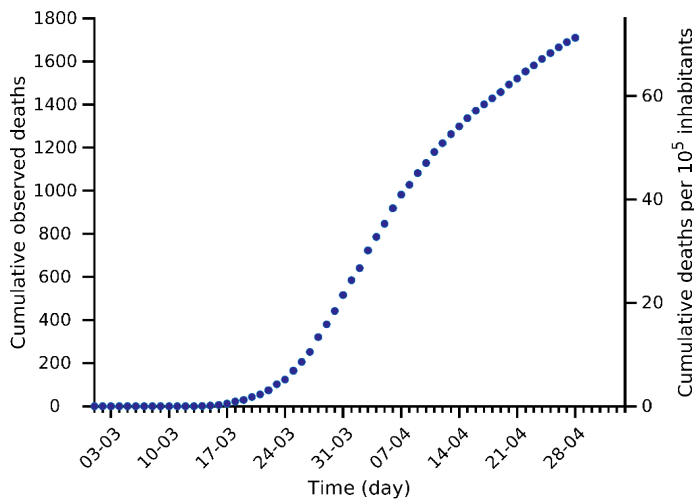
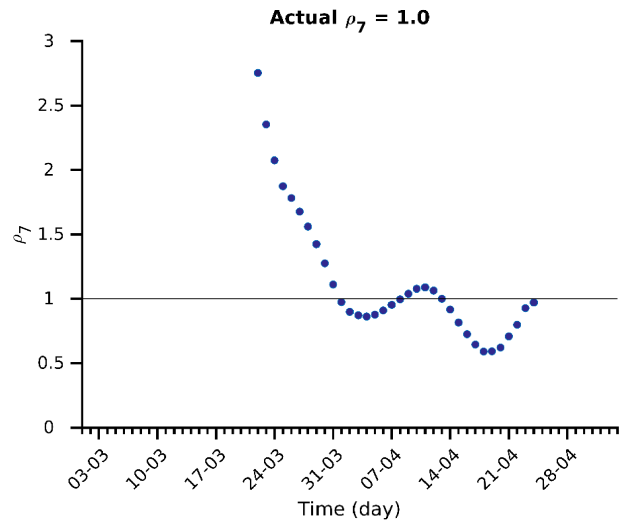
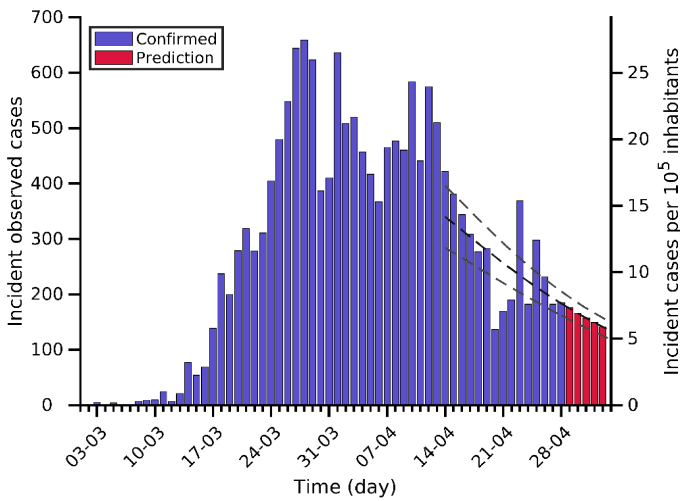
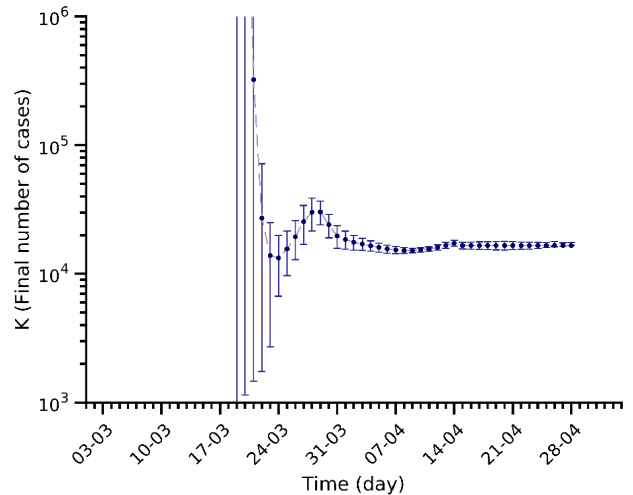
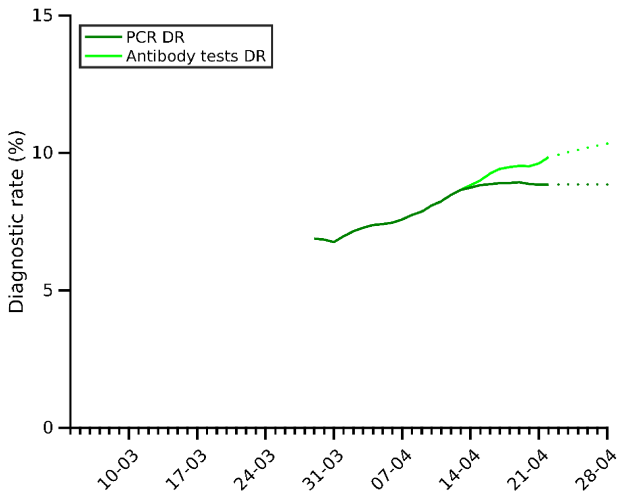
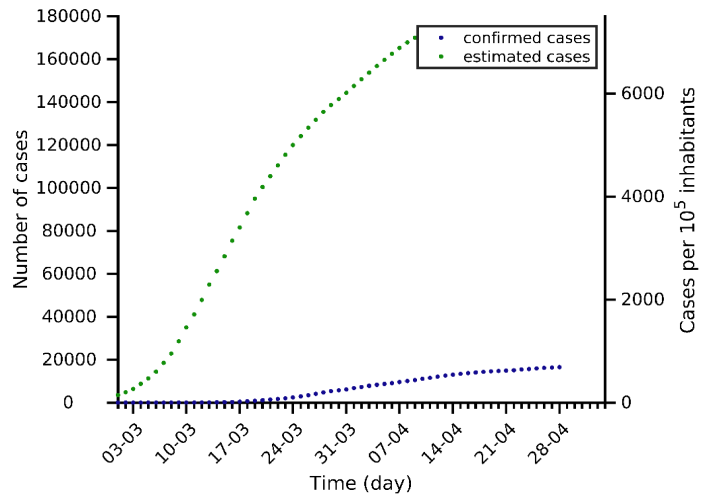
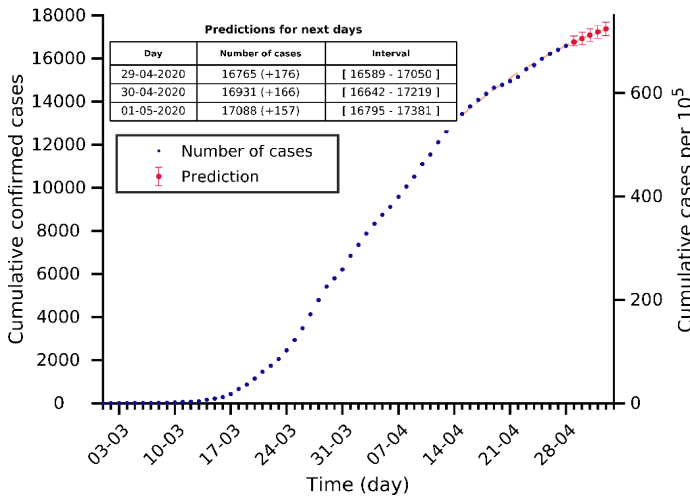
**Madrid 28-04-2020. Population: 6.7M. Current cumulated incidence: 897/10<sup>5</sup>**



**Catalunya 28-04-2020. Population: 7.7M. Current cumulated incidence: 627/10<sup>5</sup>**

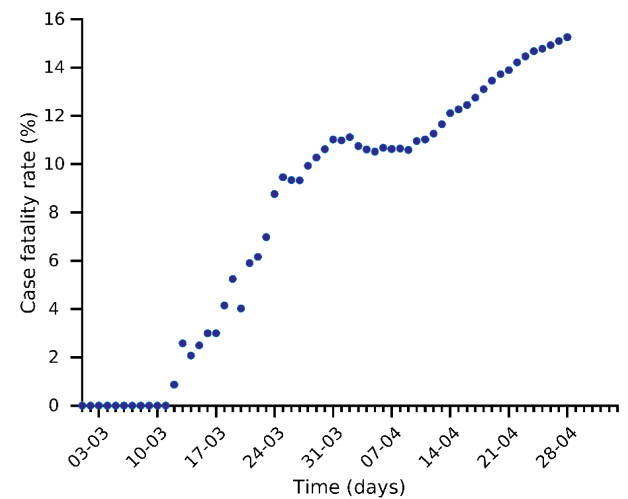
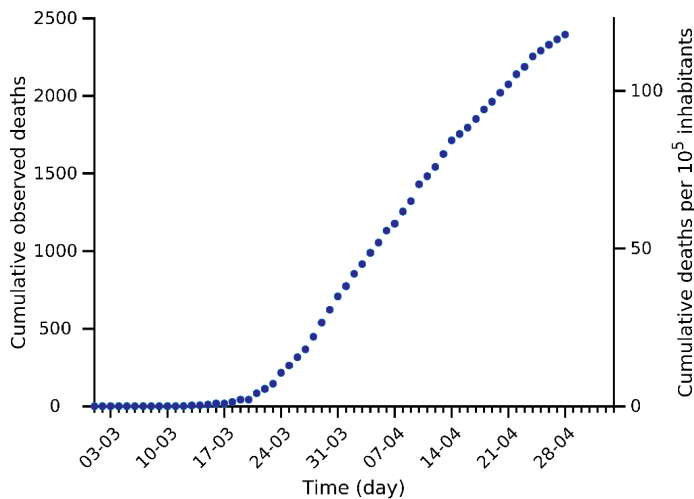
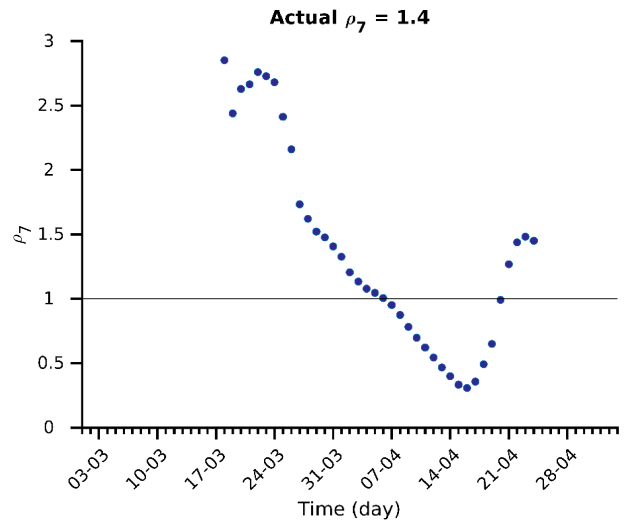
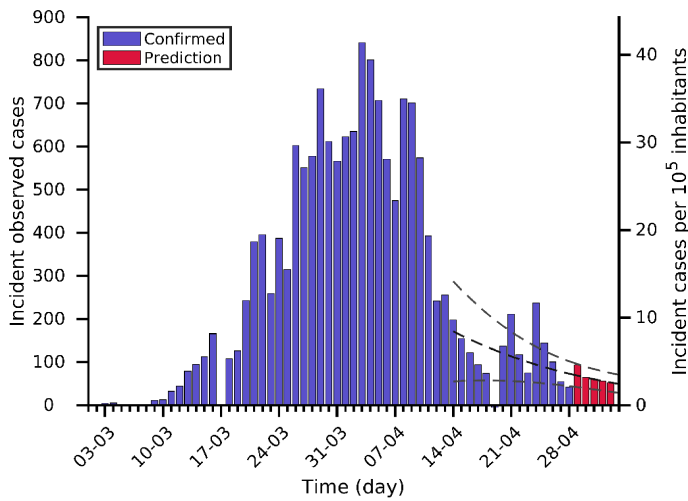
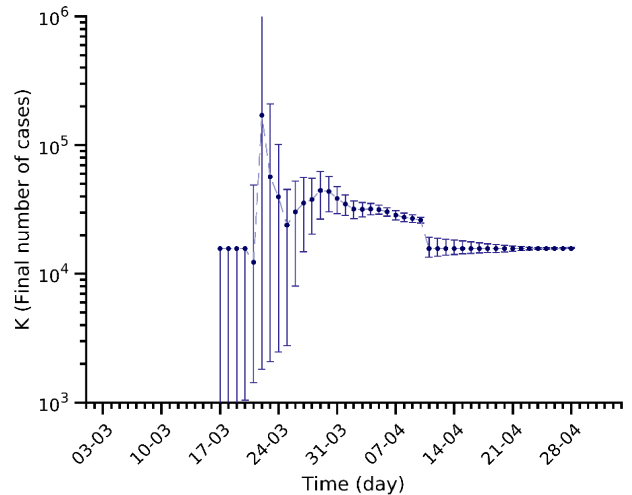
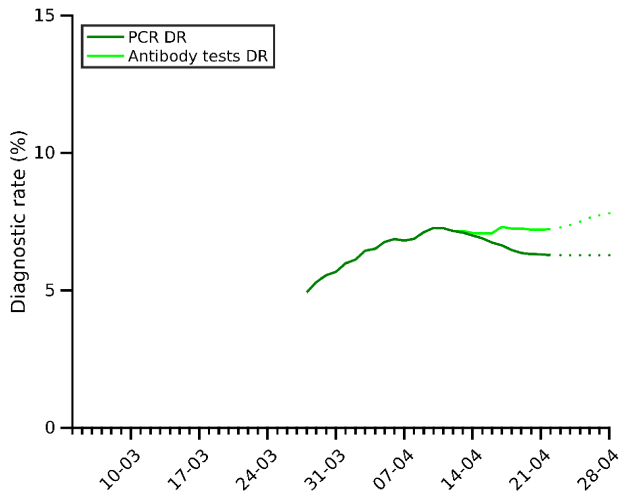
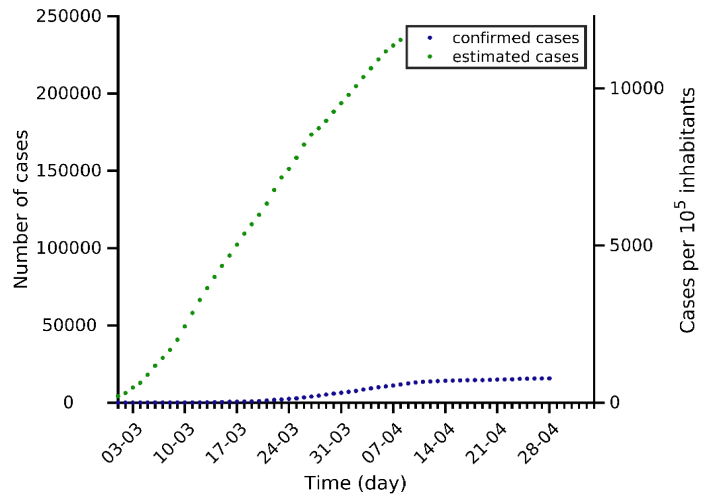
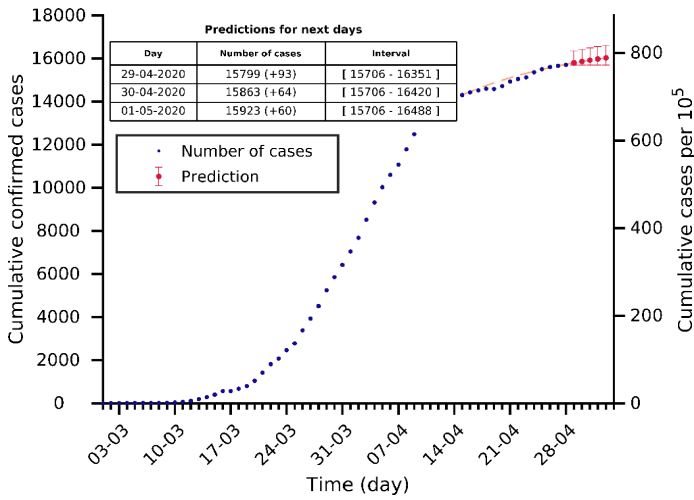


# Castilla Leon 28-04-2020. Population: 2.4M. Current cumulated incidence: 691/10<sup>5</sup>

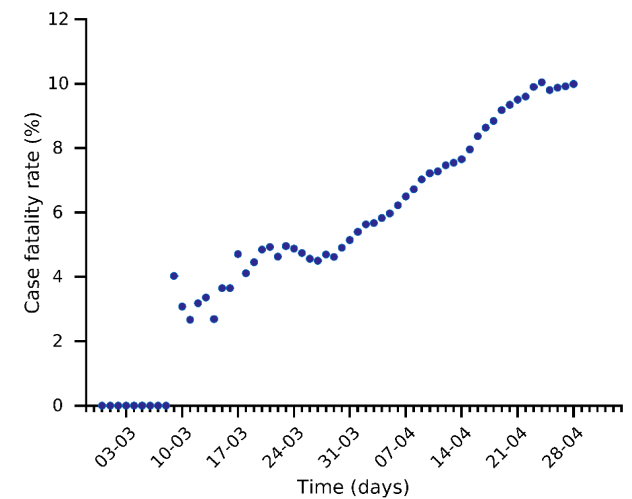
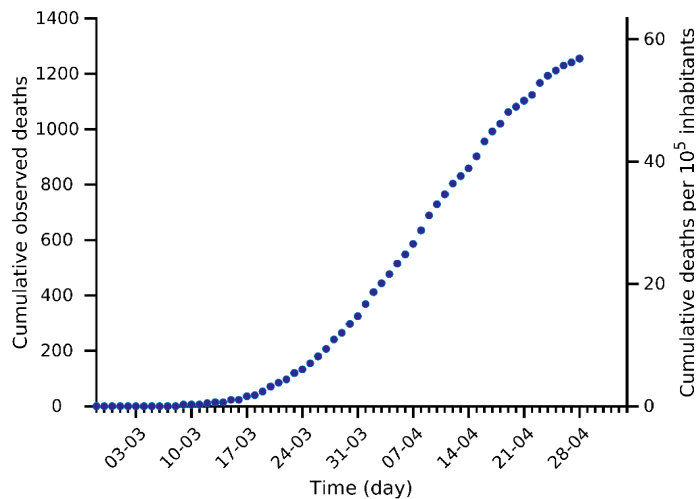
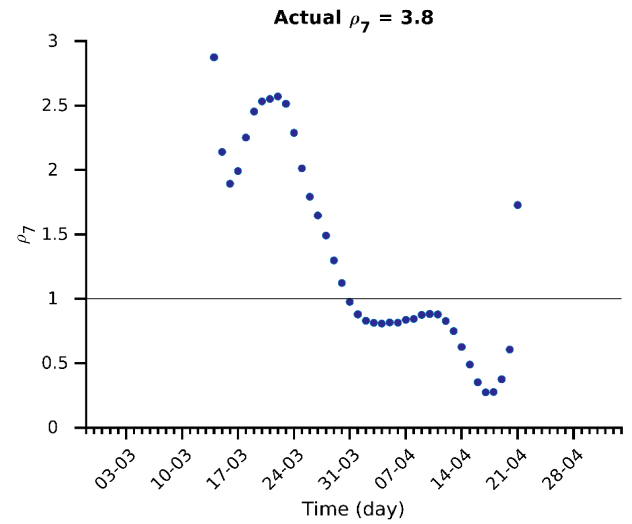
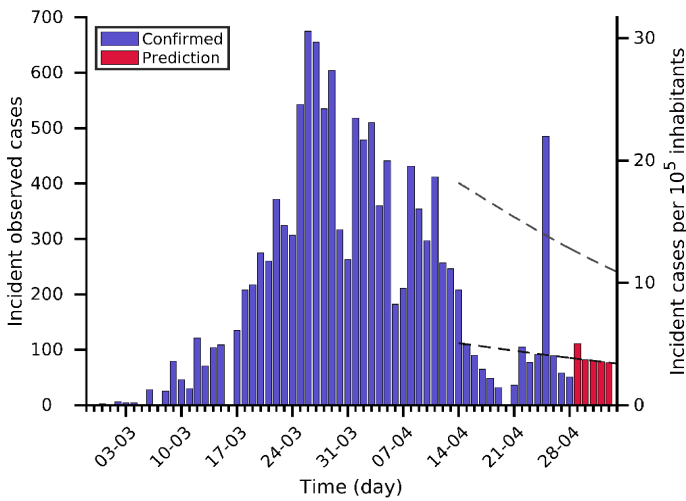
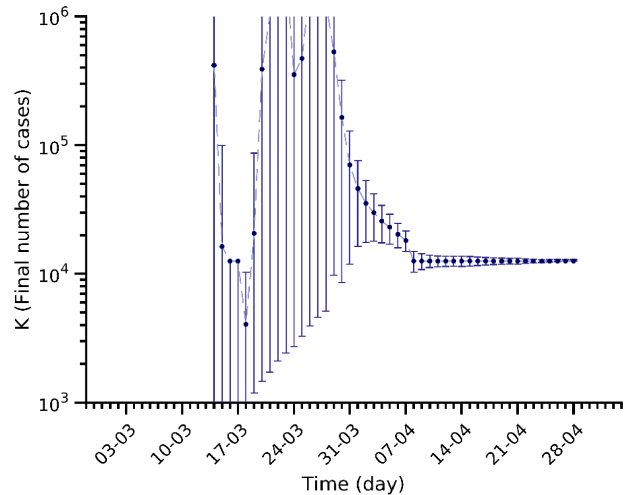
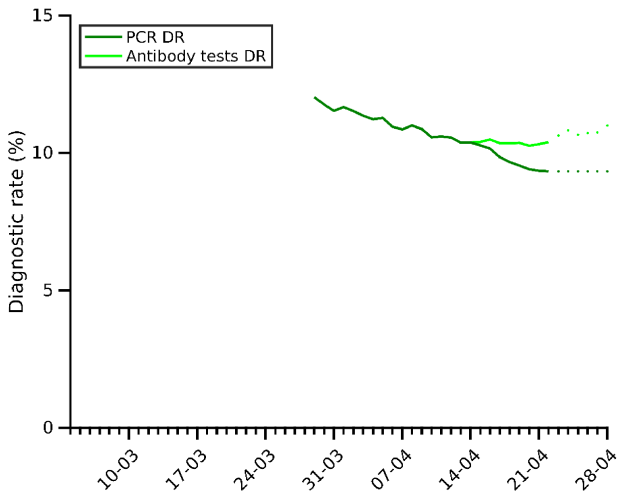
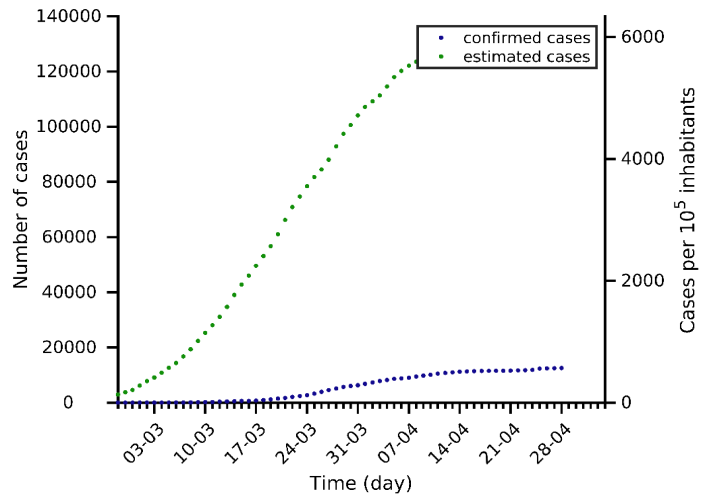
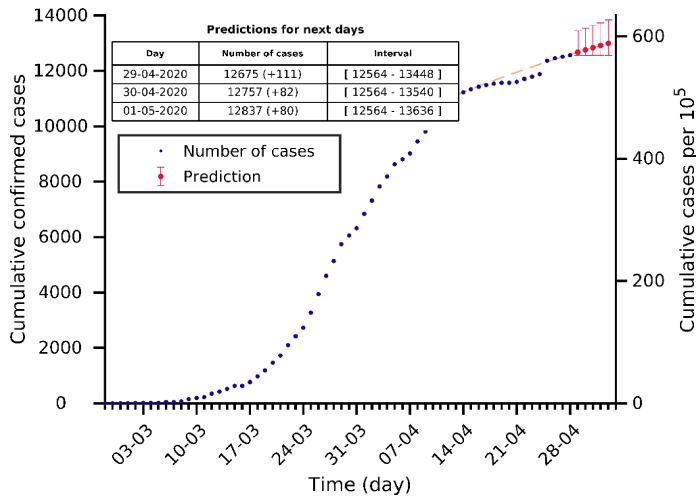




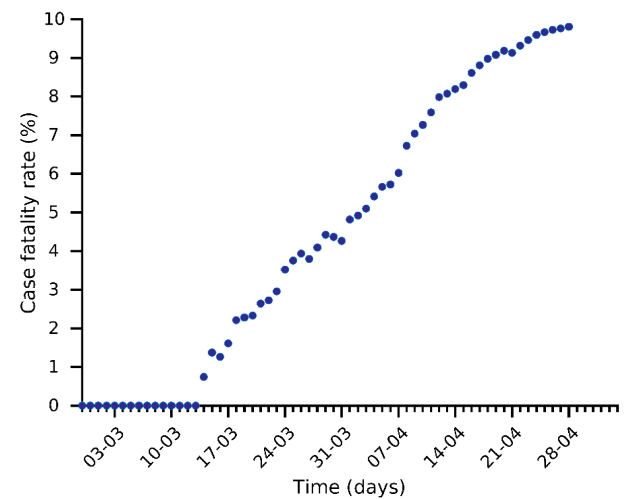
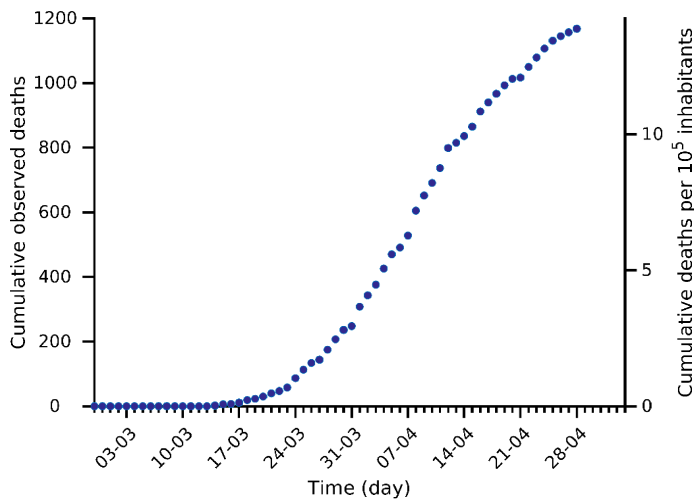
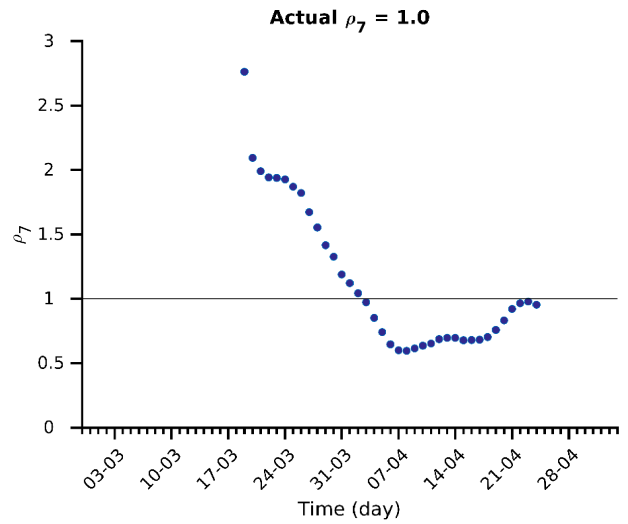
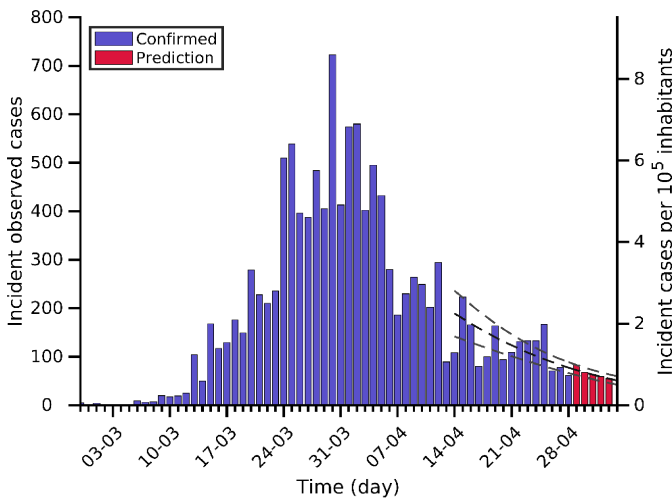
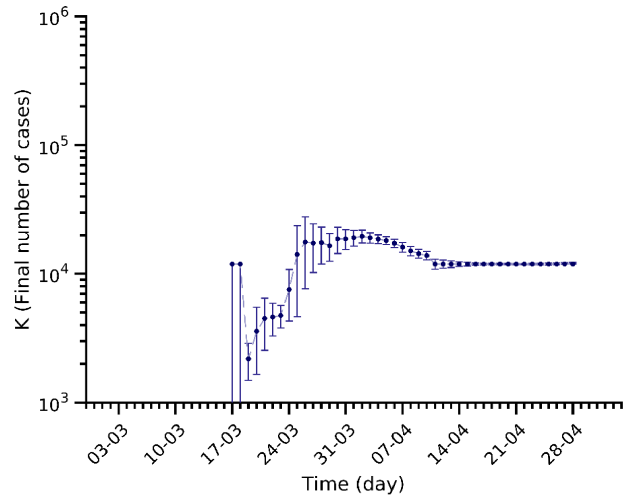
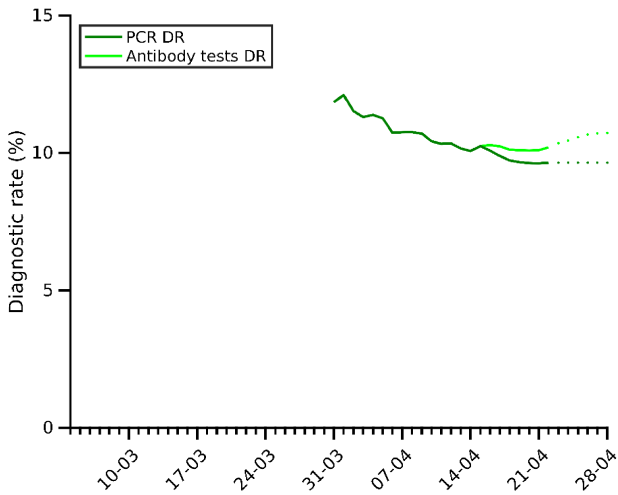
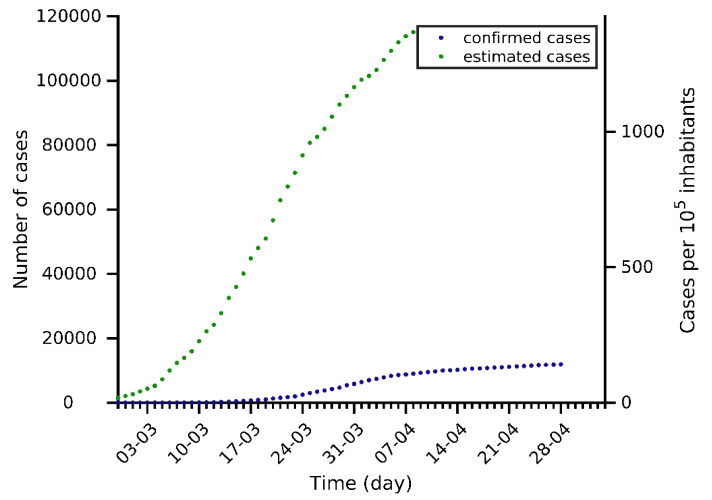
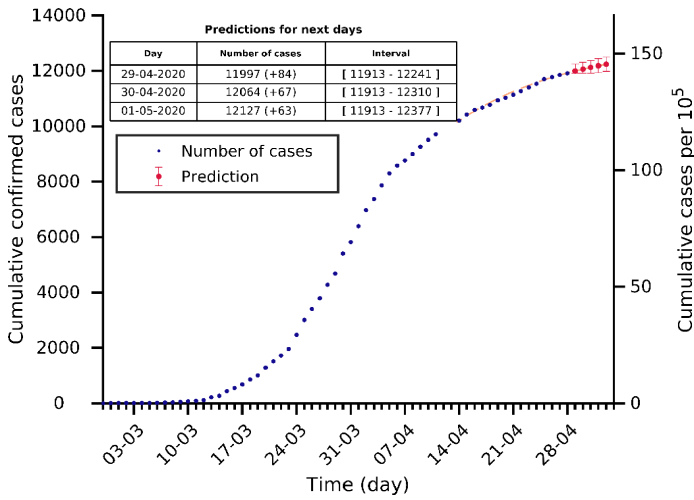
# Castilla-La Mancha 28-04-2020. Population: 2.0M. Current cumulated incidence: 77



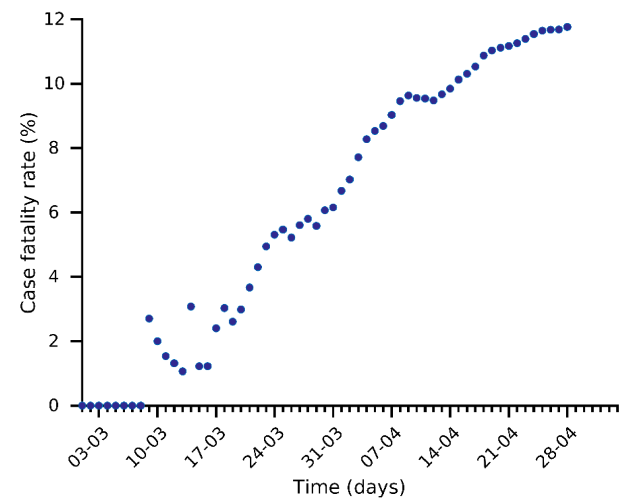
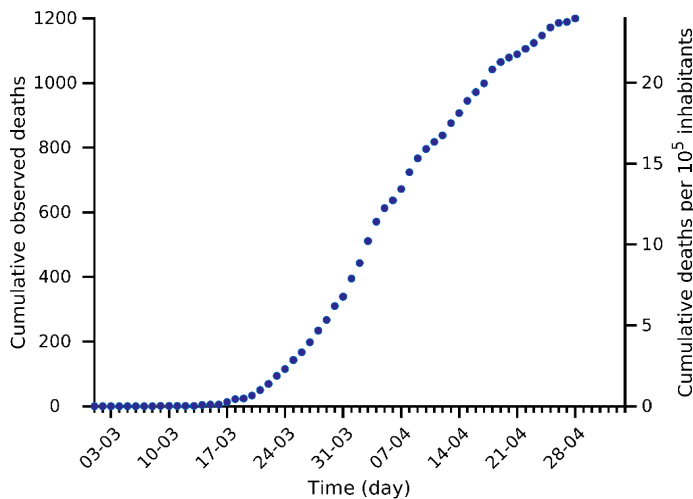
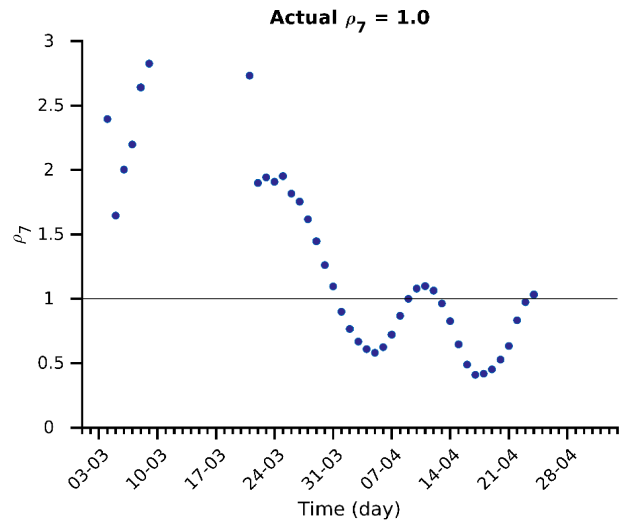
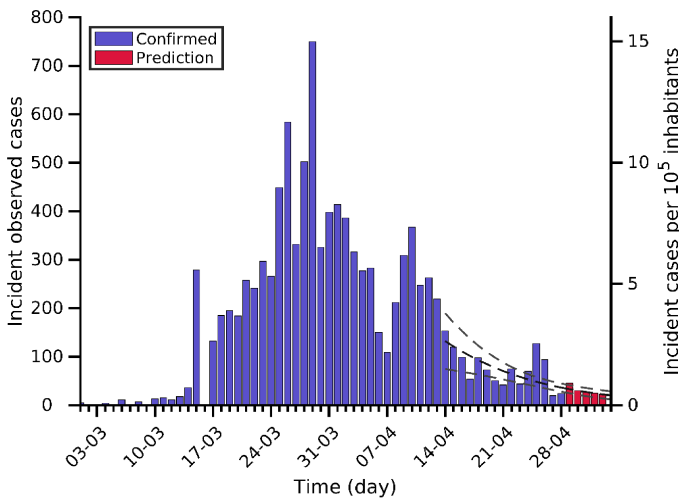
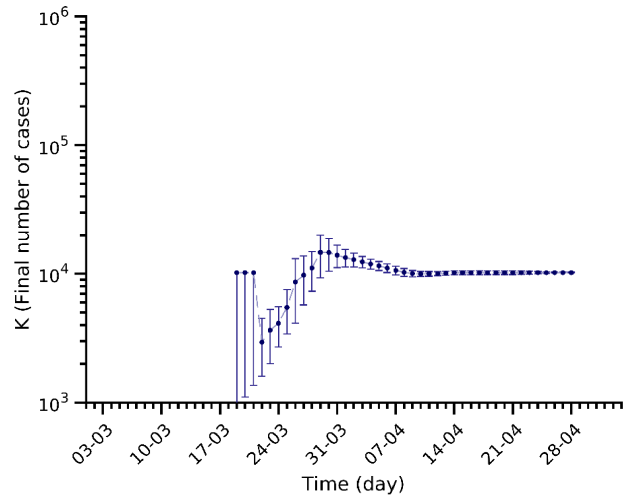
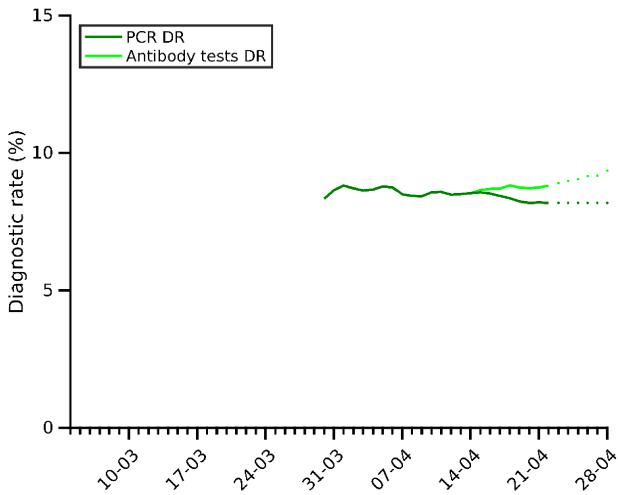
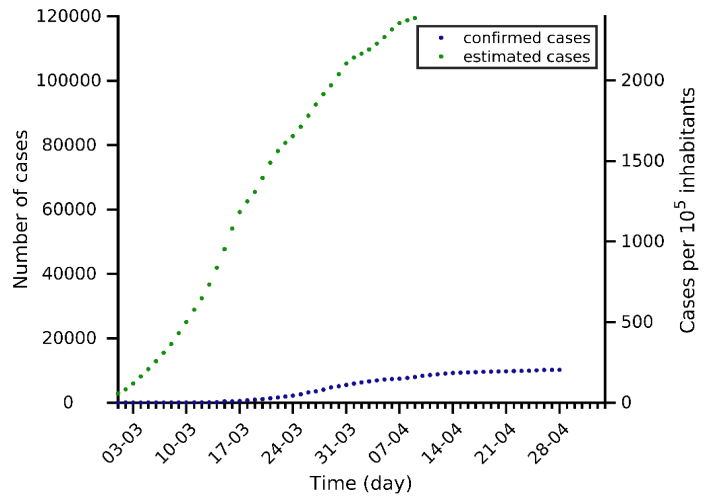
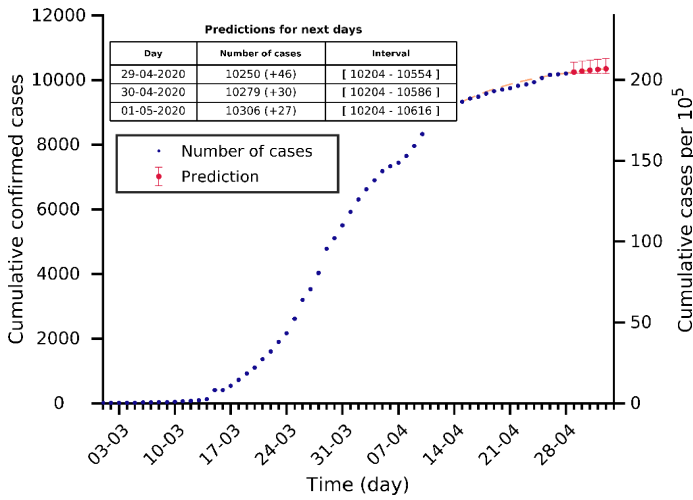
**Euskadi 28-04-2020. Population: 2.2M. Current cumulated incidence: 569/10<sup>5</sup>**



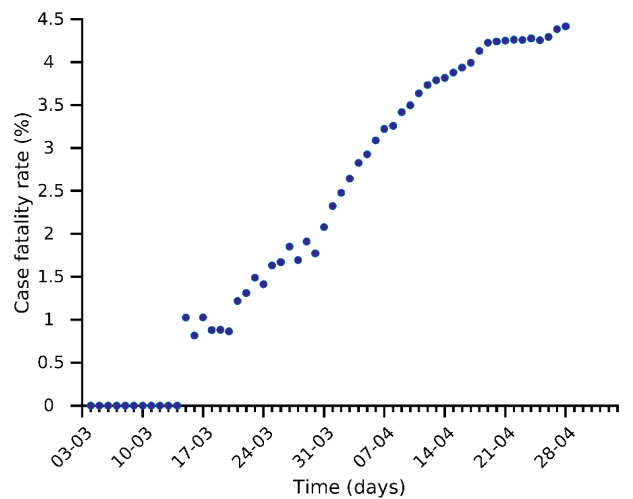
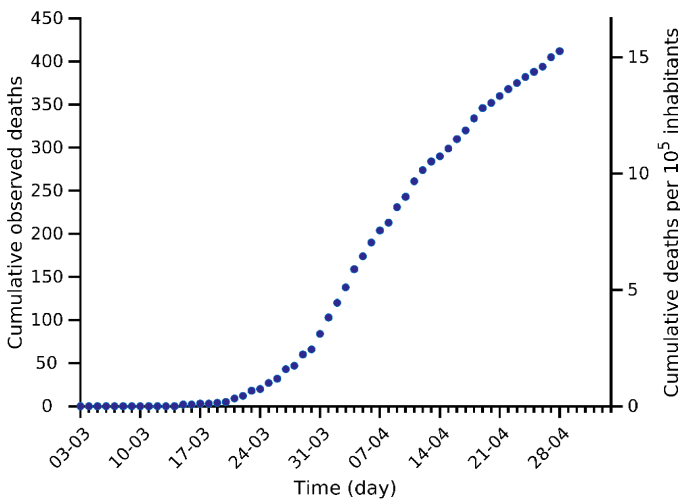
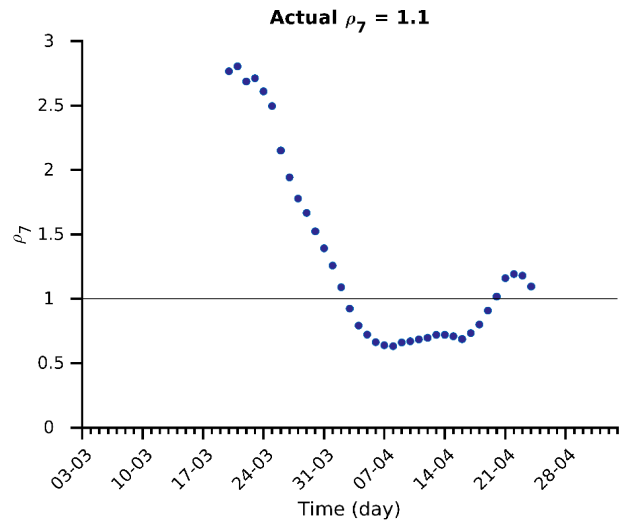
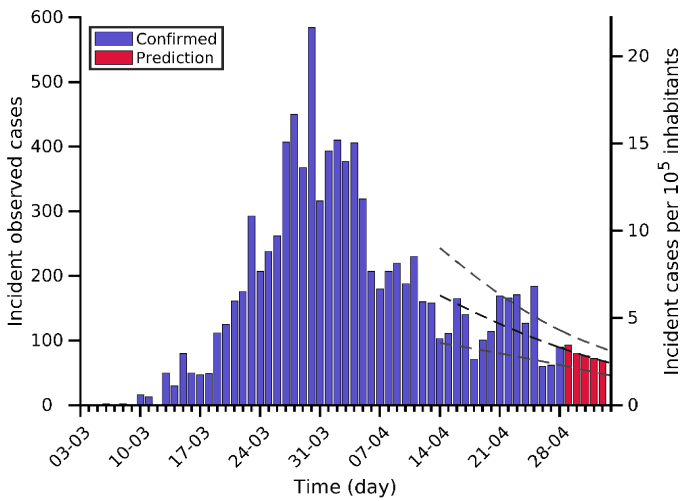
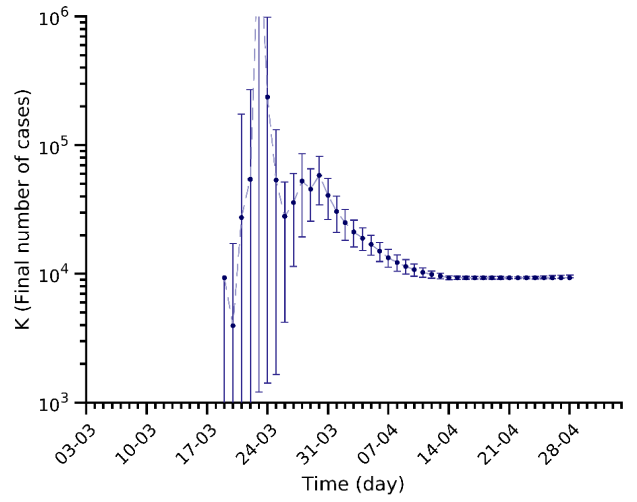
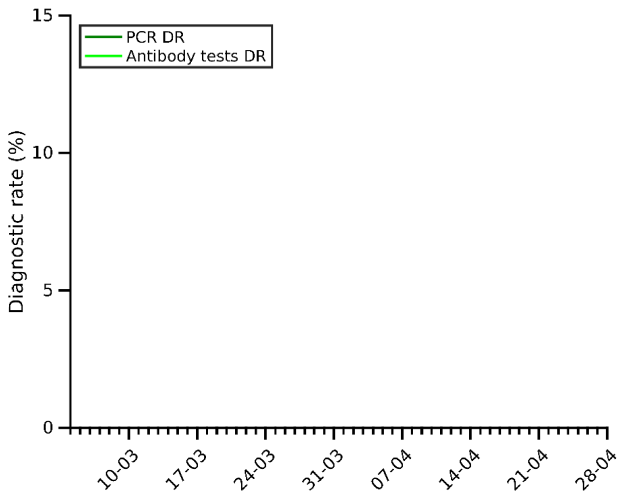
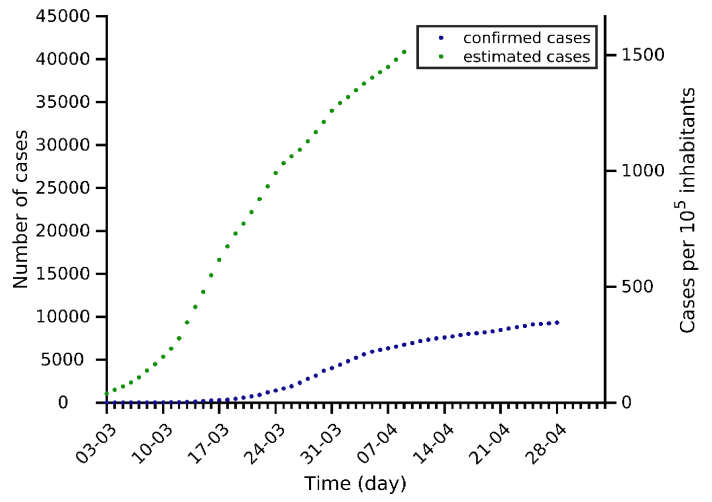
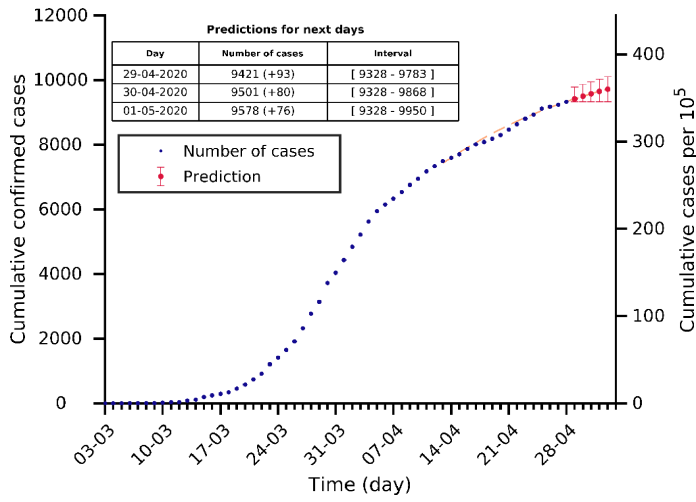
# Andalucia 28-04-2020. Population: 8.4M. Current cumulated incidence: 142/10<sup>5</sup>



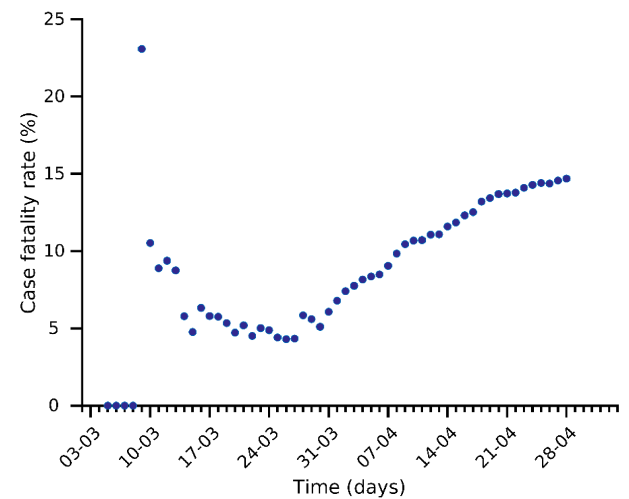
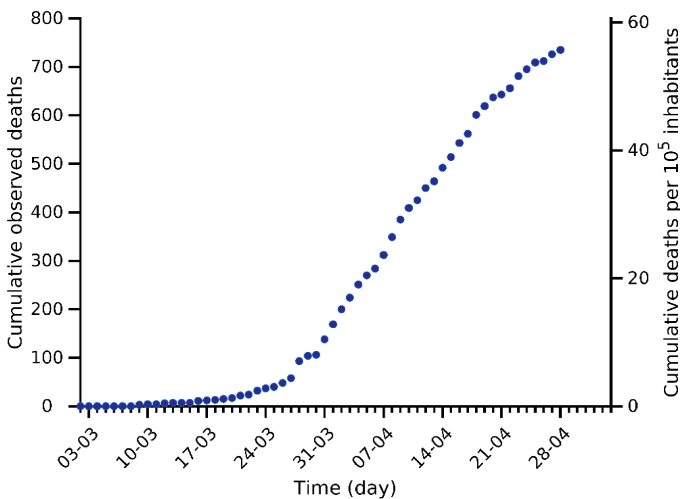
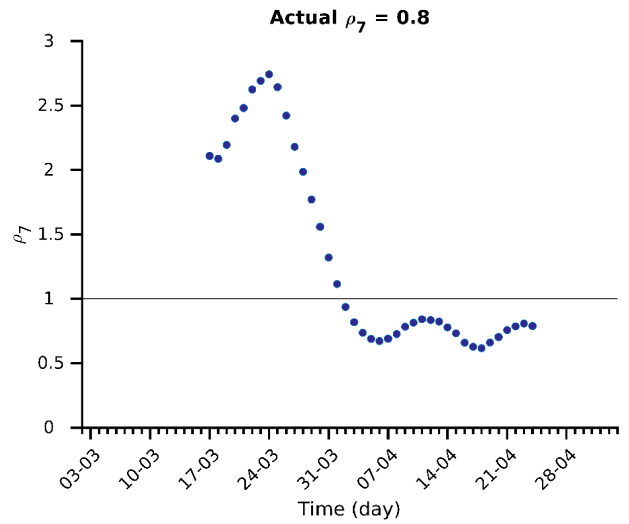
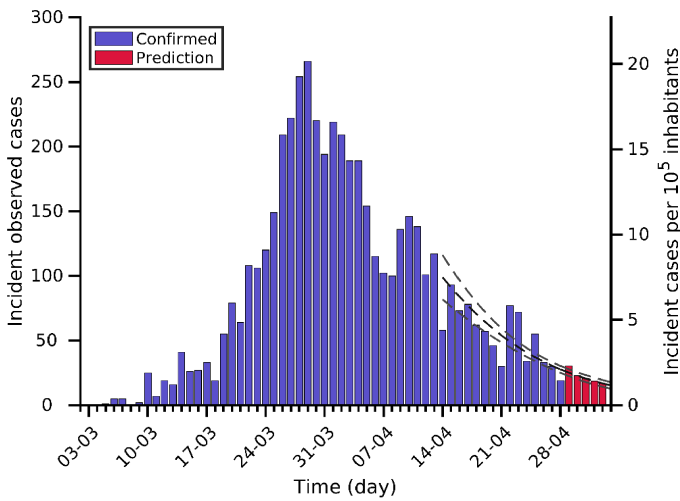
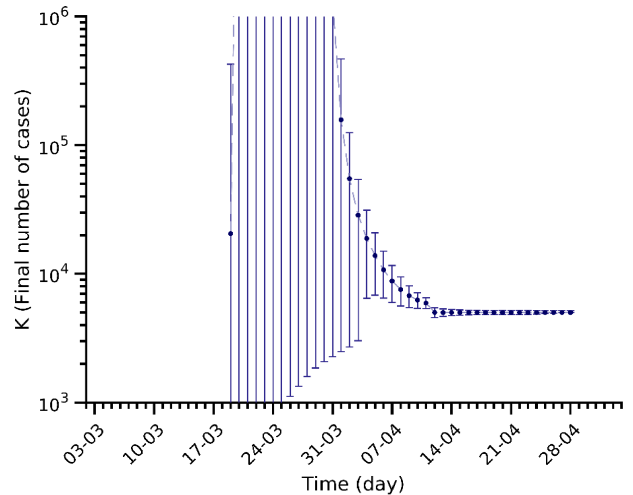
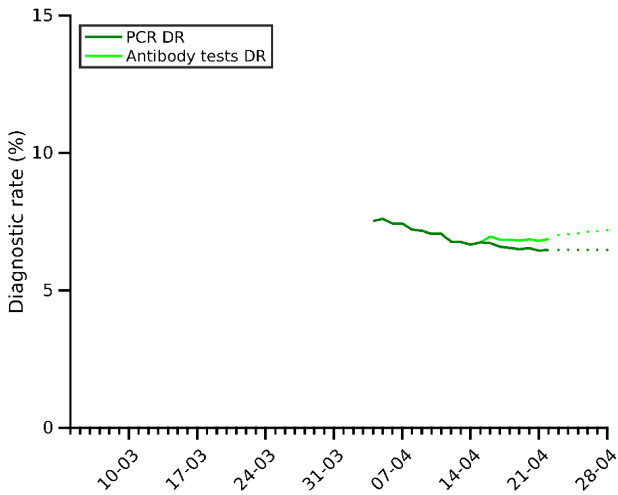
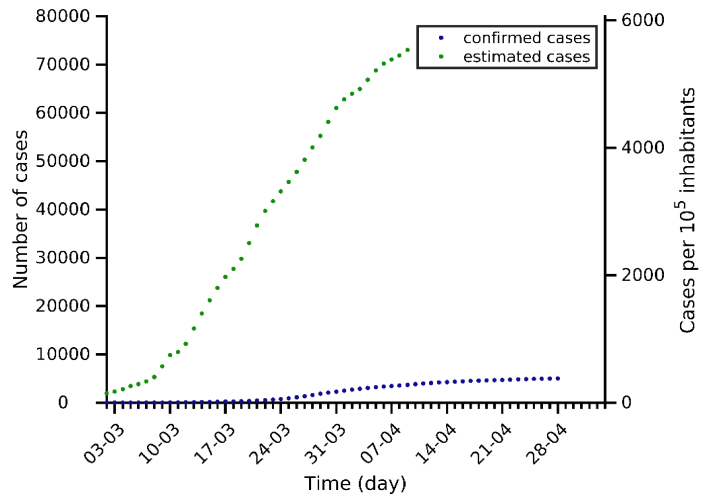
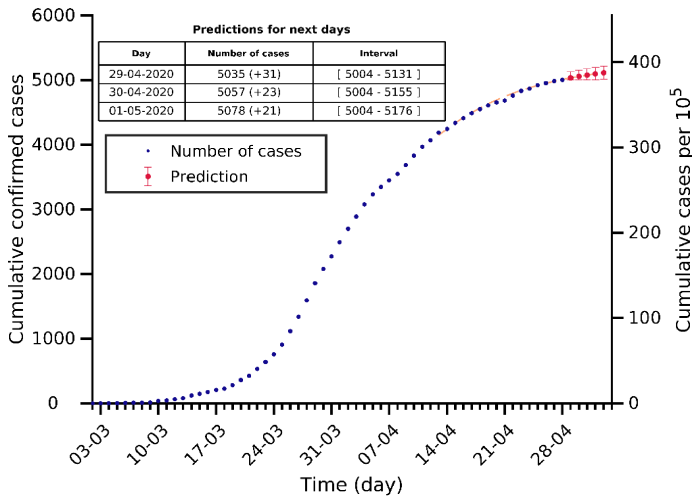
# C Valenciana 28-04-2020. Population: 5.0M. Current cumulated incidence: 204/10<sup>5</sup>



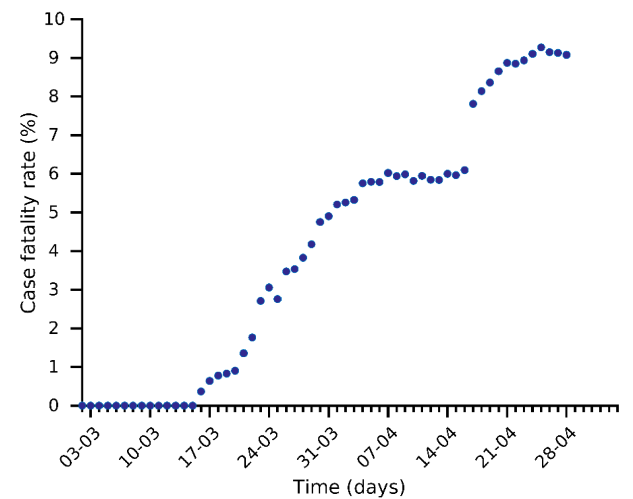
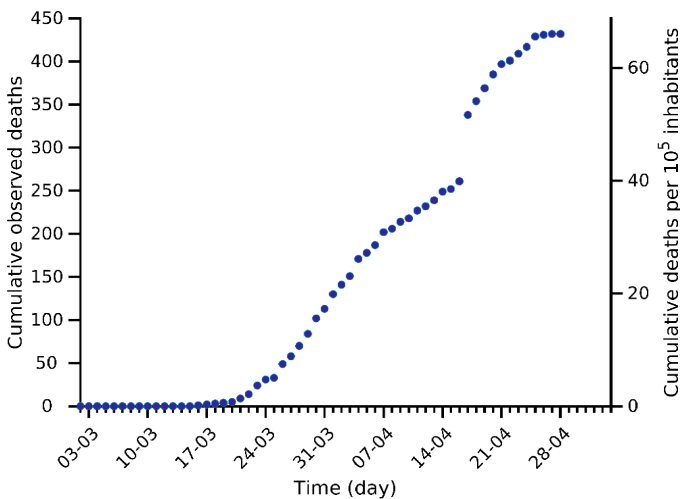
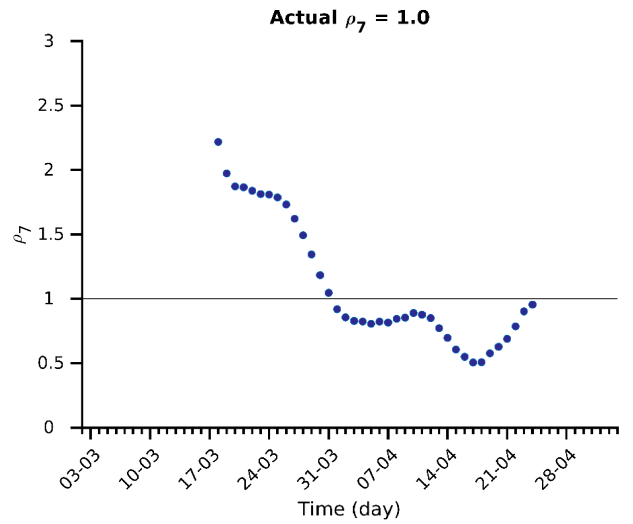
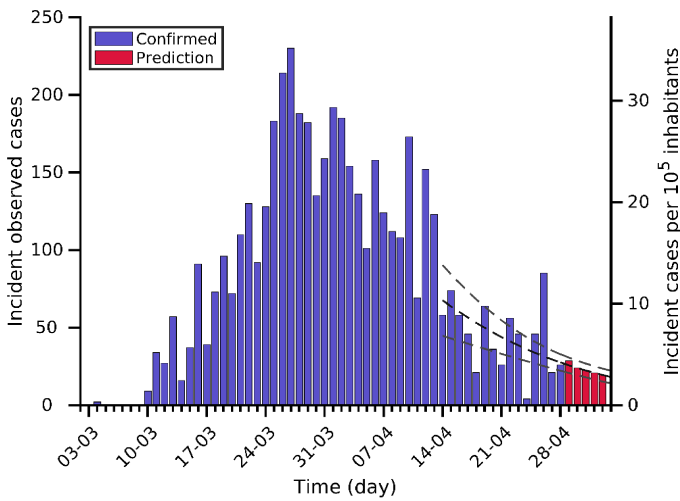
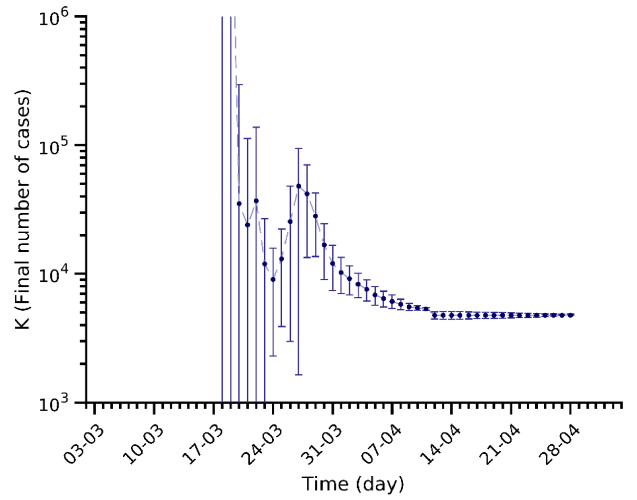
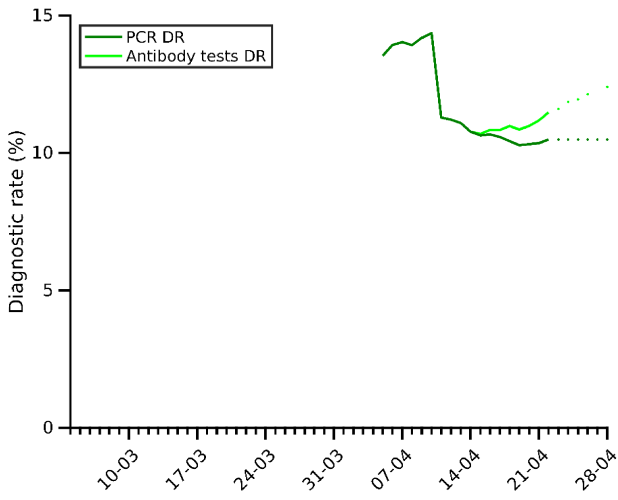
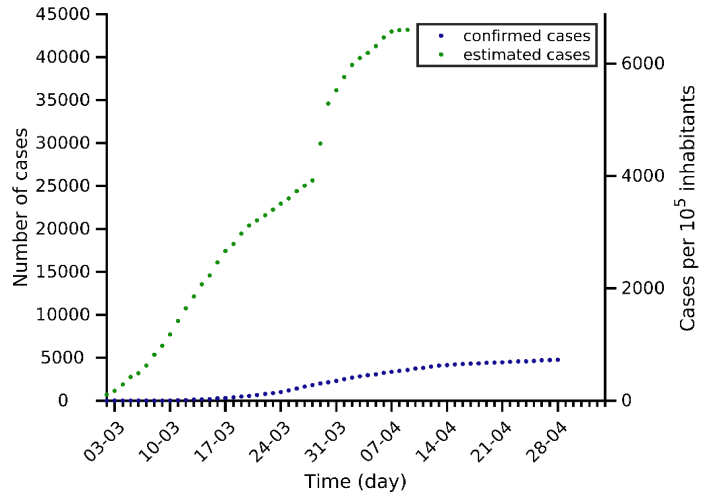
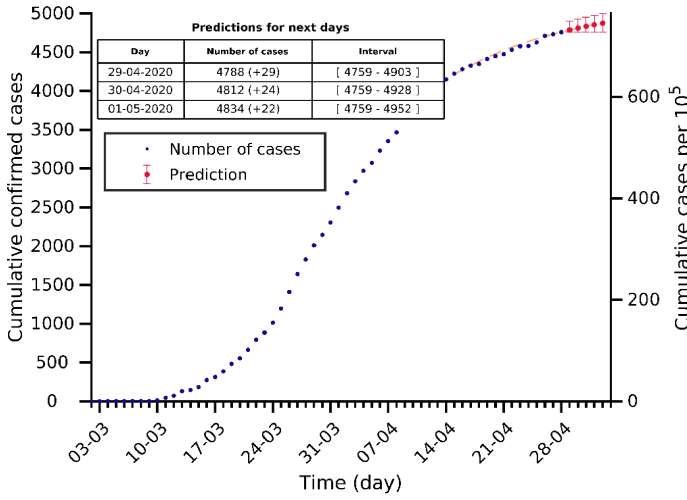
**Galicia 28-04-2020. Population: 2.7M. Current cumulated incidence: 346/10<sup>5</sup>**



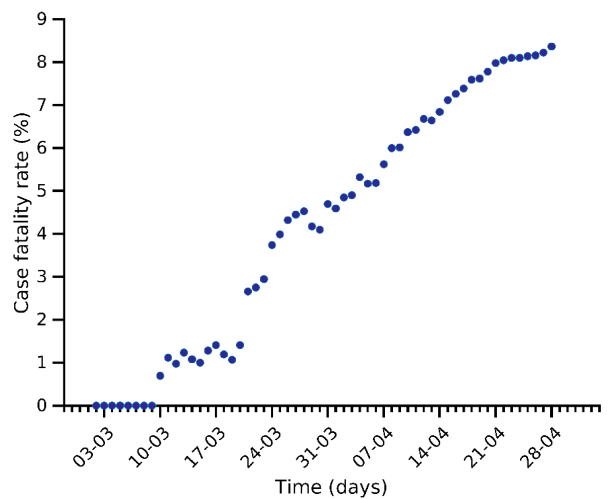
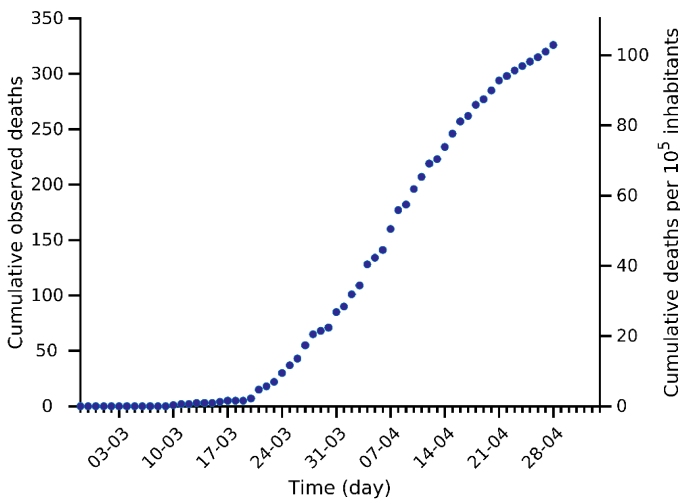
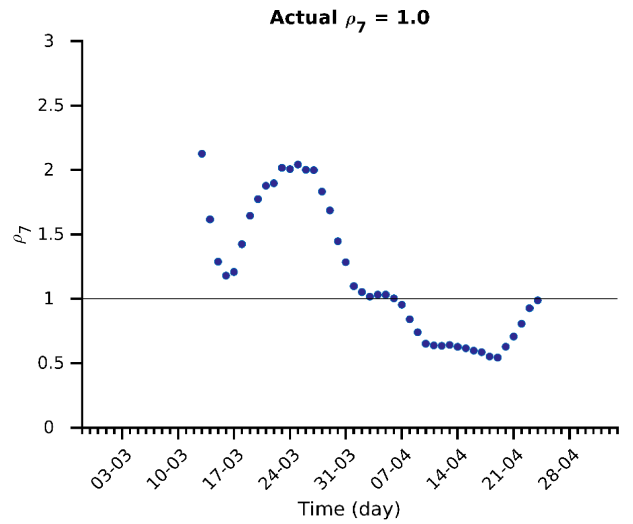
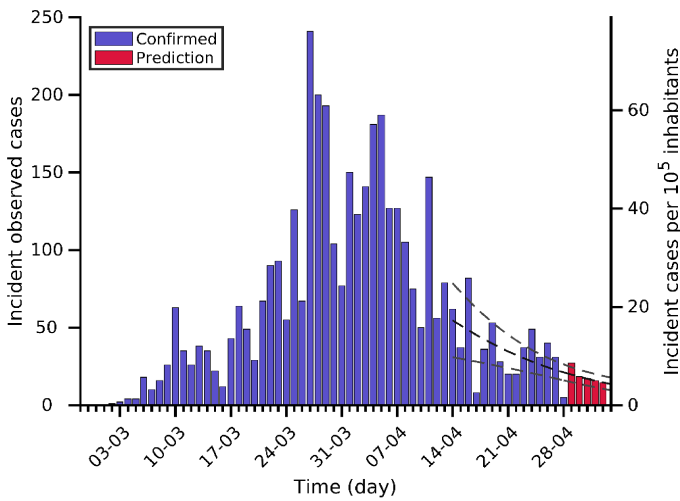
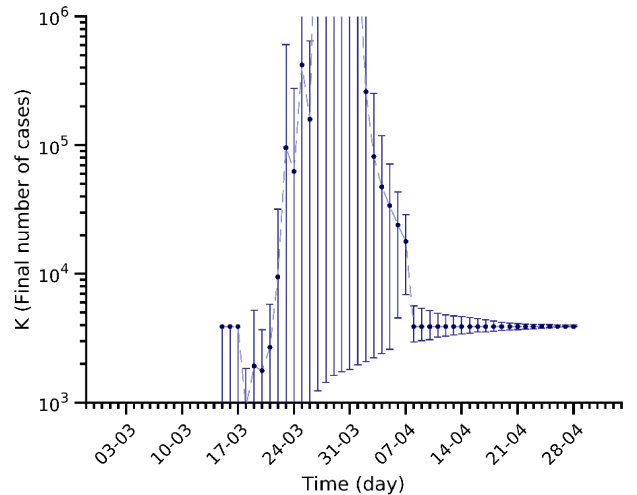
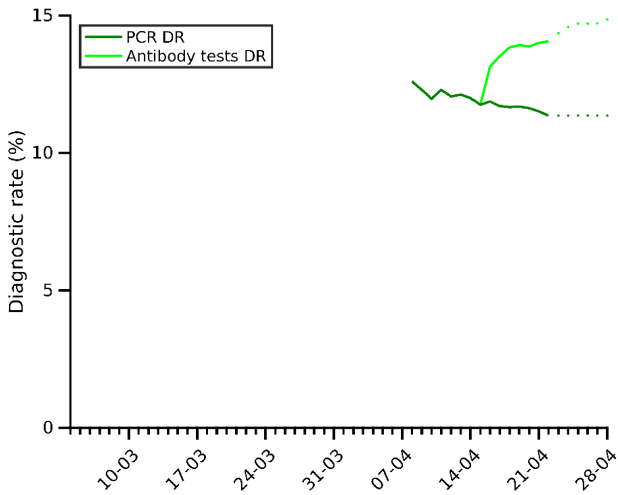
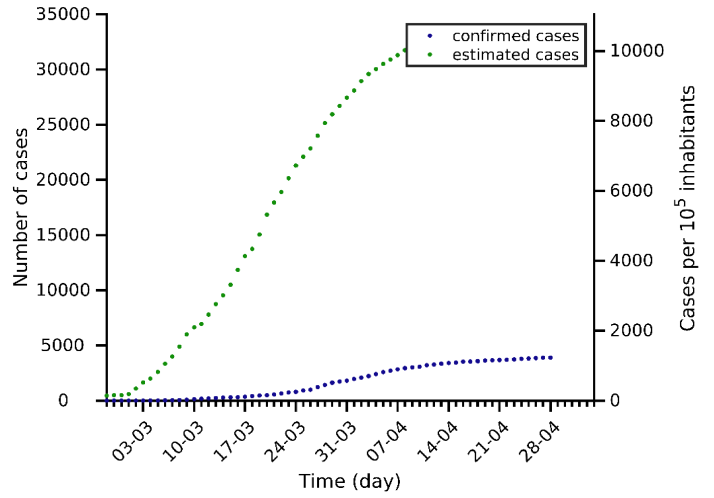
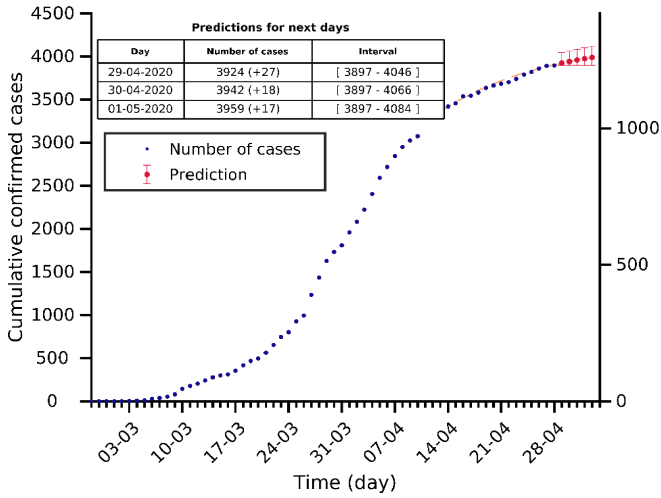
**Aragon 28-04-2020. Population: 1.3M. Current cumulated incidence: 379/10<sup>5</sup>**



**Navarra 28-04-2020. Population: 0.7M. Current cumulated incidence: 727/10<sup>5</sup>**

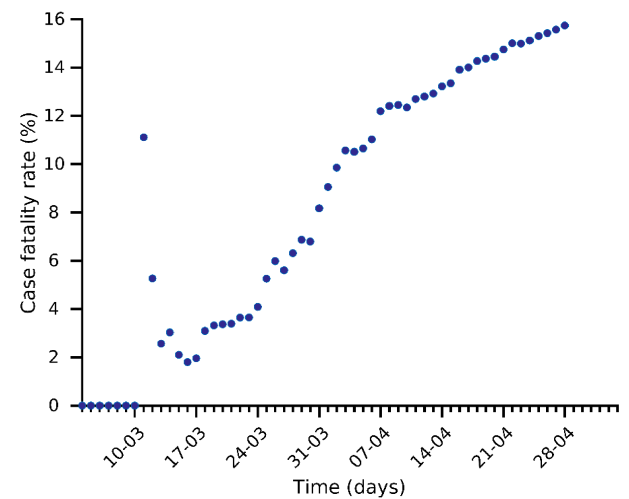
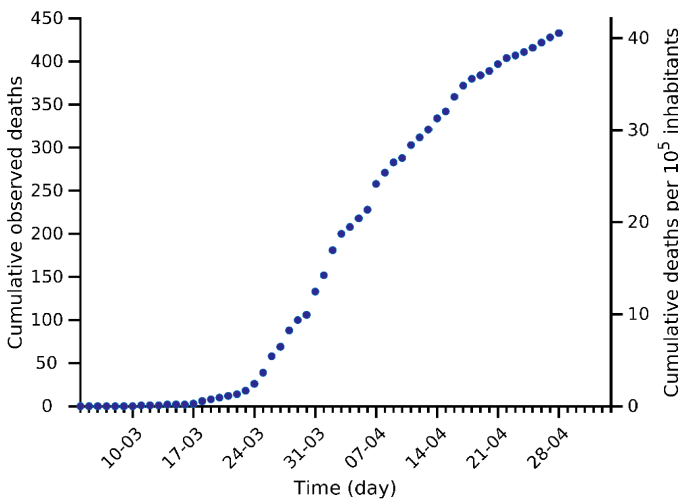
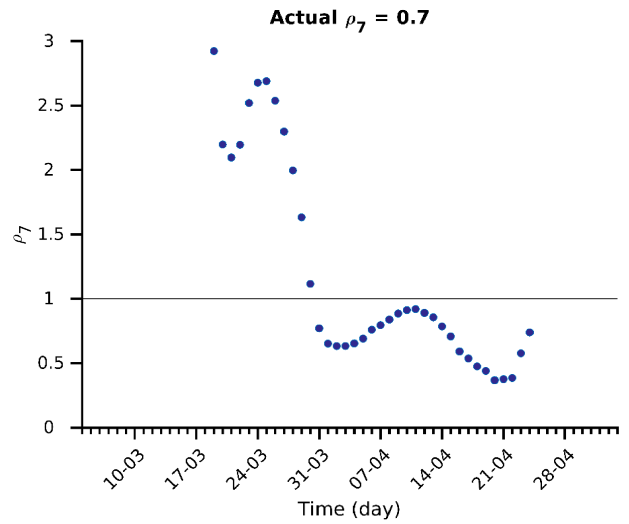
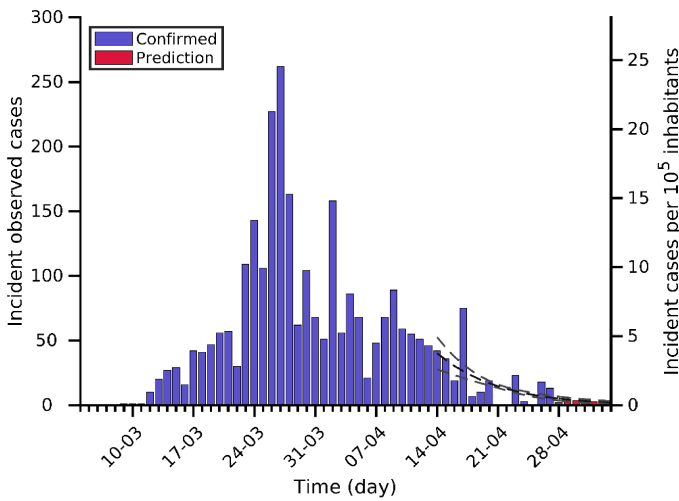
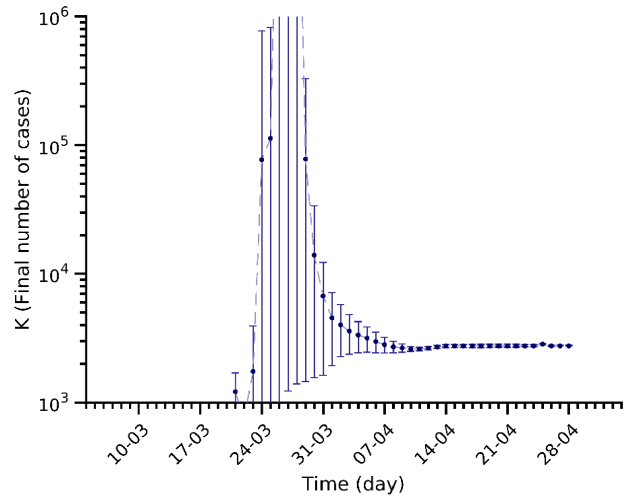
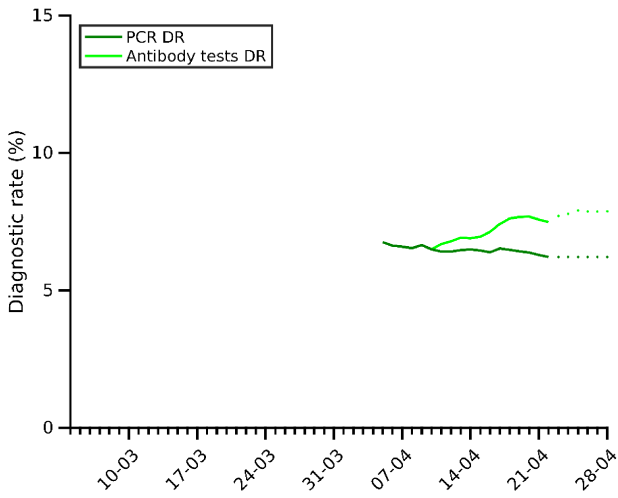
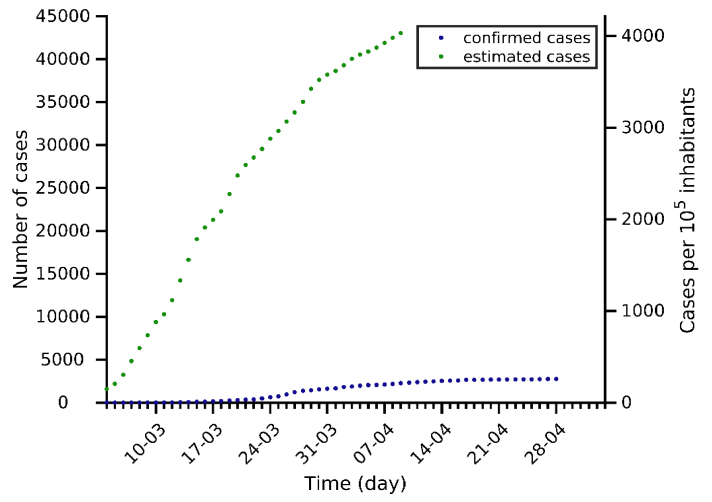
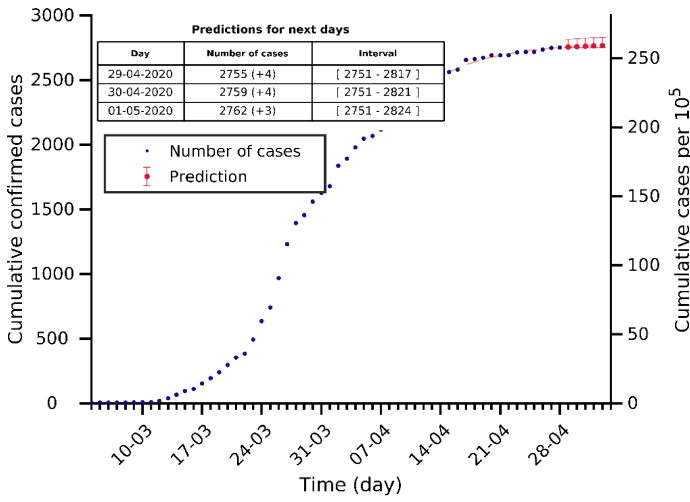


**La Rioja 28-04-2020. Population: 0.3M. Current cumulated incidence: 1230/10<sup>5</sup>**

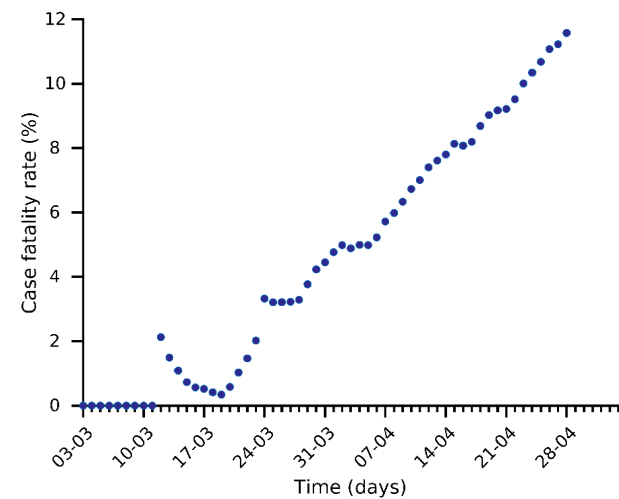
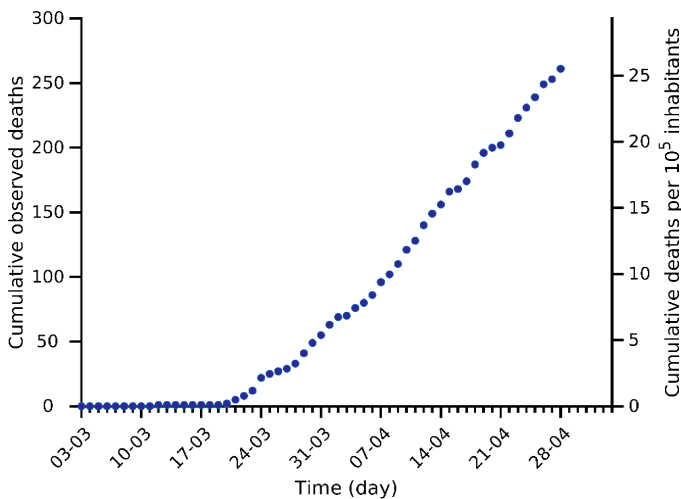
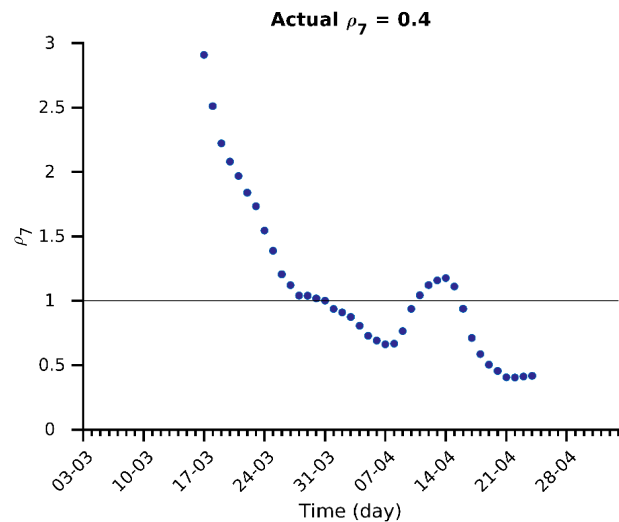
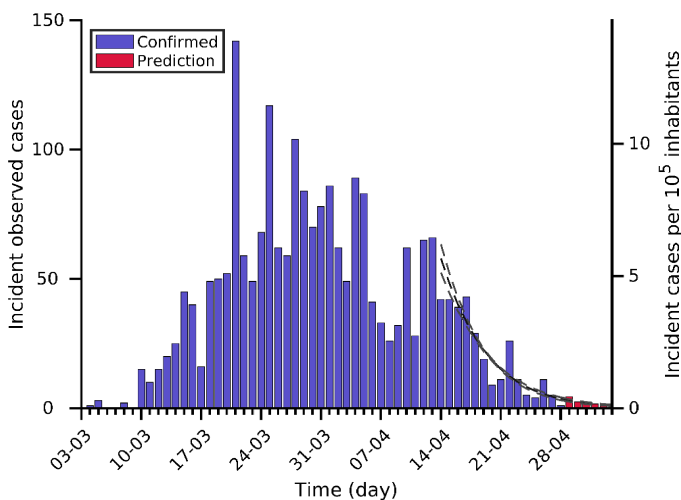
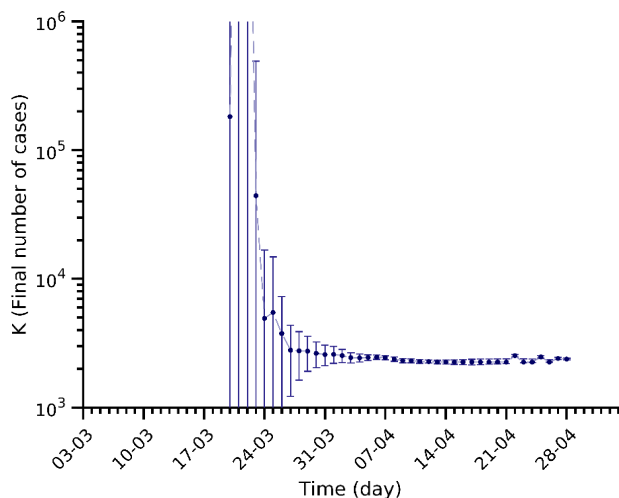
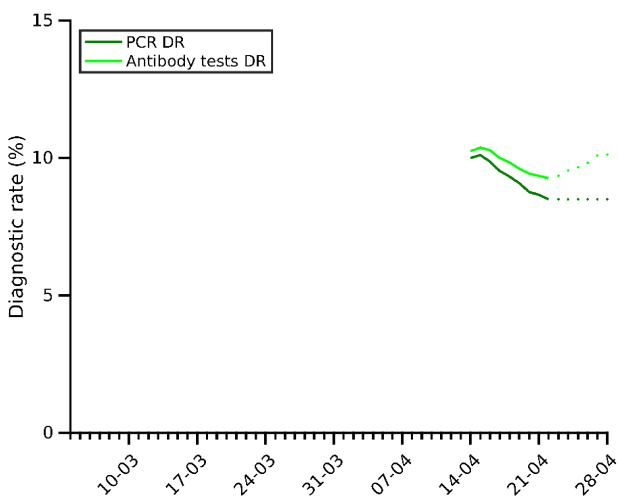
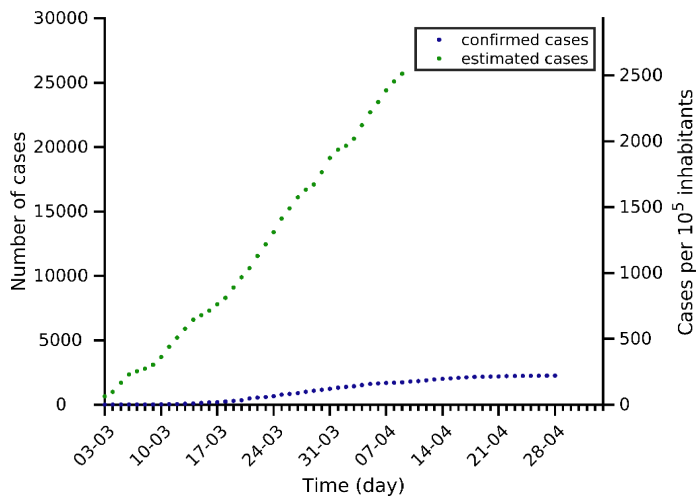
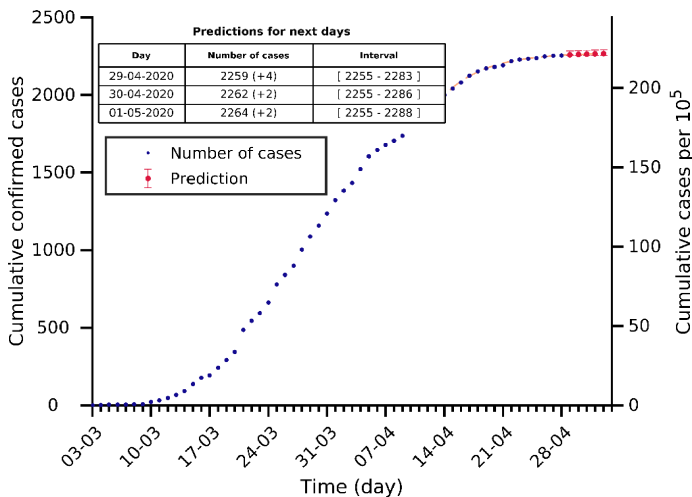




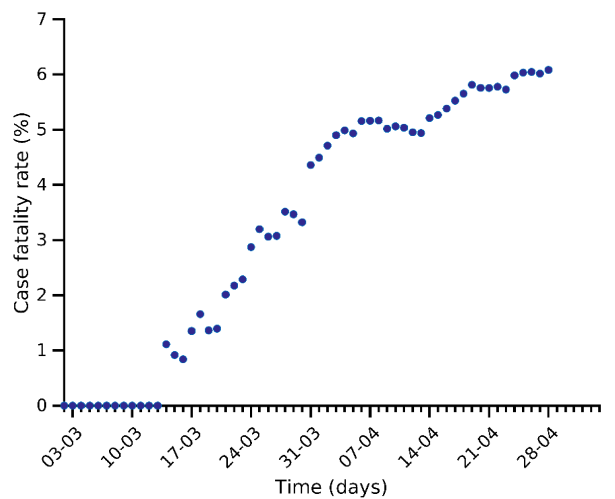
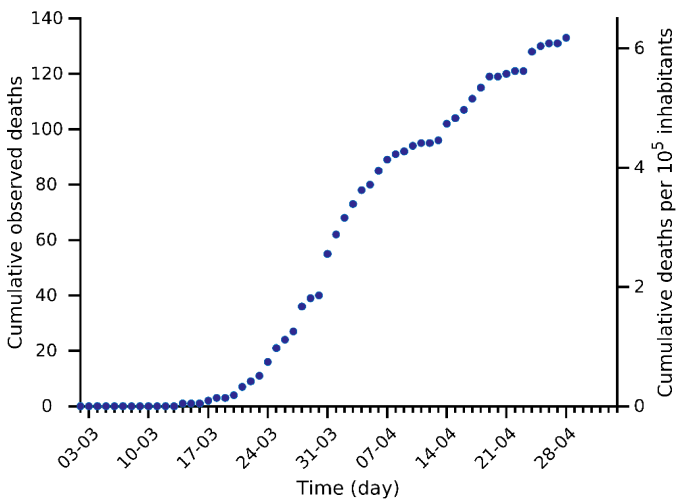
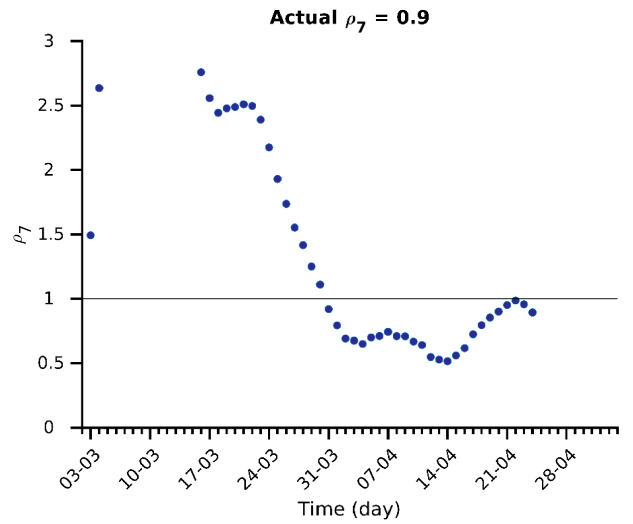
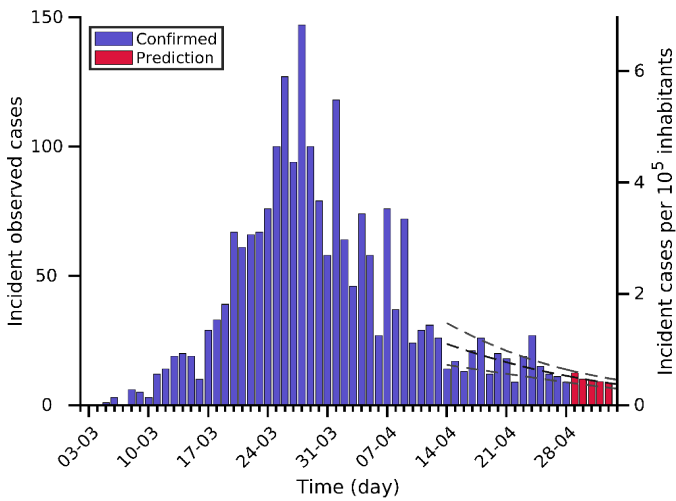
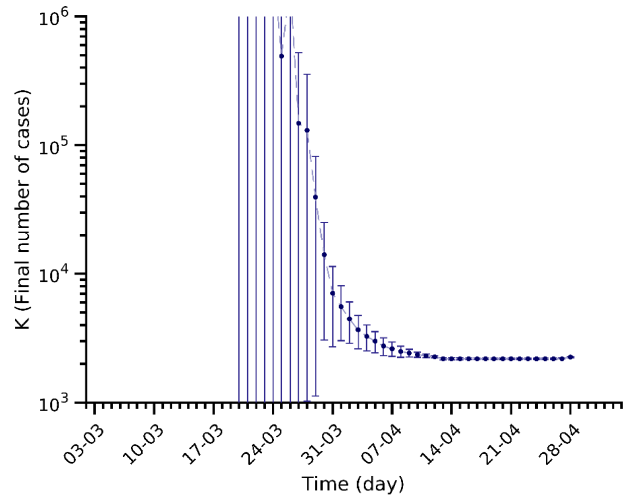
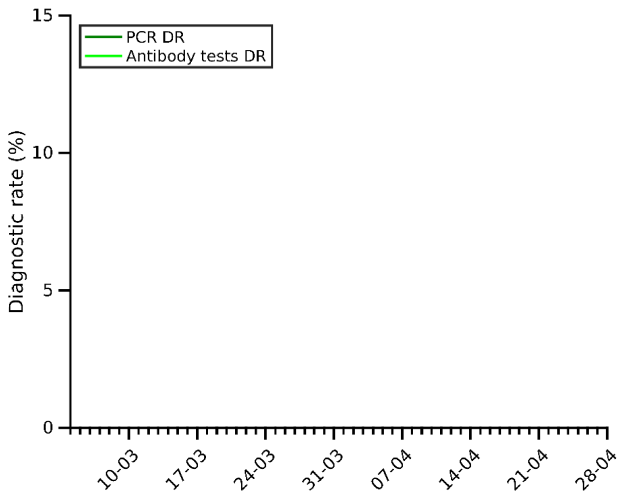
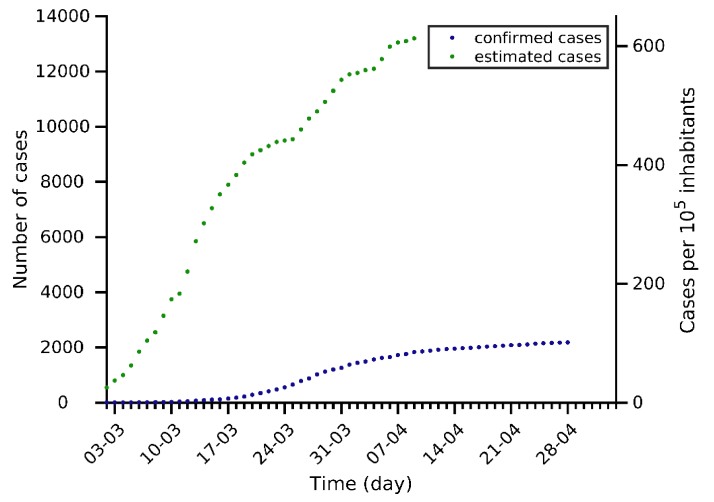
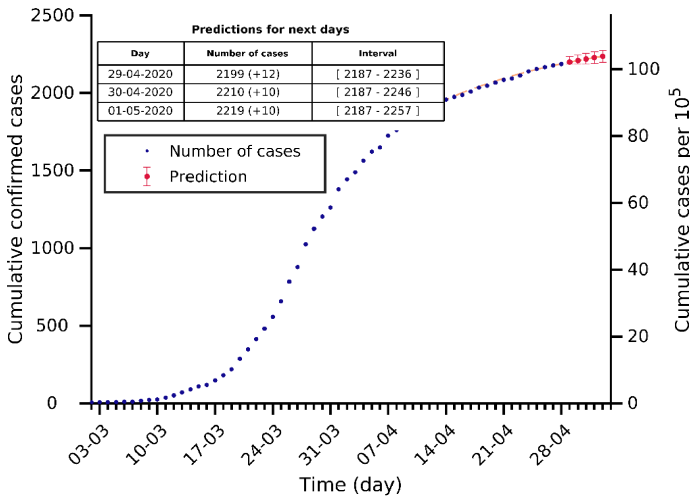
**Extremadura 28-04-2020. Population: 1.1M. Current cumulated incidence: 258/10<sup>5</sup>**



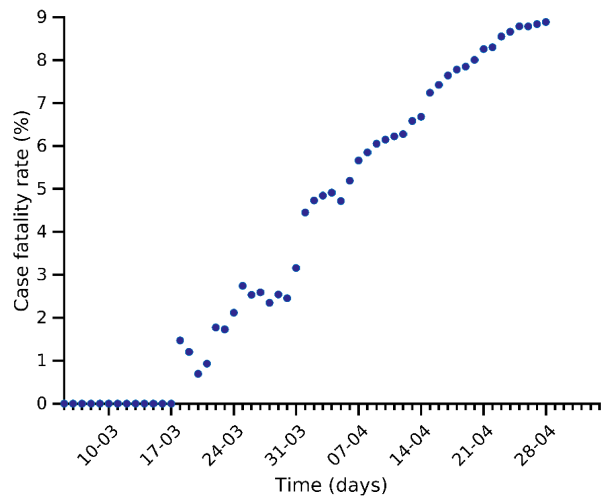
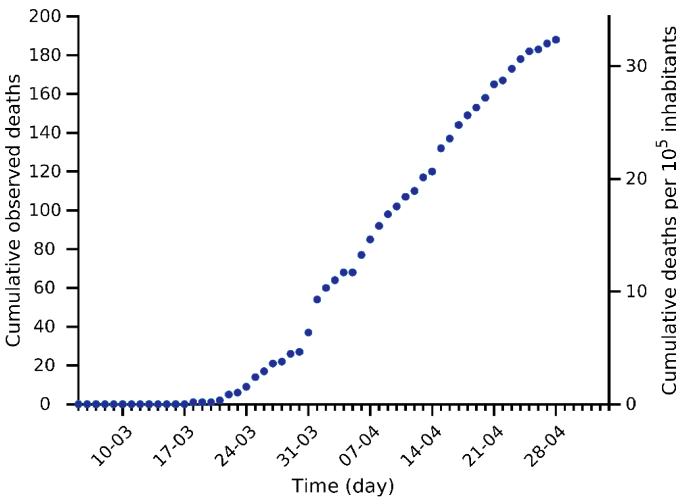
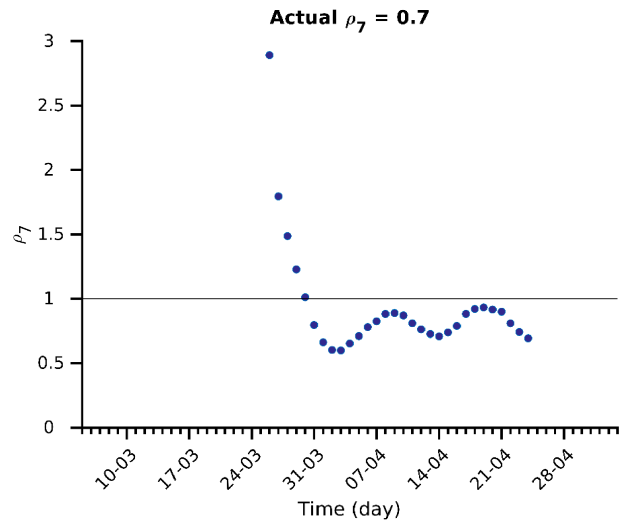
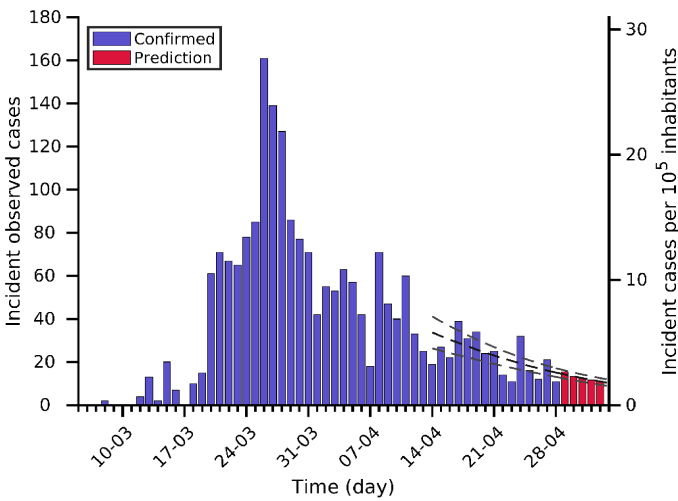
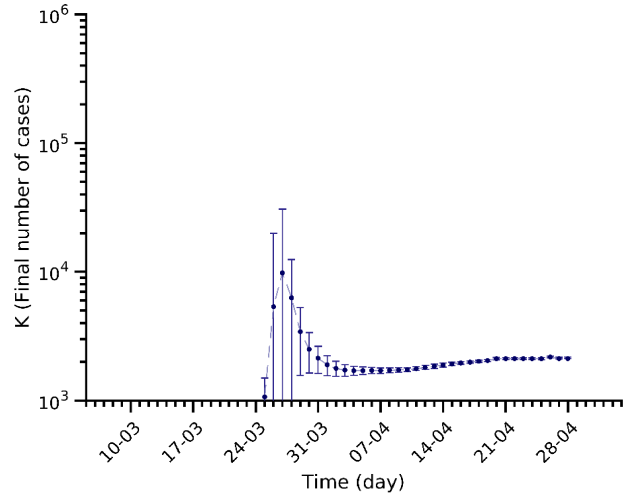
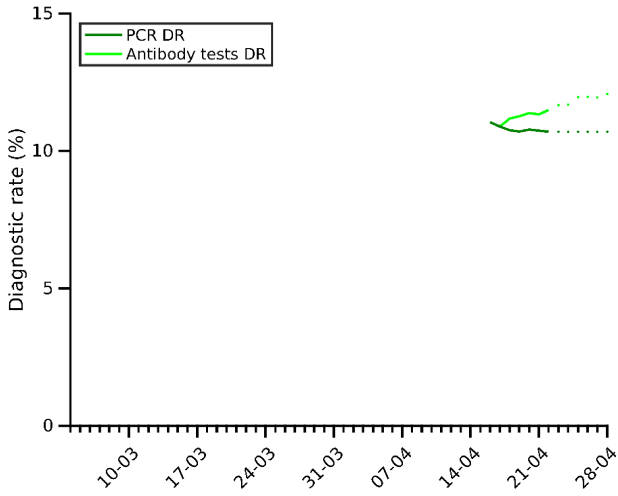
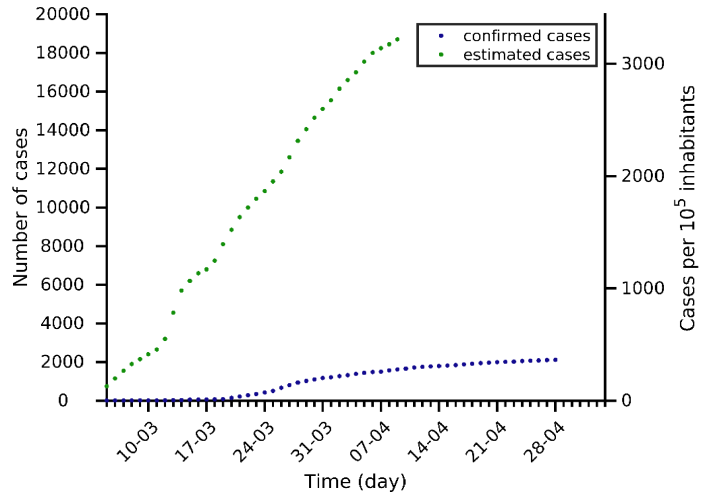
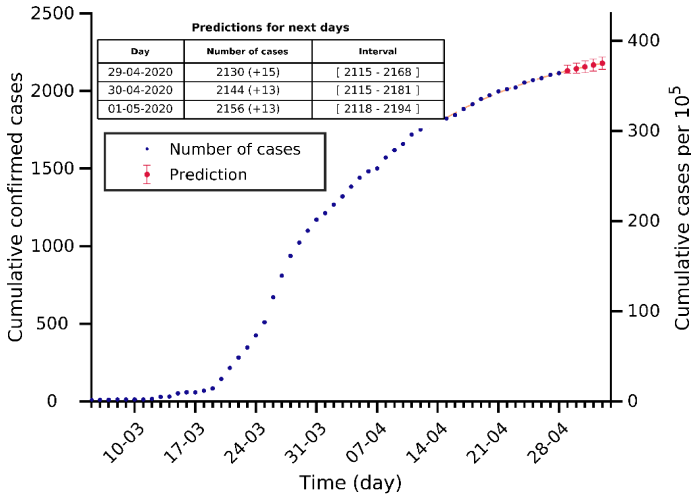
# Asturias 28-04-2020. Population: 1.0M. Current cumulated incidence: 220/10<sup>5</sup>



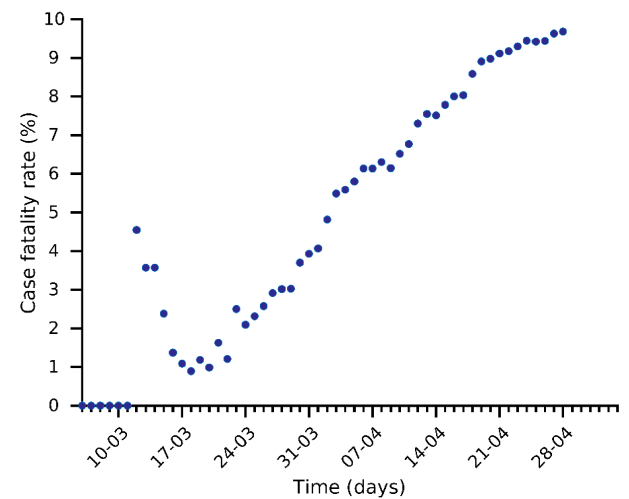
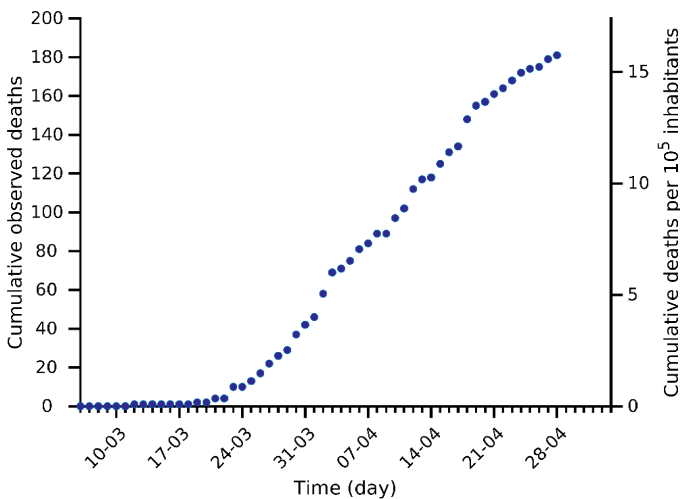
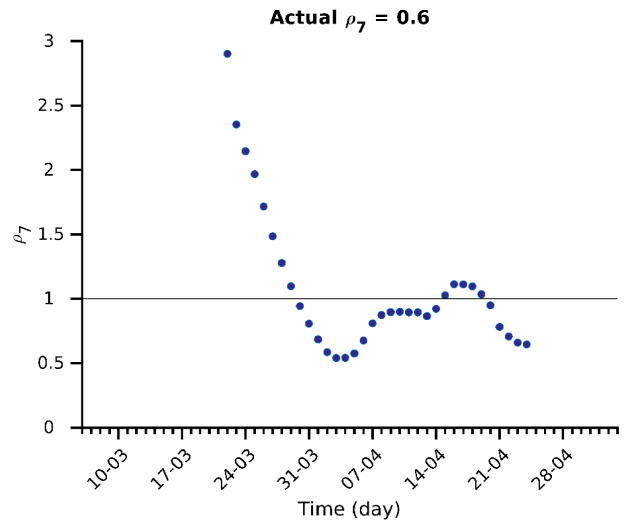
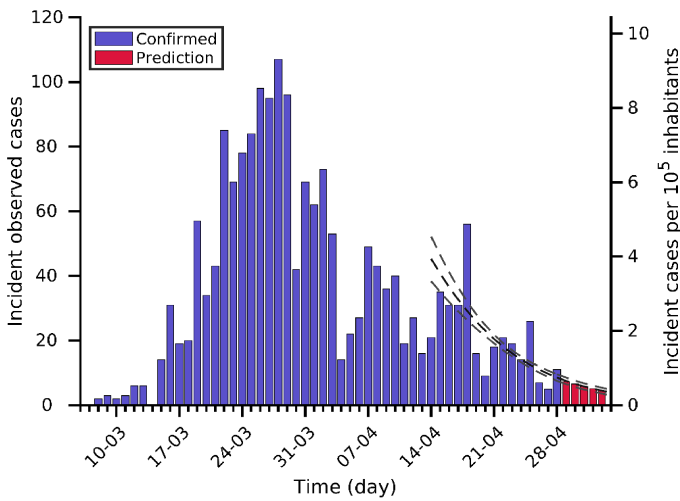
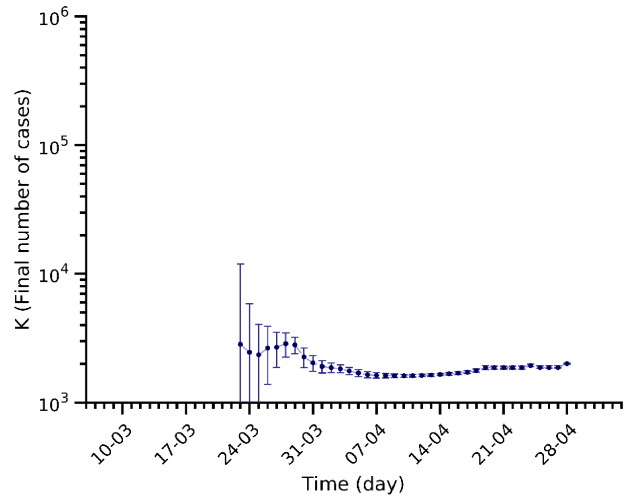
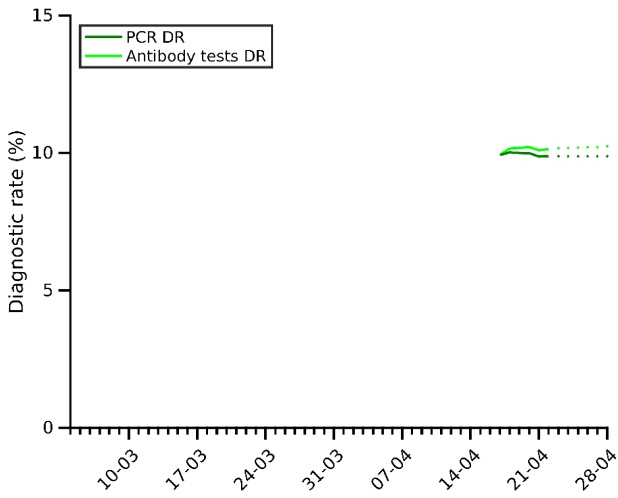
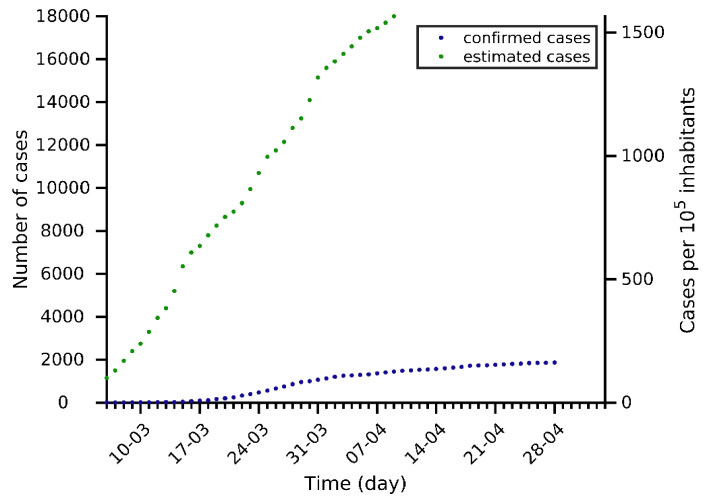
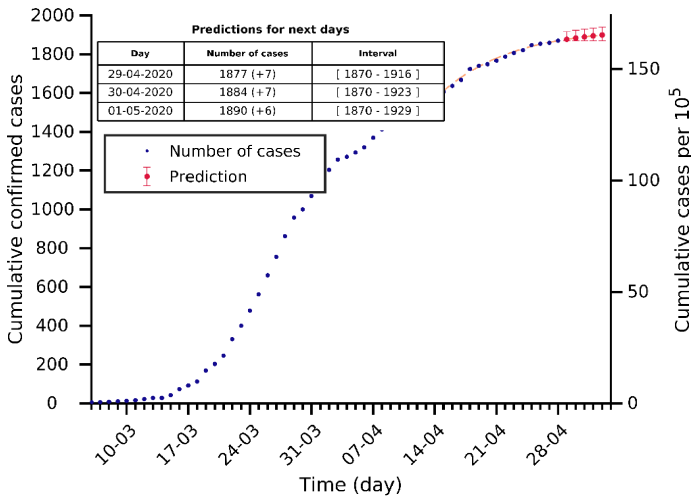
**Canarias 28-04-2020. Population: 2.2M. Current cumulated incidence: 102/10<sup>5</sup>**



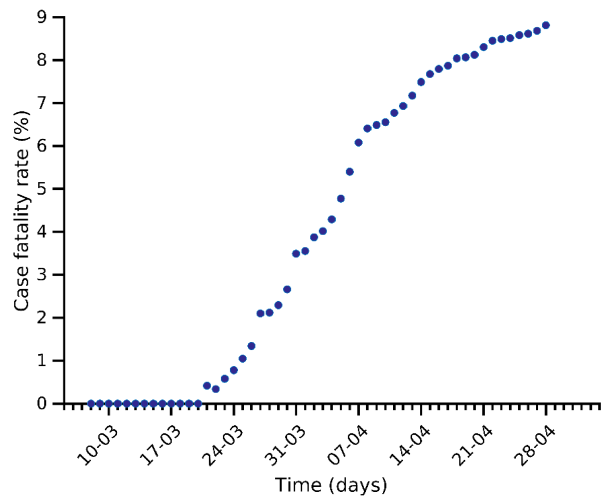
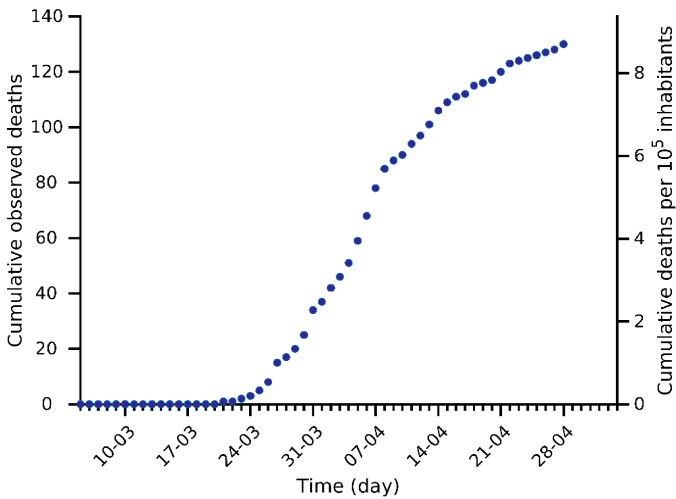
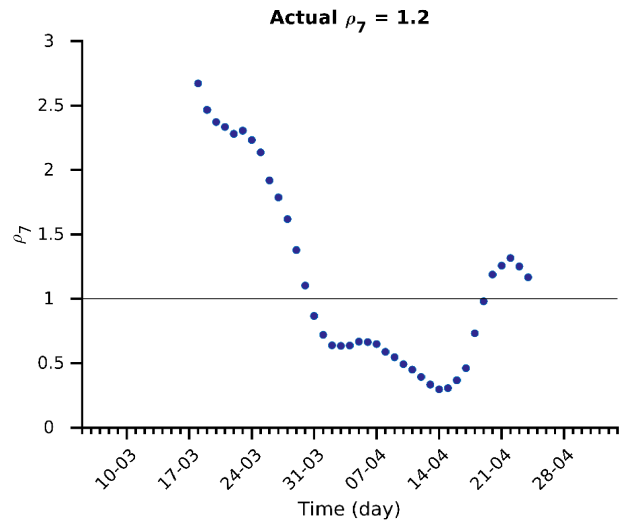
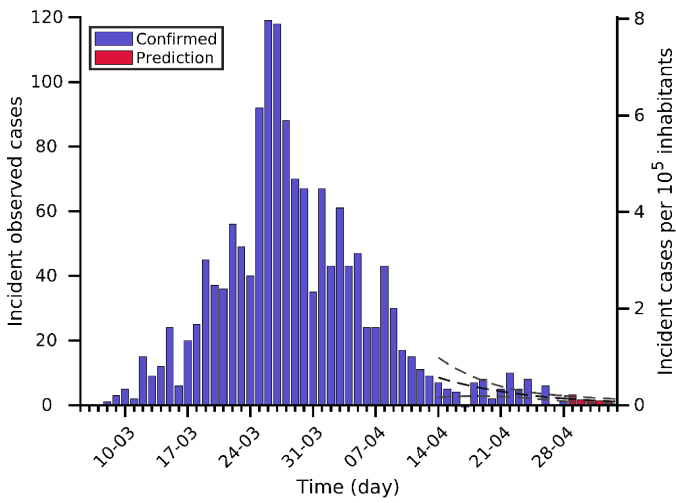
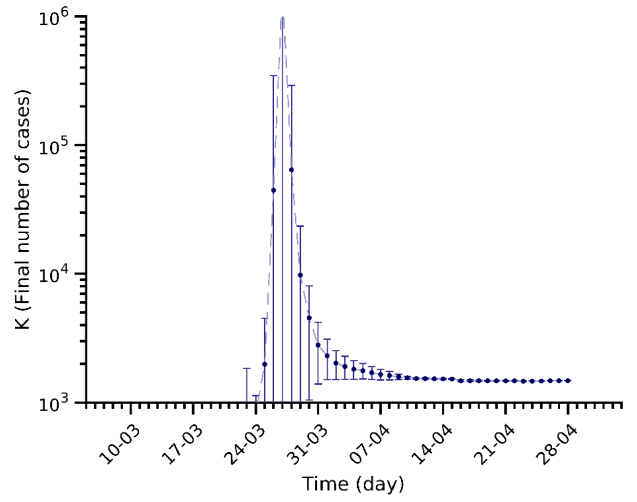
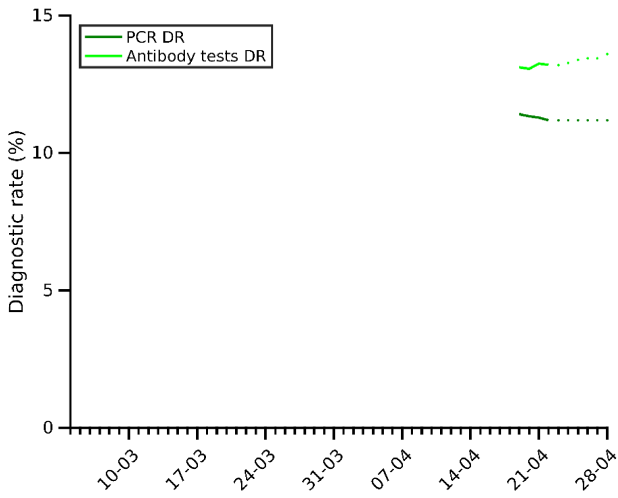
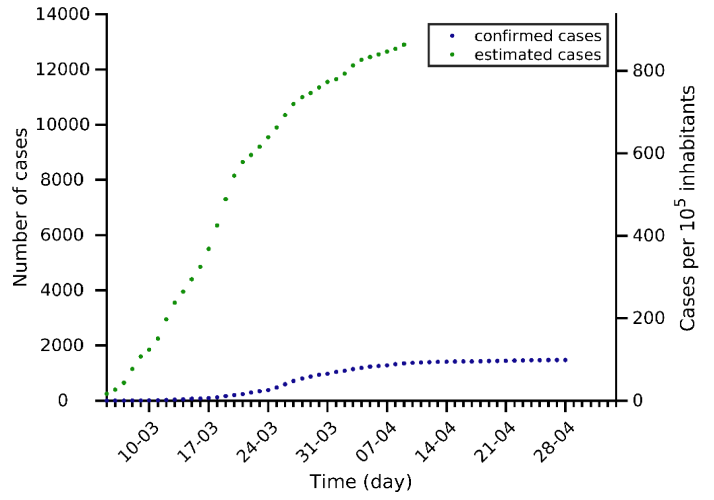
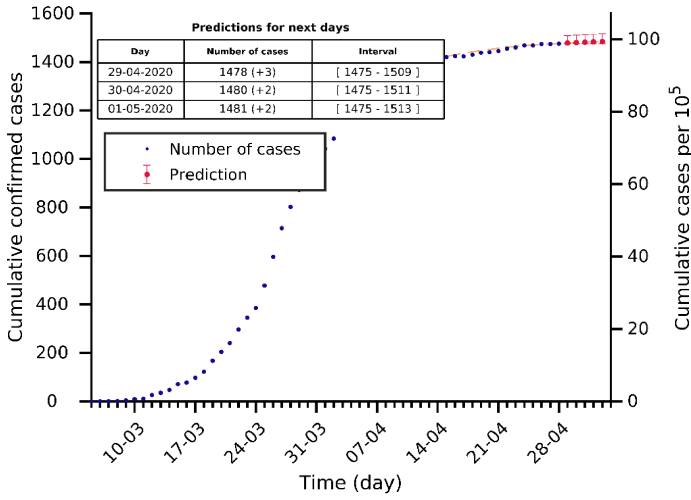
**Cantabria 28-04-2020. Population: 0.6M. Current cumulated incidence: 364/10<sup>5</sup>**



**Baleares 28-04-2020. Population: 1.1M. Current cumulated incidence: 163/10<sup>5</sup>**



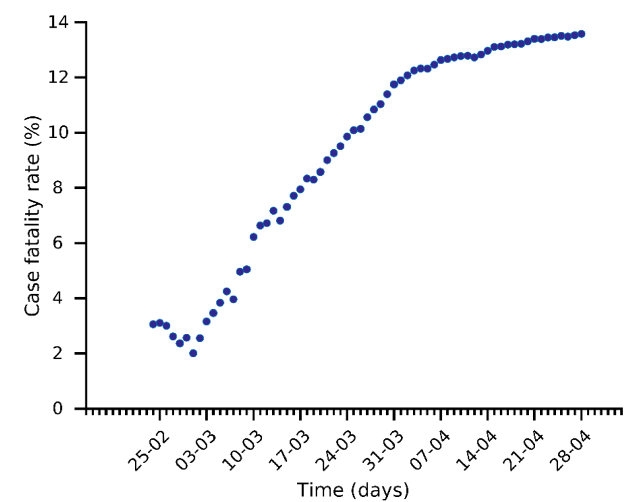
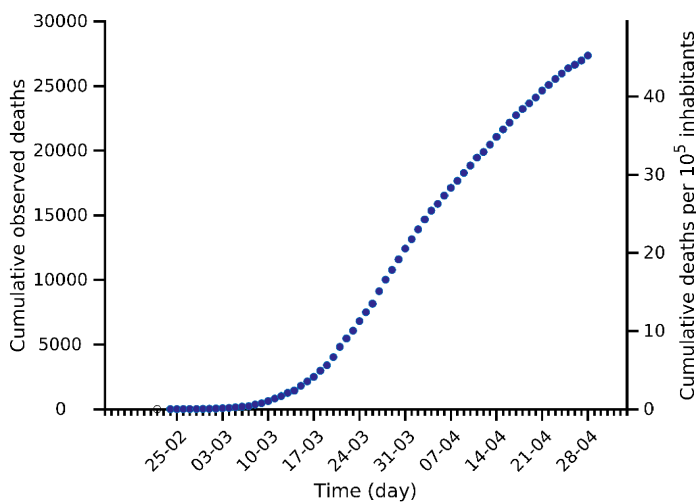
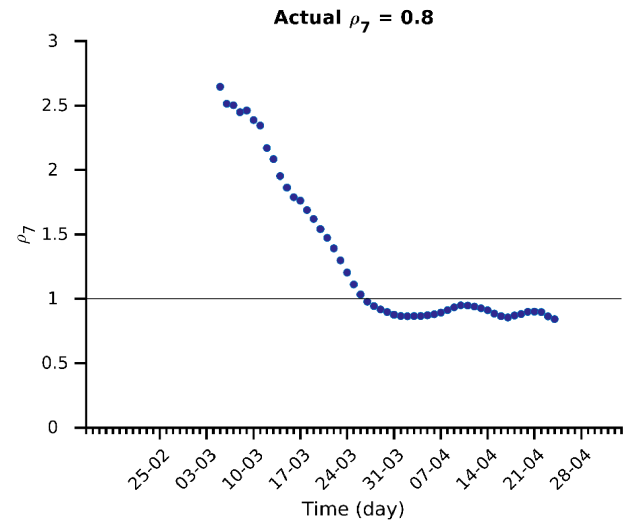
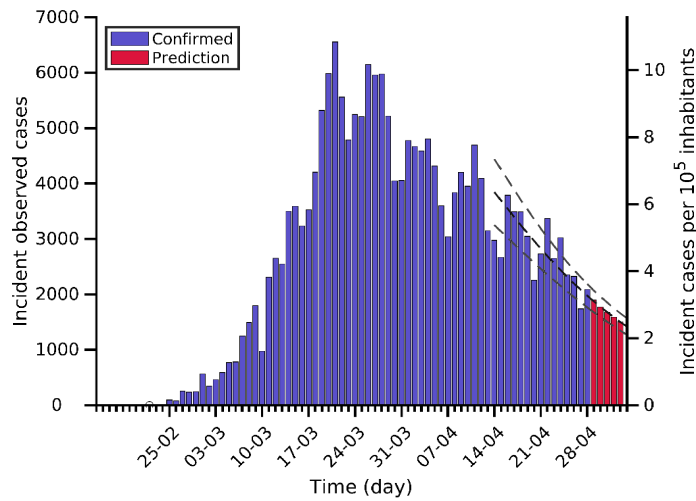
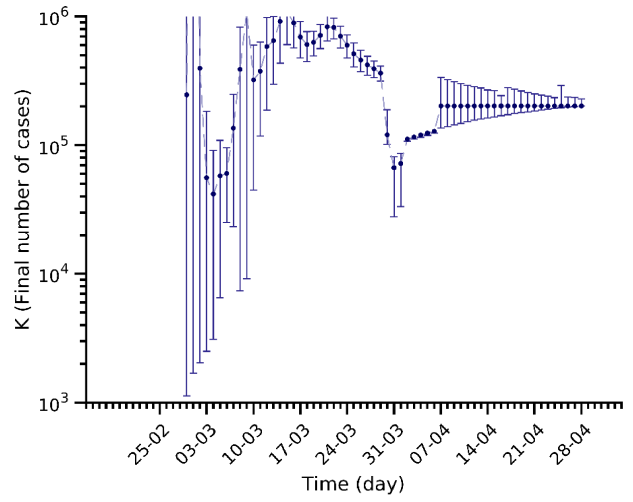
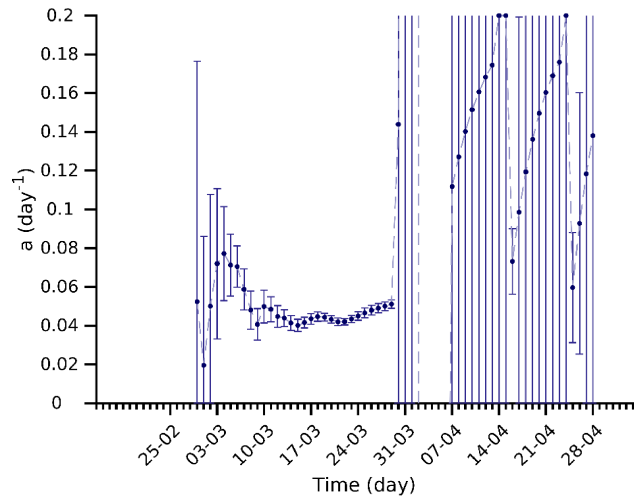
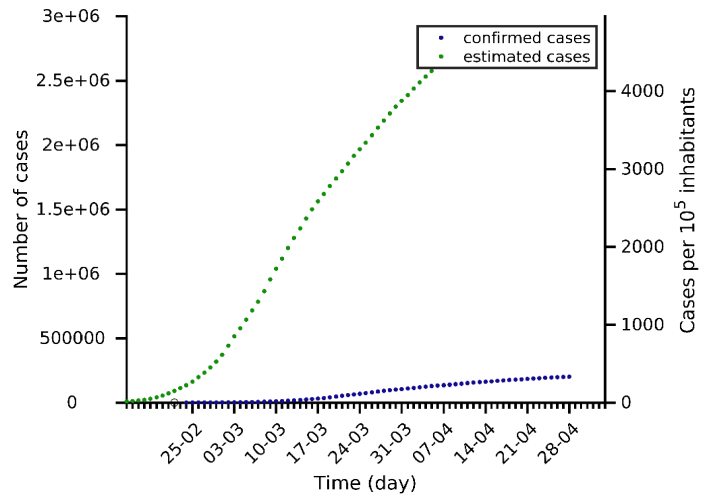
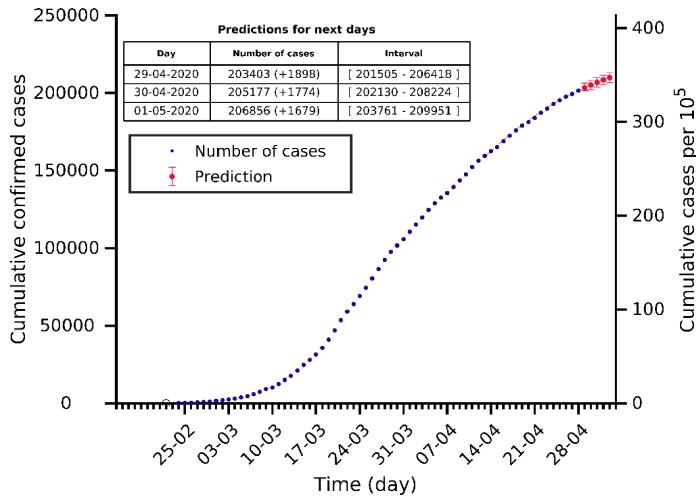
**Murcia 28-04-2020. Population: 1.5M. Current cumulated incidence: 99/10<sup>5</sup>**



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

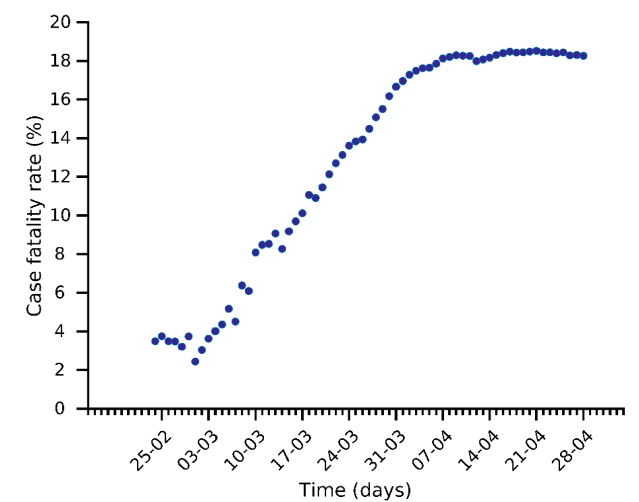
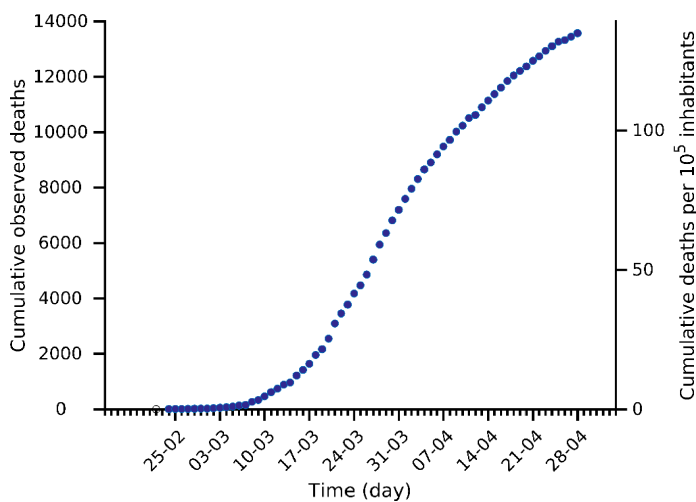
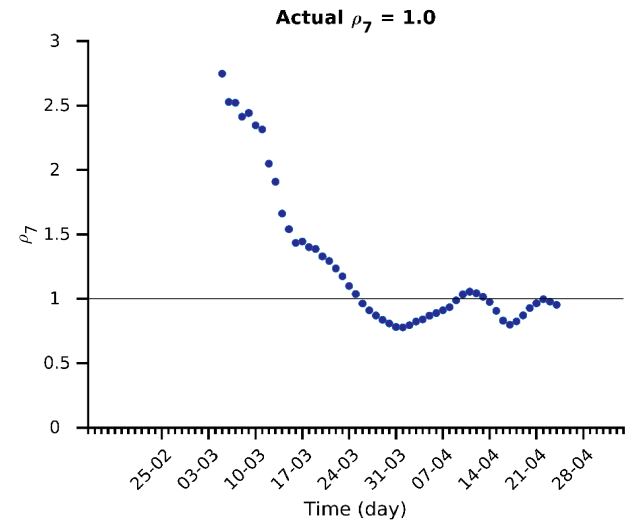
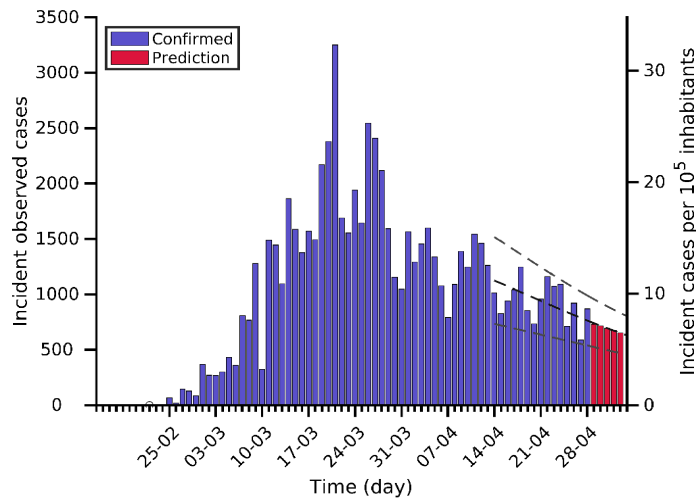
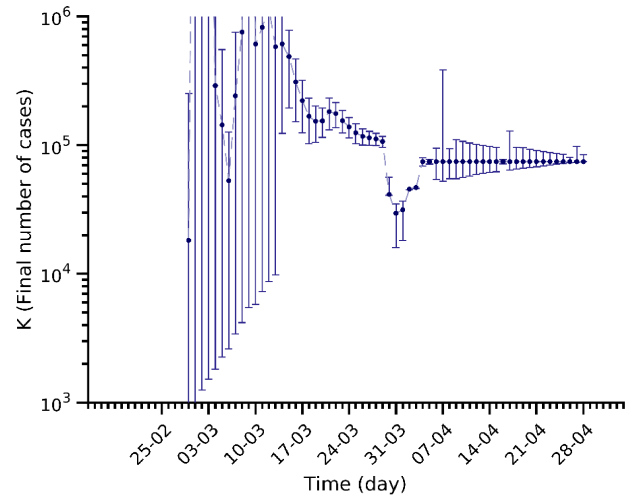
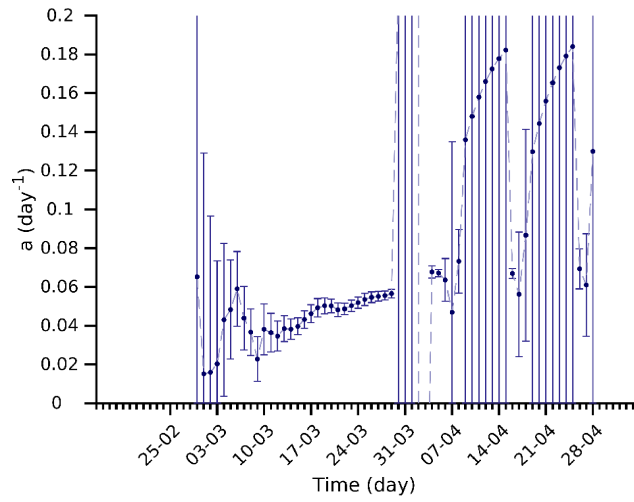
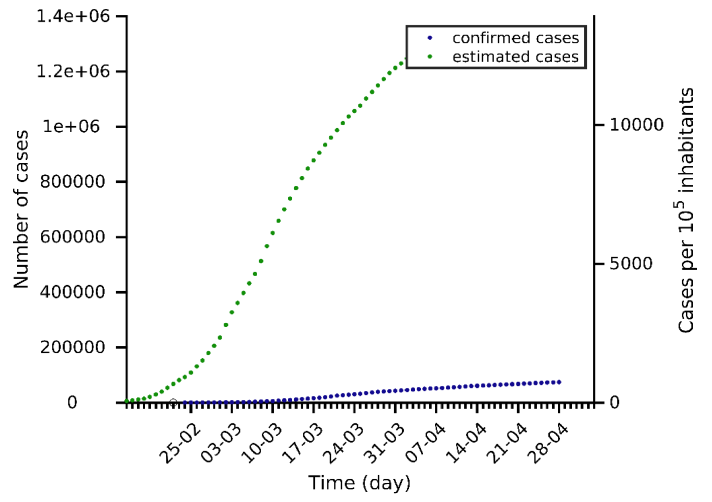
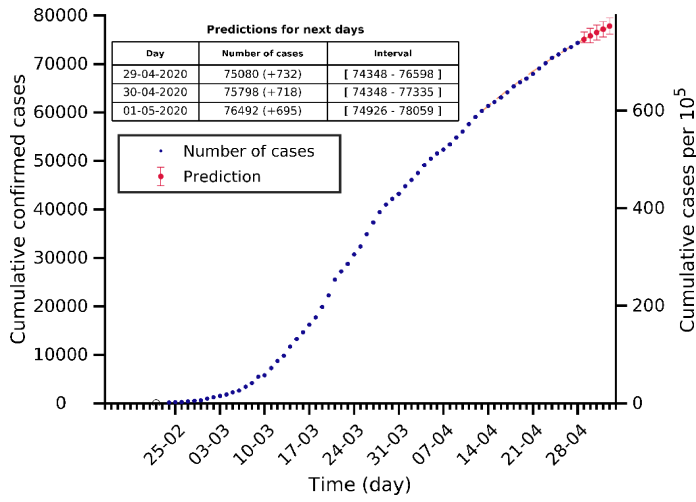
Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

Italy 28-04-2020. Population: 60.5M. Current cumulated incidence: 333/10<sup>5</sup>

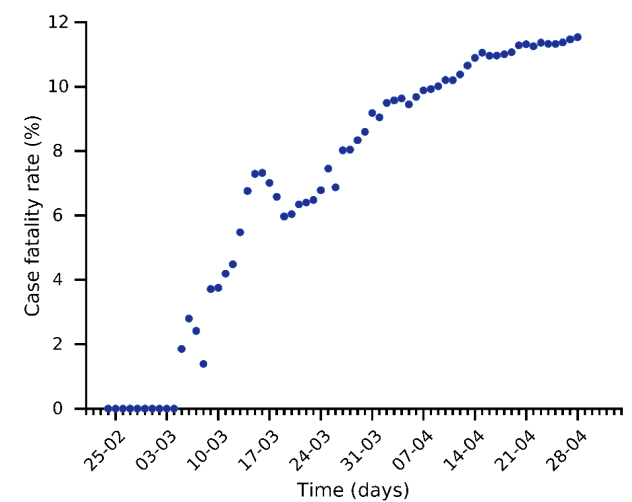
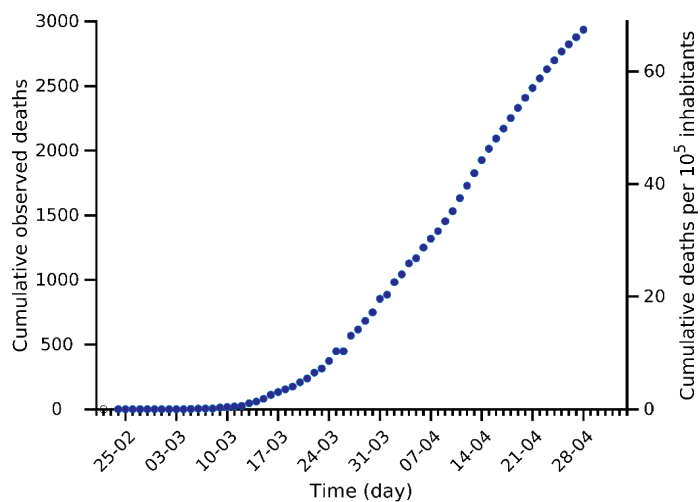
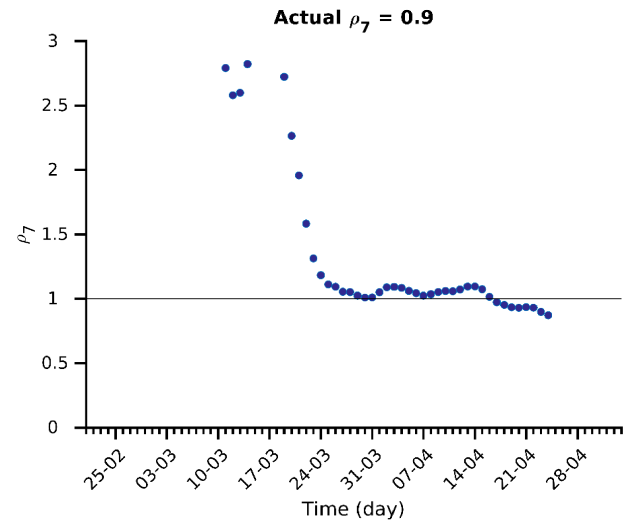
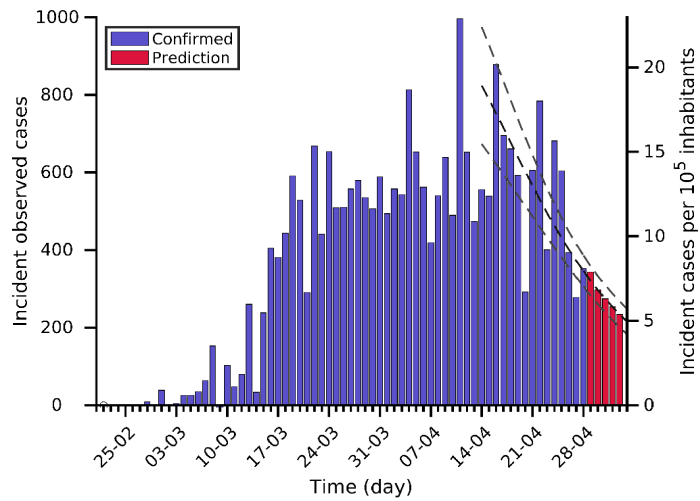
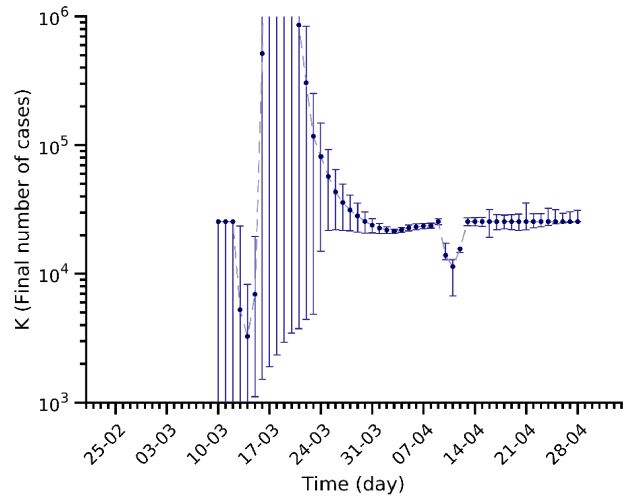
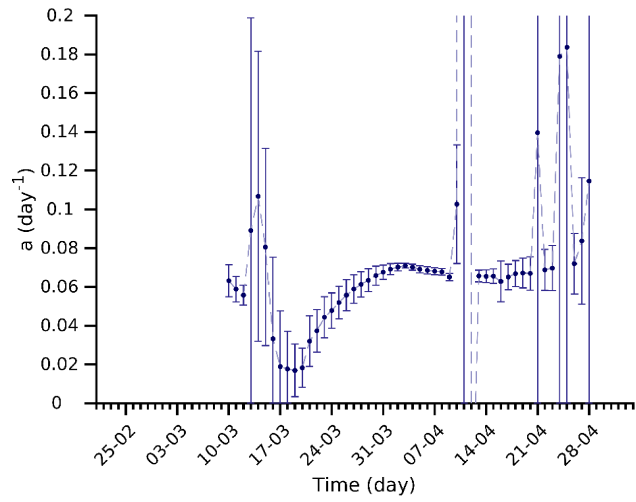
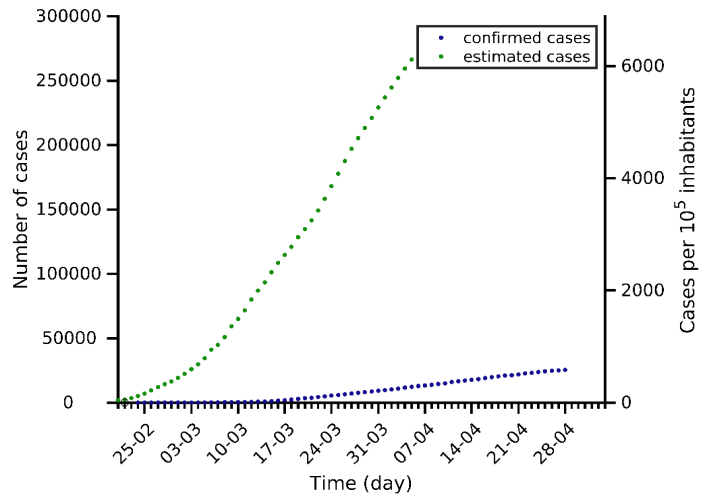
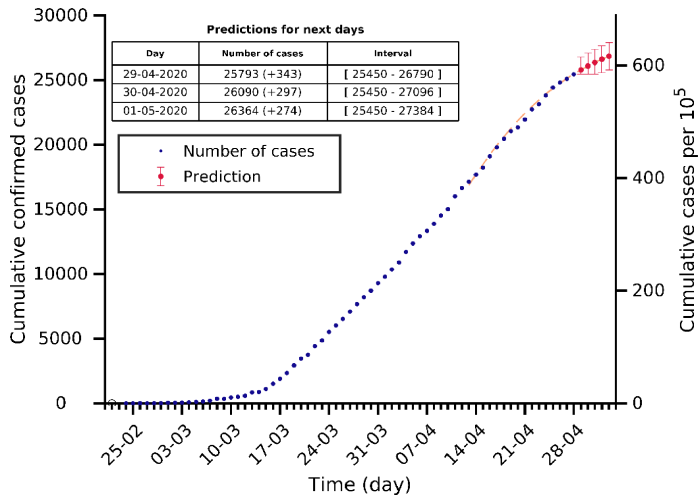




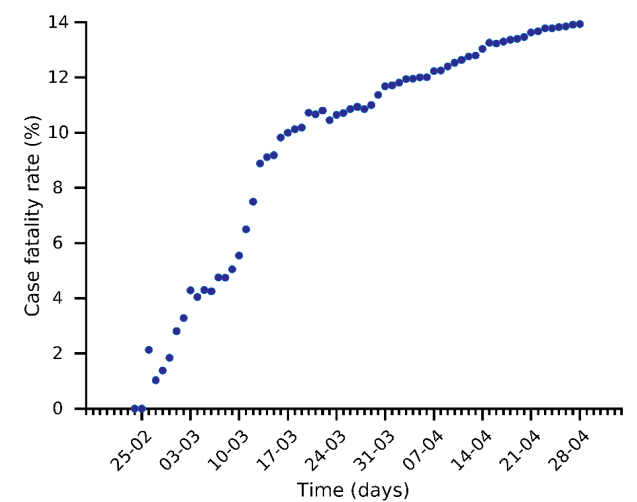
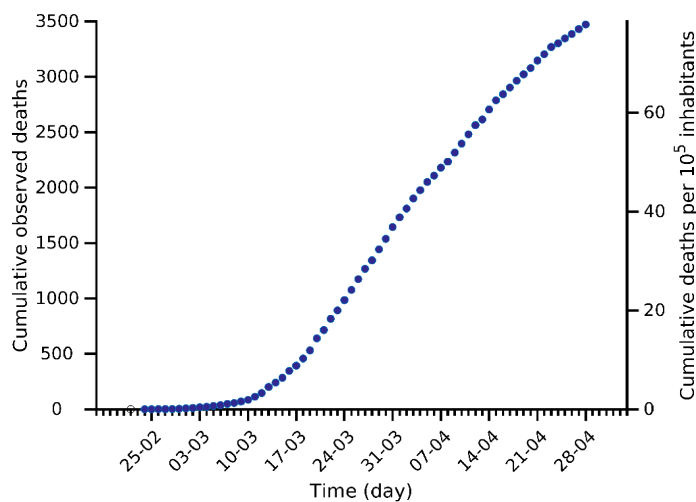
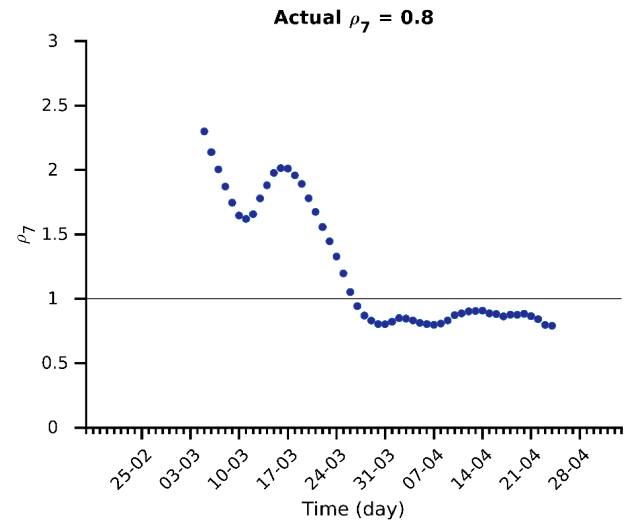
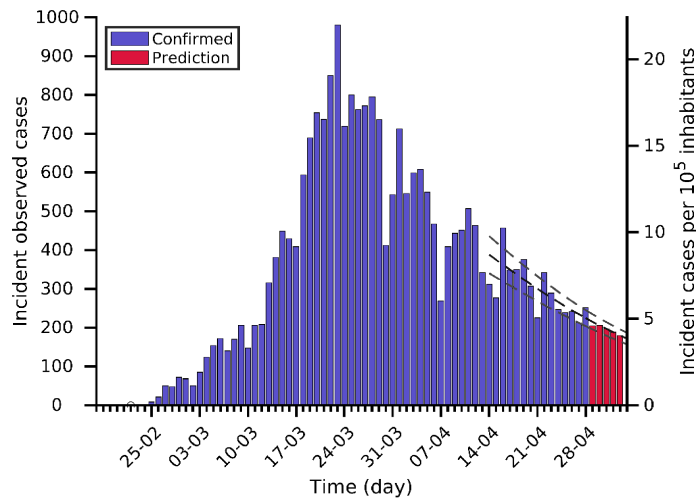
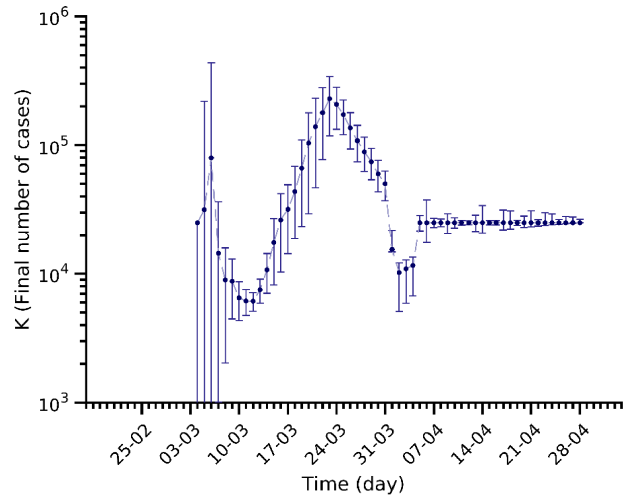
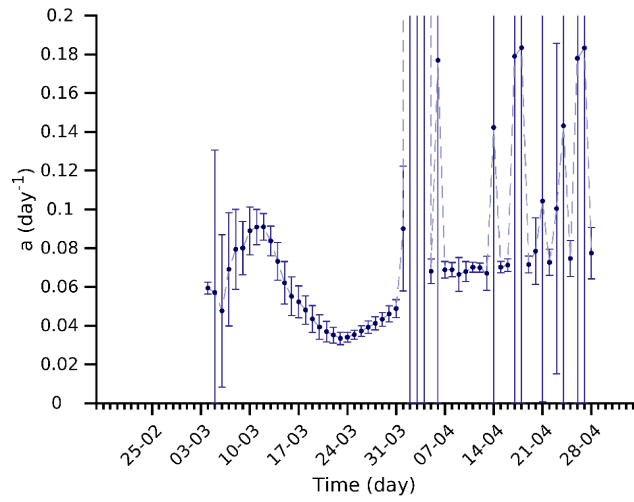
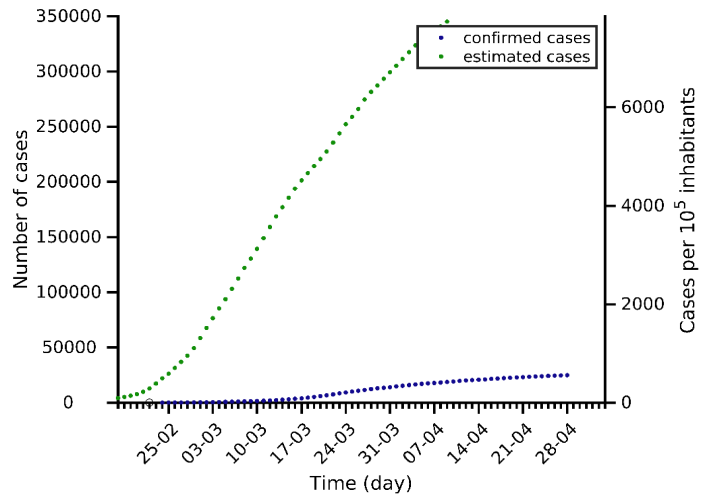
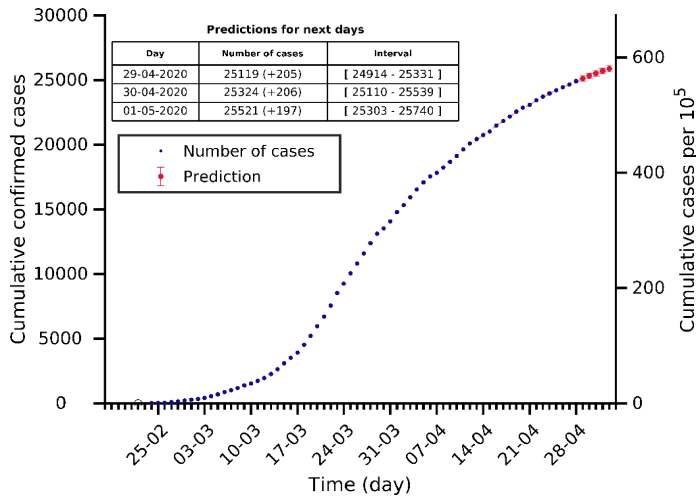
**Lombardia 28-04-2020. Population: 10.1M. Current cumulated incidence: 739/10<sup>5</sup>**



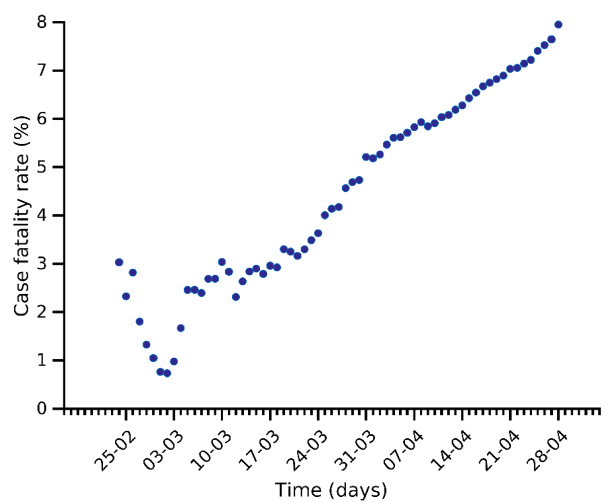
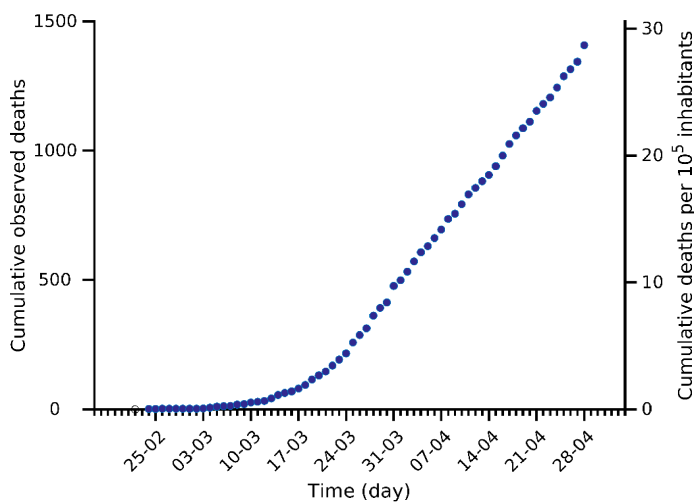
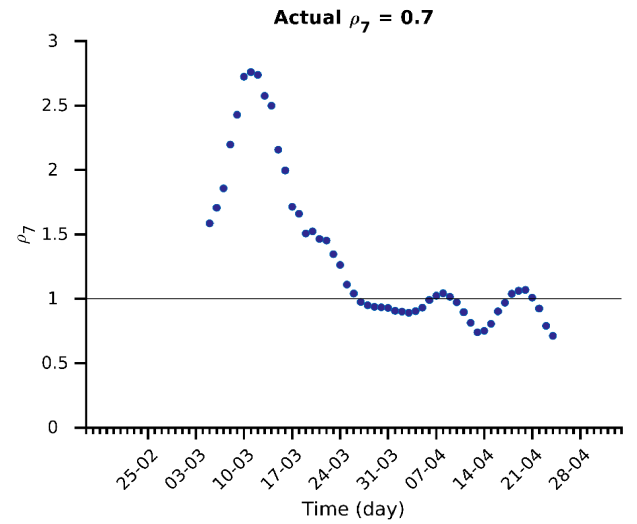
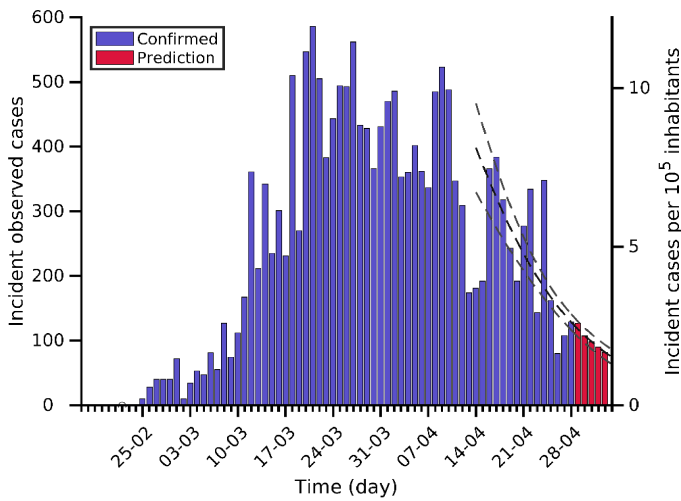
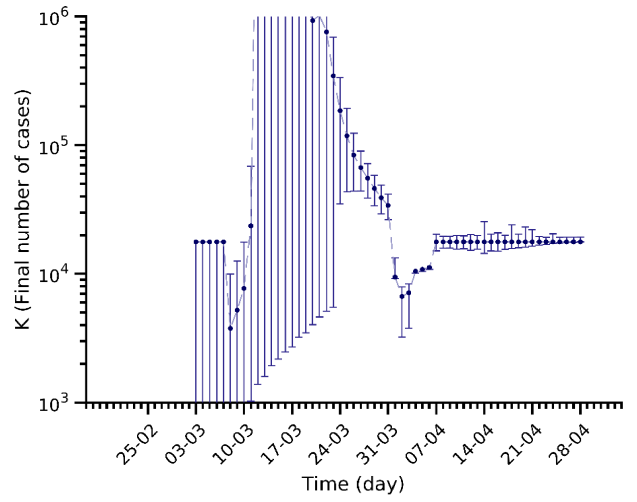
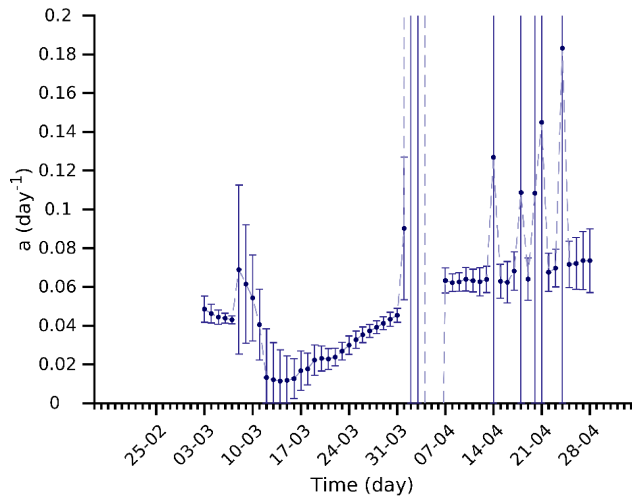
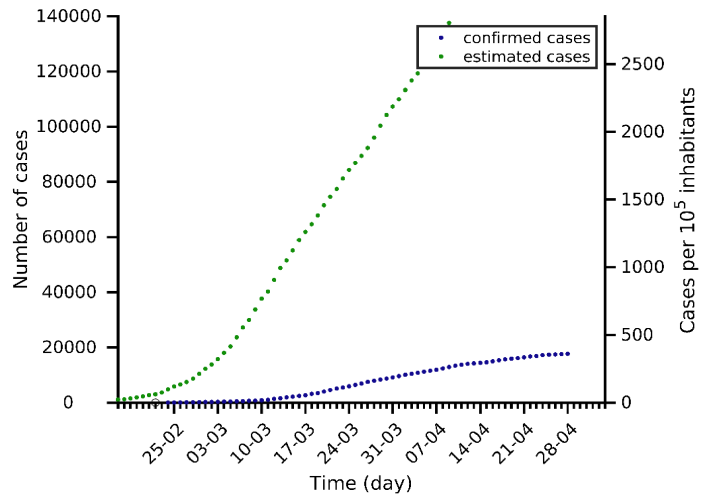
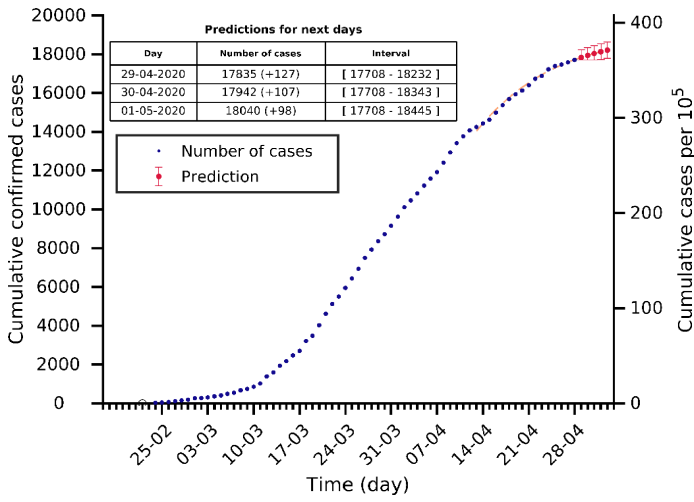
**Piemonte 28-04-2020. Population: 4.4M. Current cumulated incidence: 584/10<sup>5</sup>**



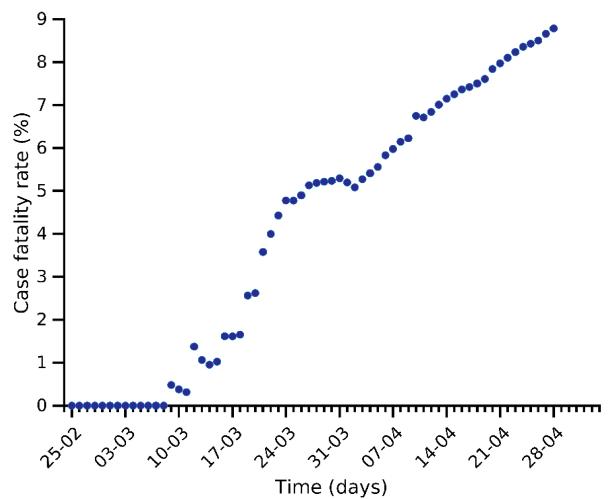
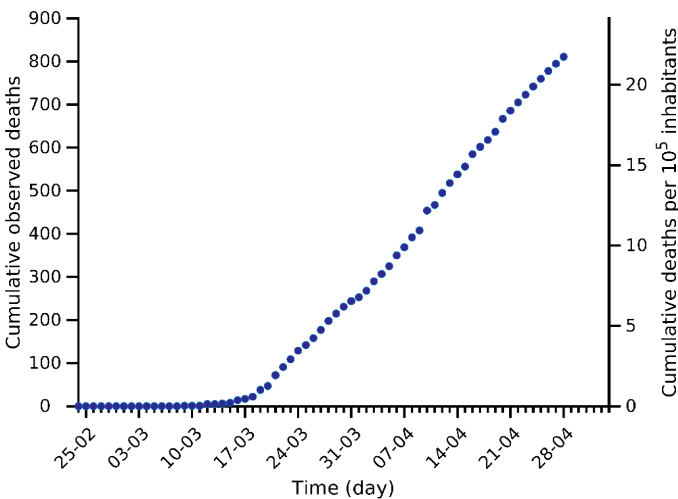
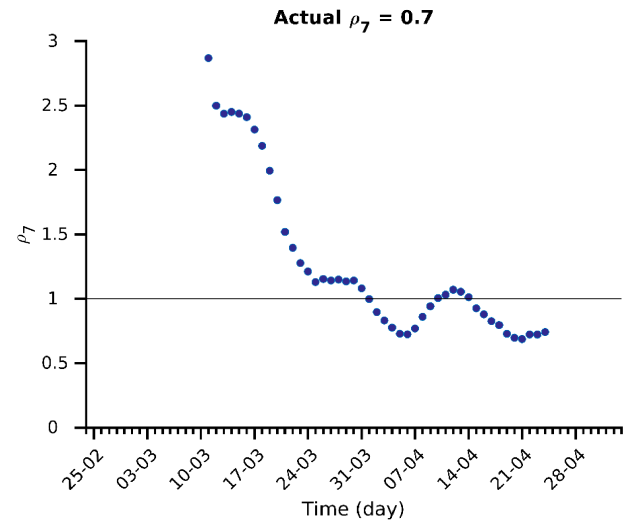
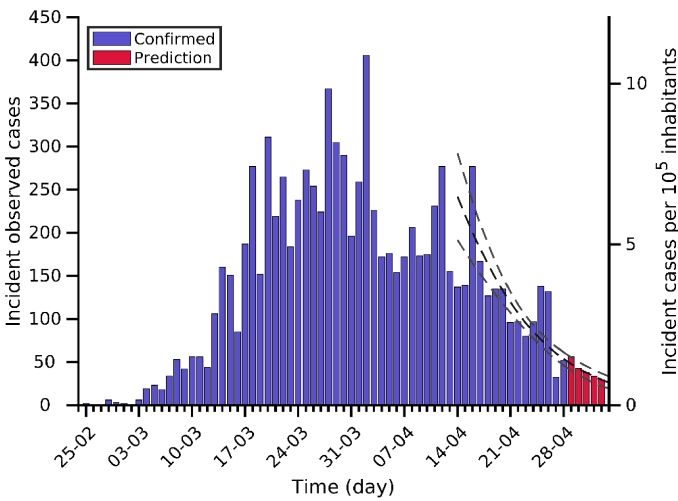
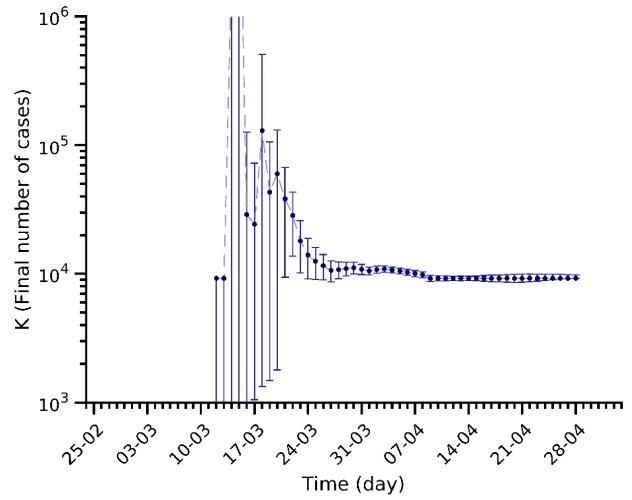
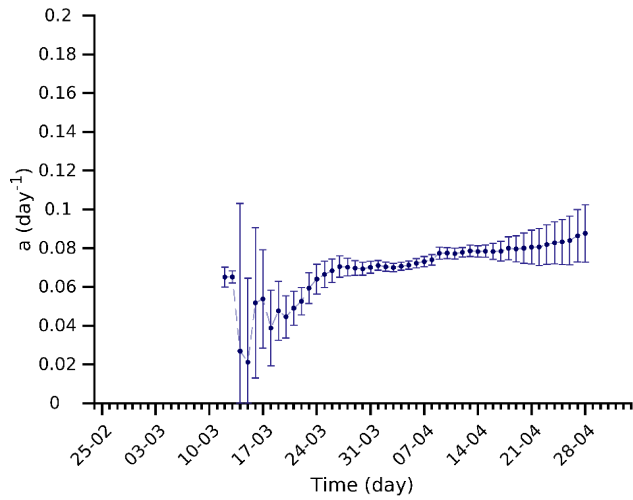
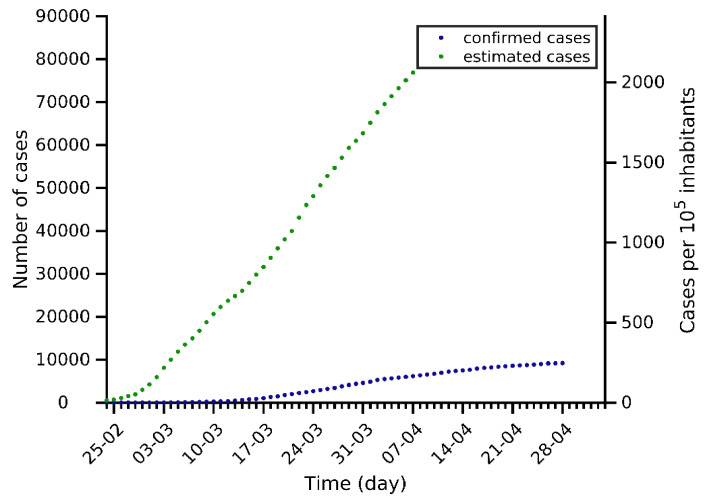
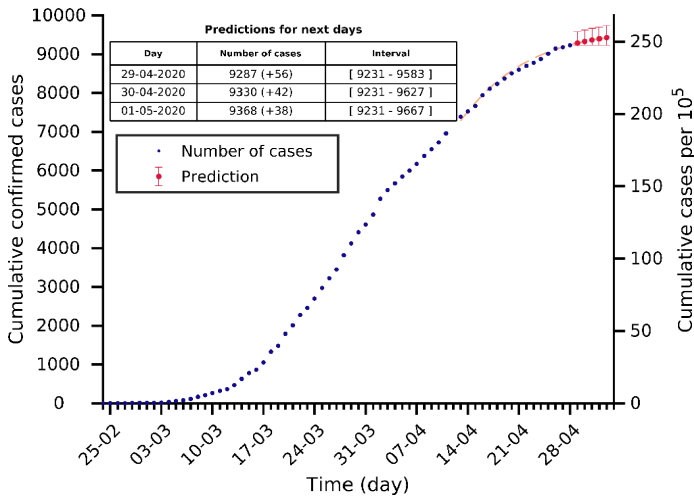
# Emilia Romagna 28-04-2020. Population: 4.5M. Current cumulated incidence: 559/10<sup>5</sup>



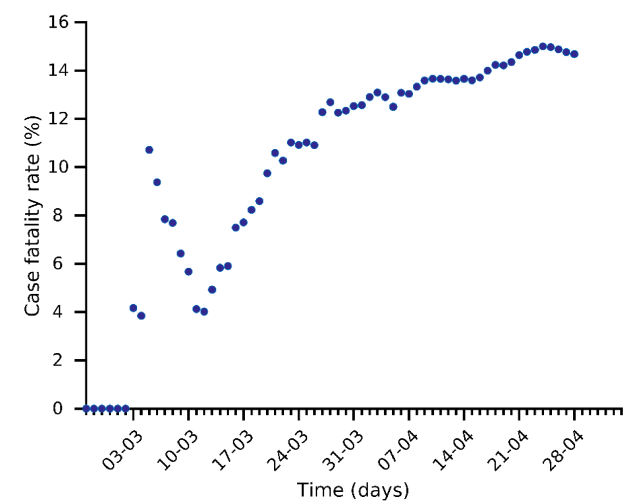
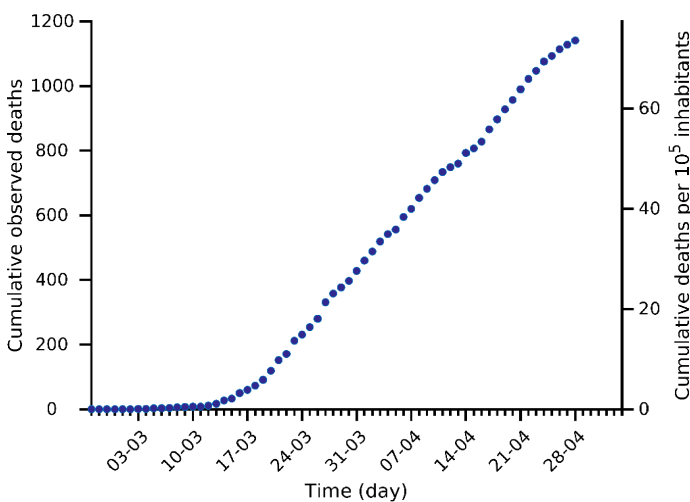
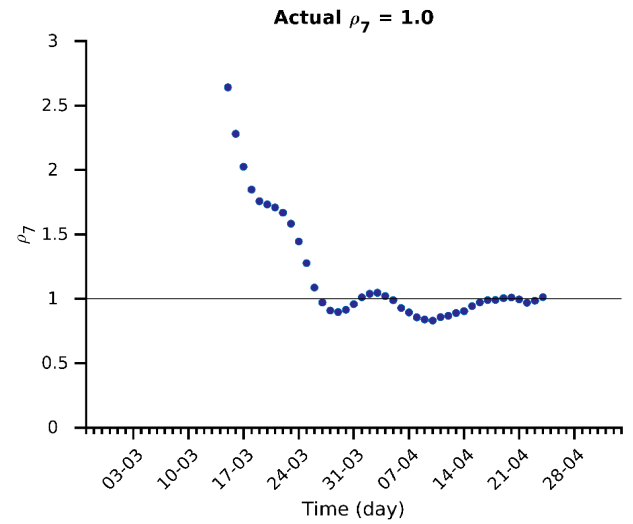
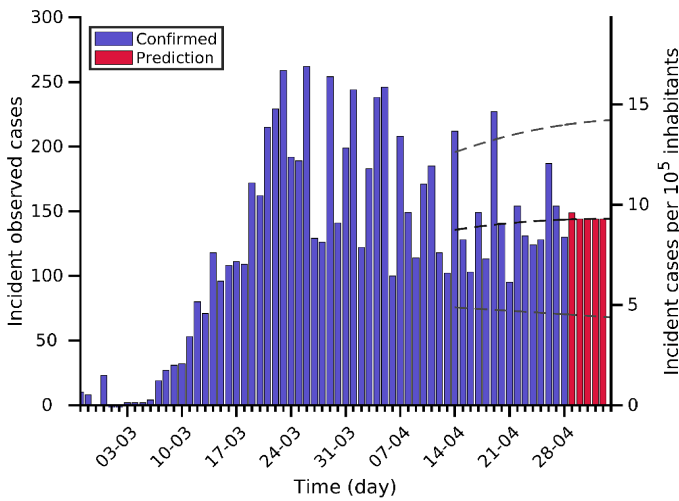
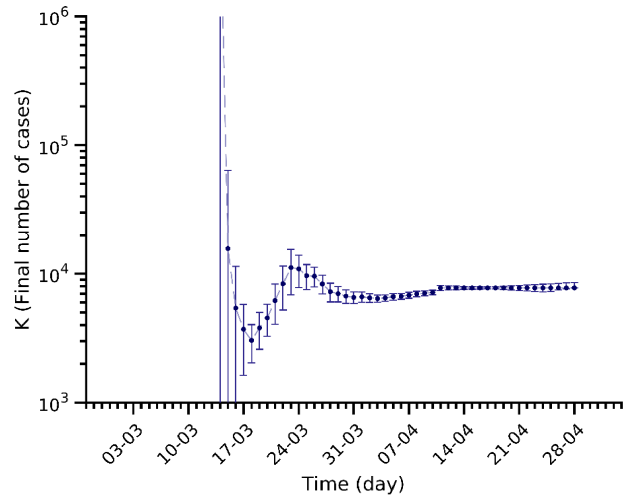
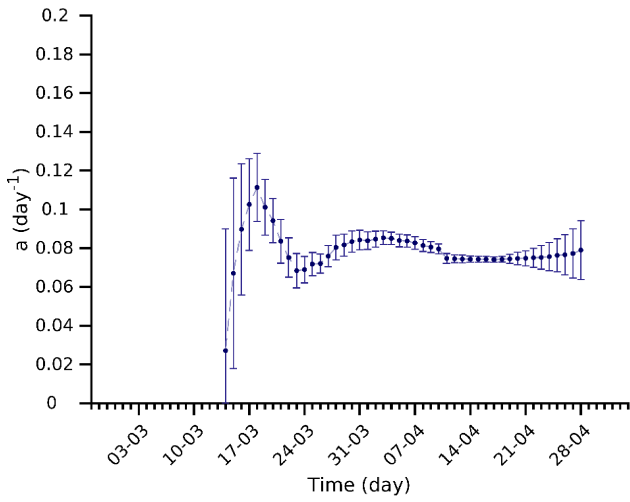
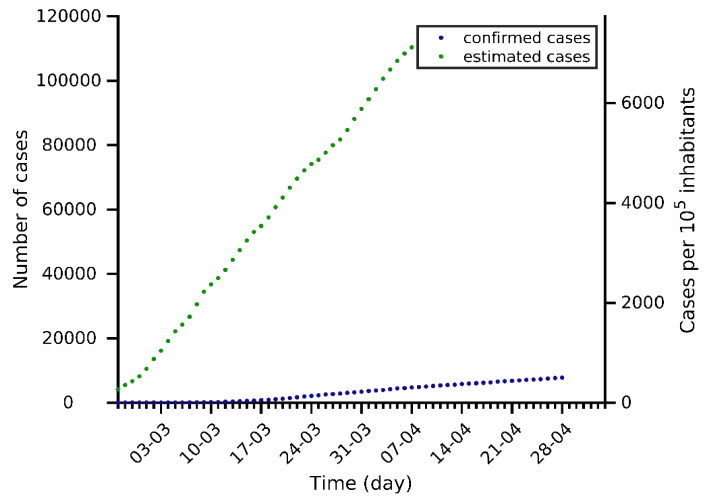
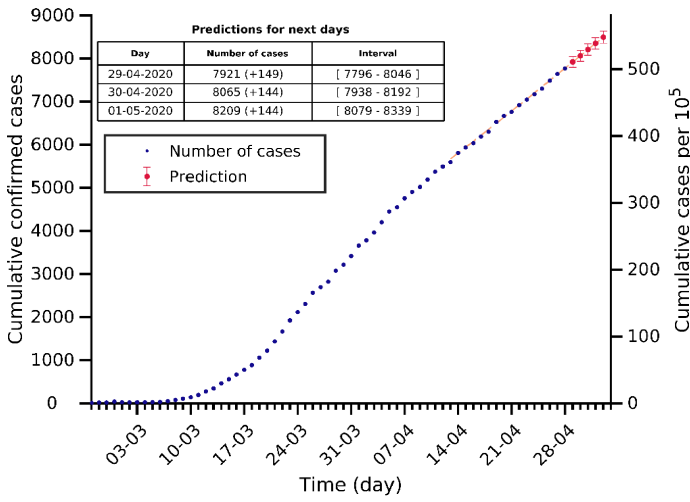
**Veneto 28-04-2020. Population: 4.9M. Current cumulated incidence: 361/10<sup>5</sup>**



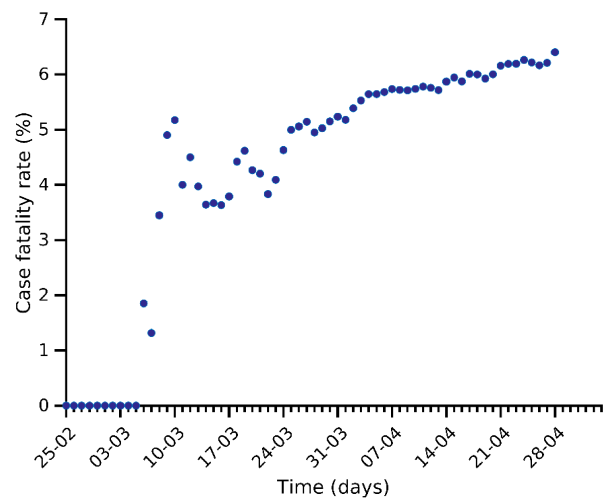
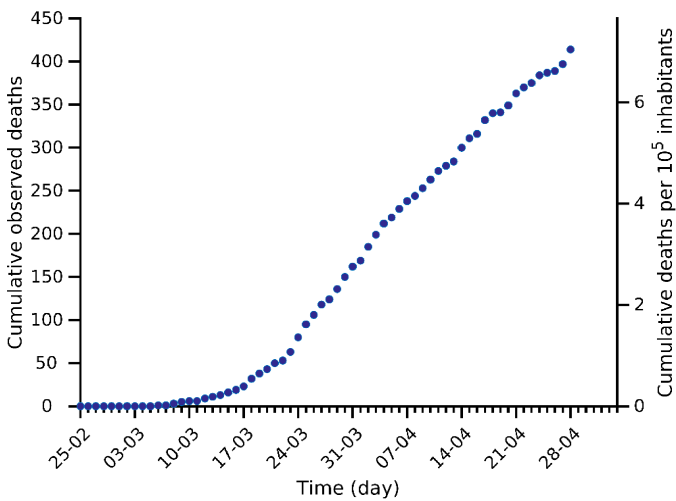
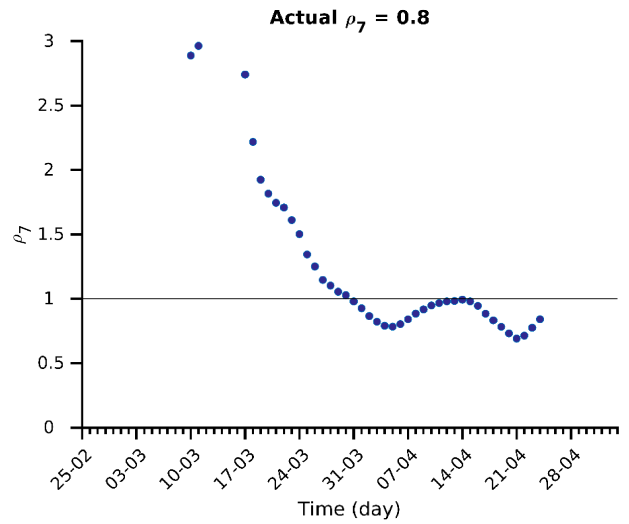
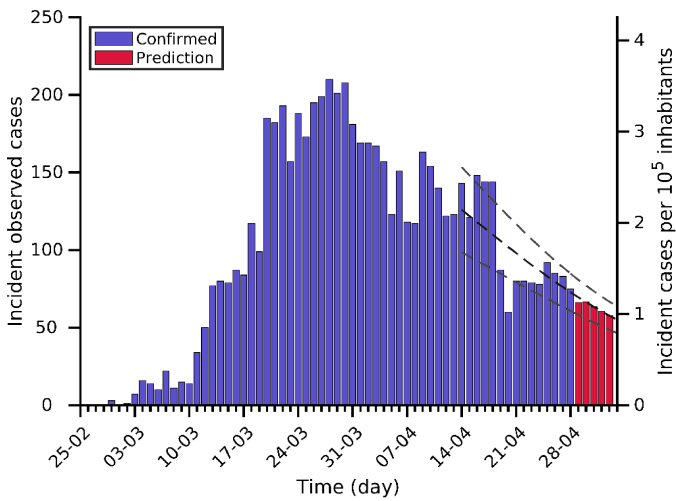
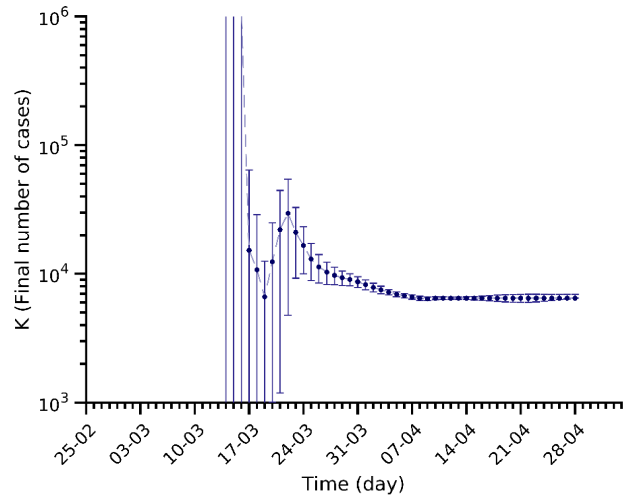
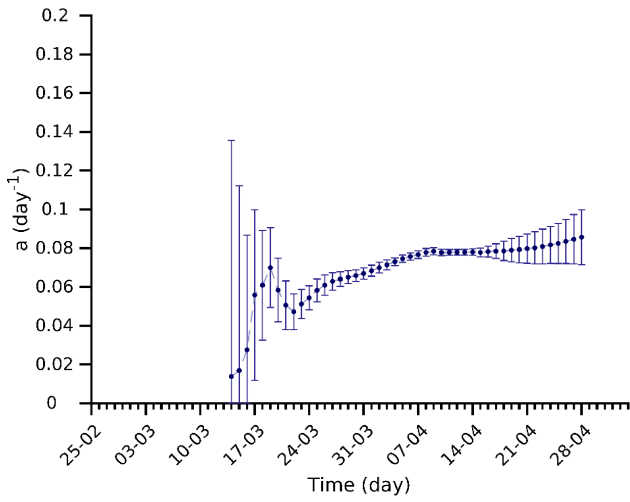
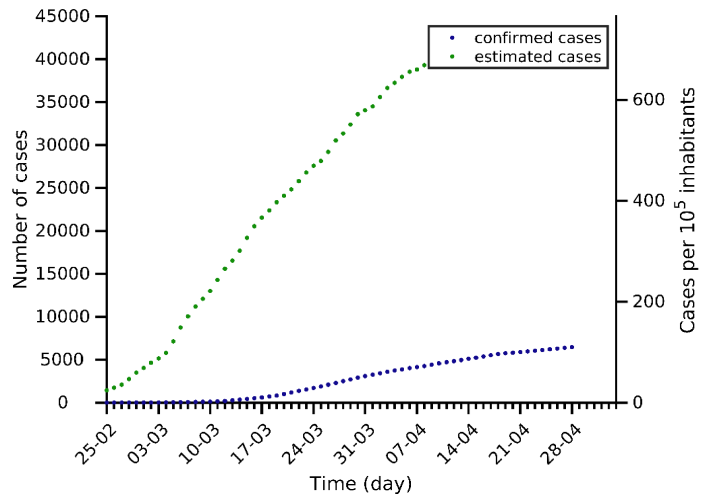
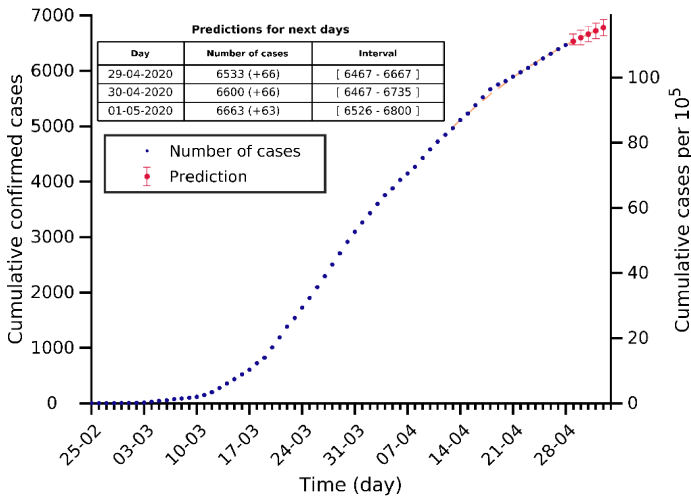
**Toscana 28-04-2020. Population: 3.7M. Current cumulated incidence: 247/10<sup>5</sup>**



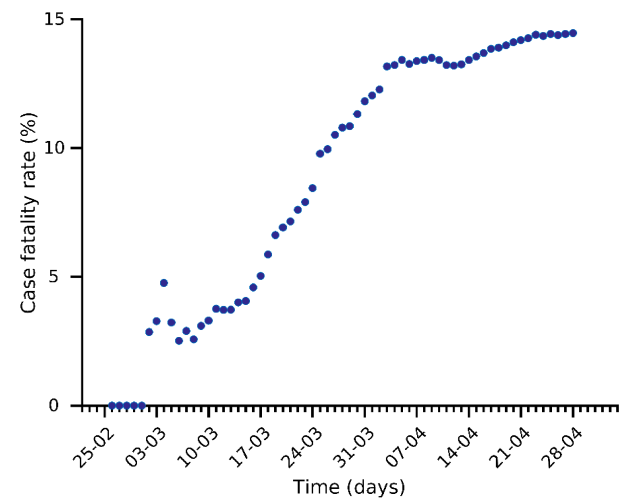
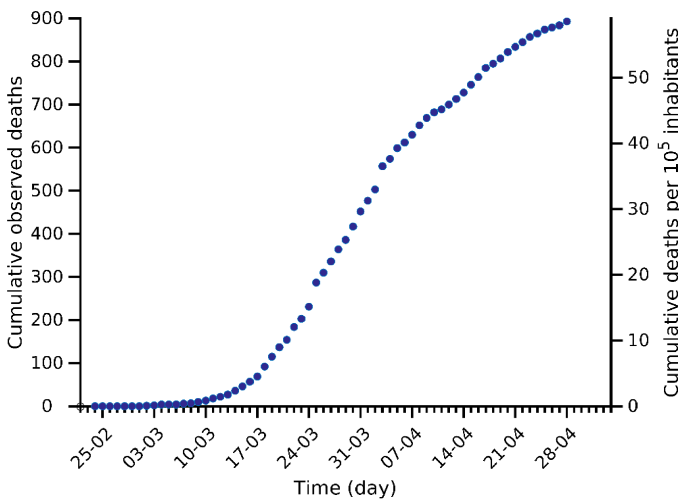
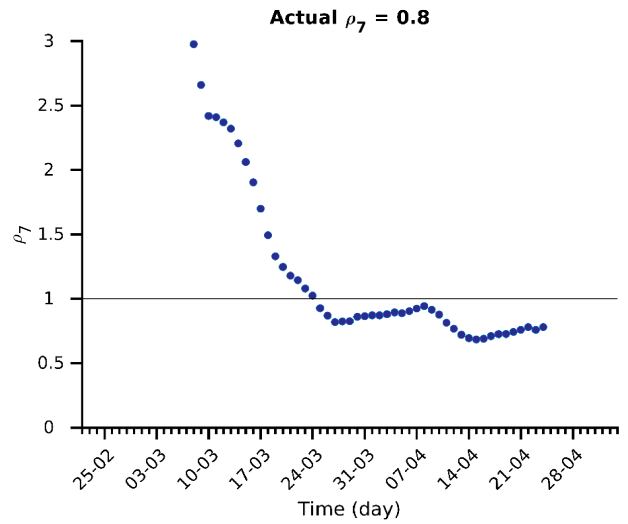
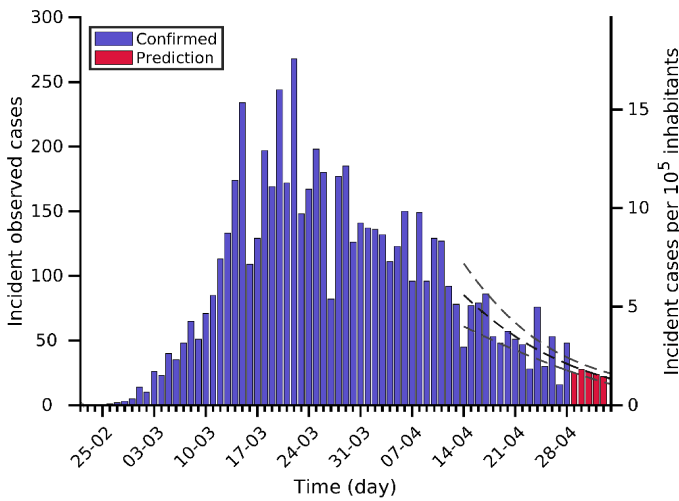
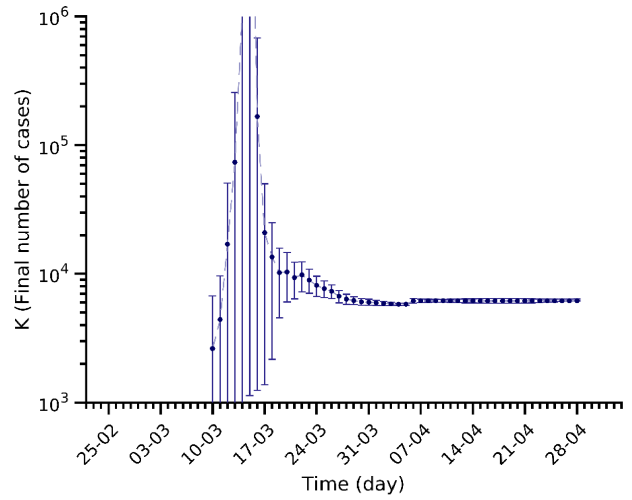
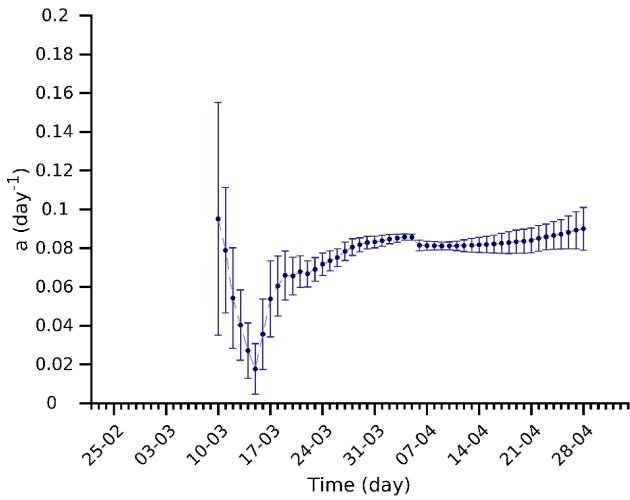
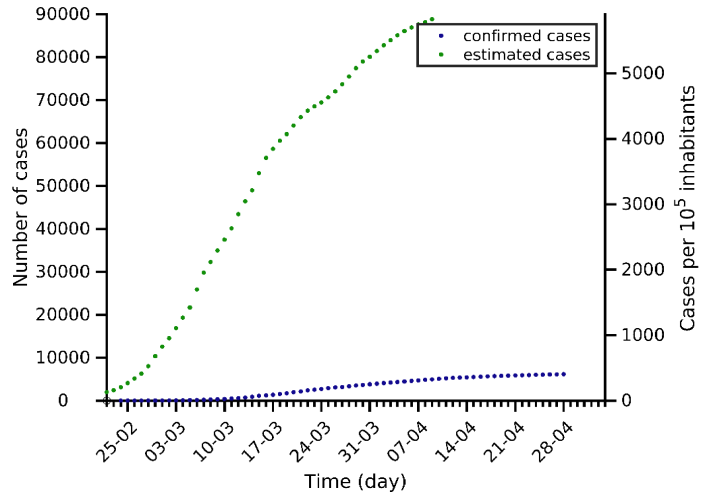
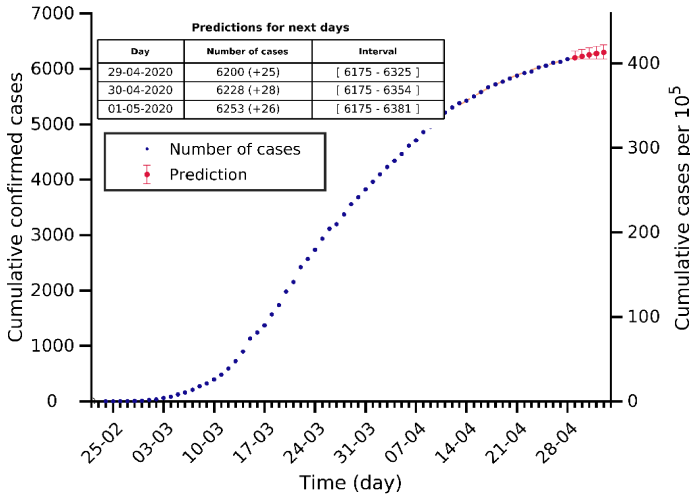
**Liguria 28-04-2020. Population: 1.6M. Current cumulated incidence: 501/10<sup>5</sup>**



**Lazio 28-04-2020. Population: 5.9M. Current cumulated incidence: 110/10<sup>5</sup>**

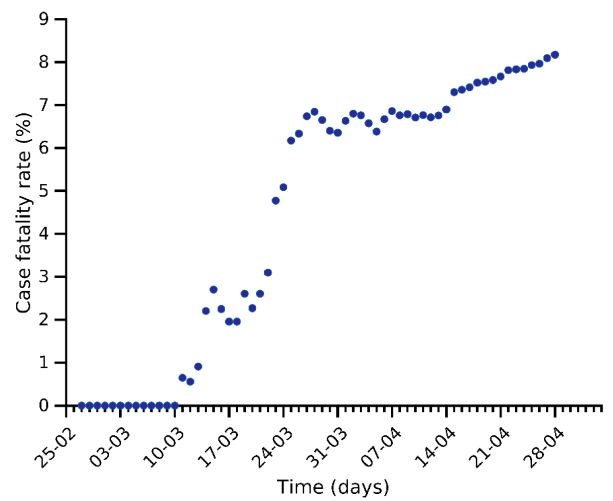
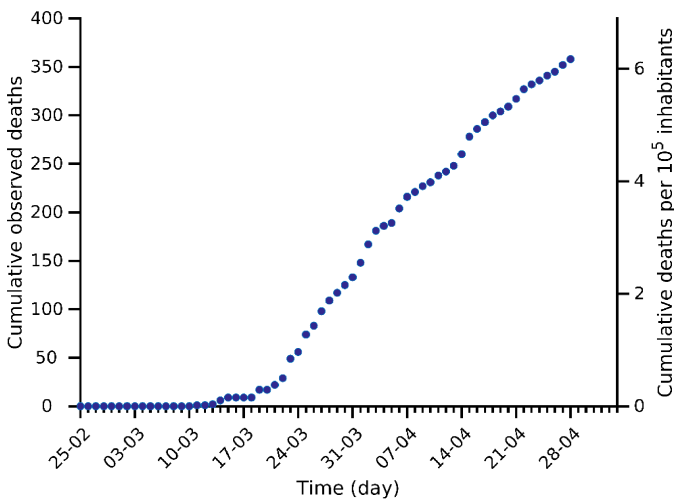
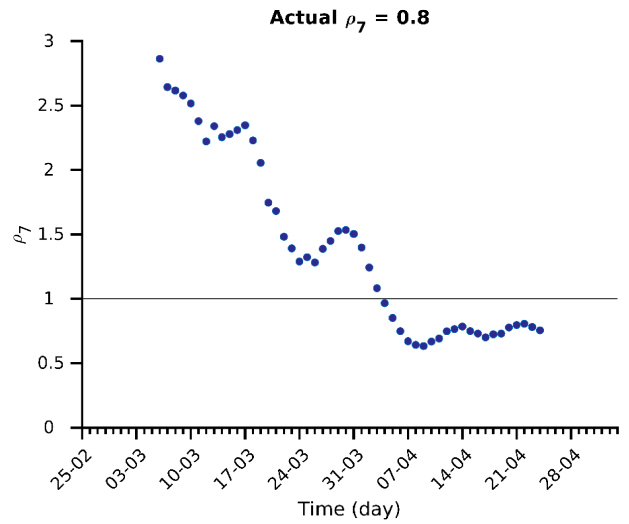
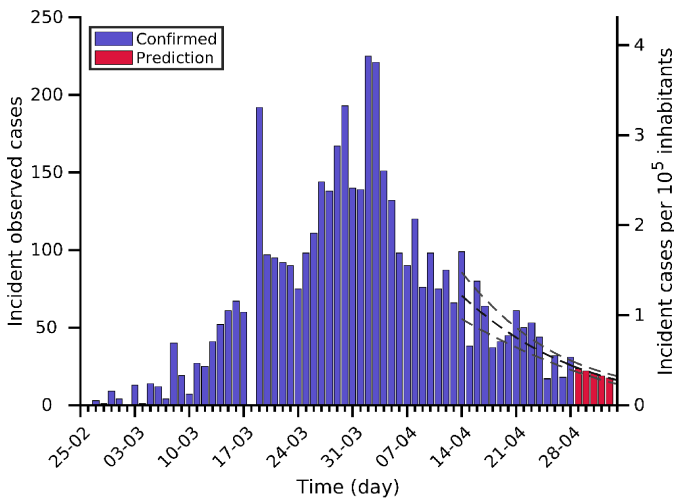
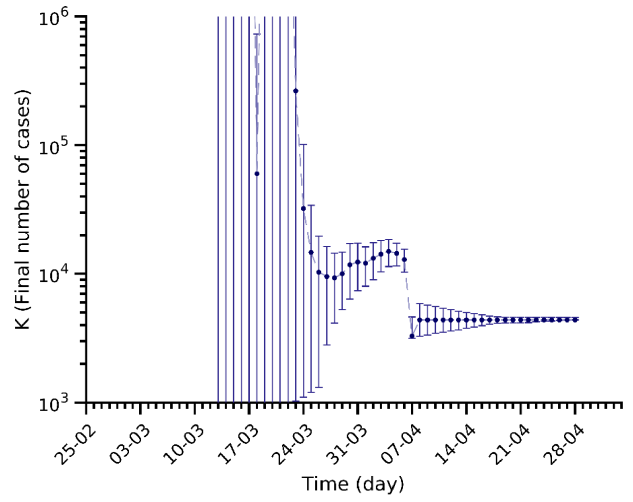
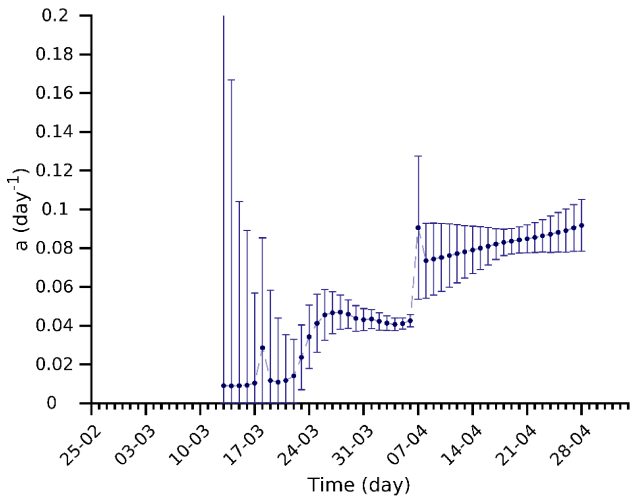
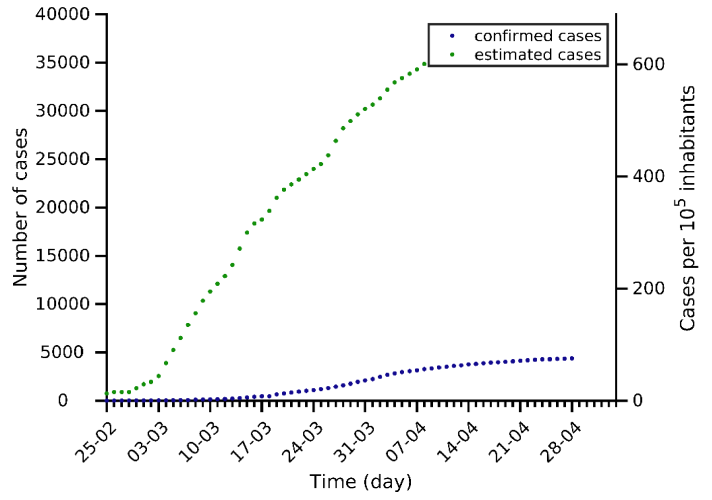
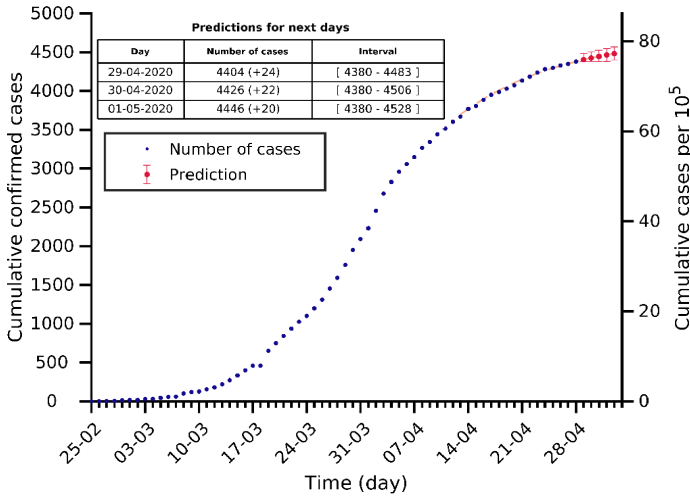


**Marche 28-04-2020. Population: 1.5M. Current cumulated incidence: 405/10<sup>5</sup>**

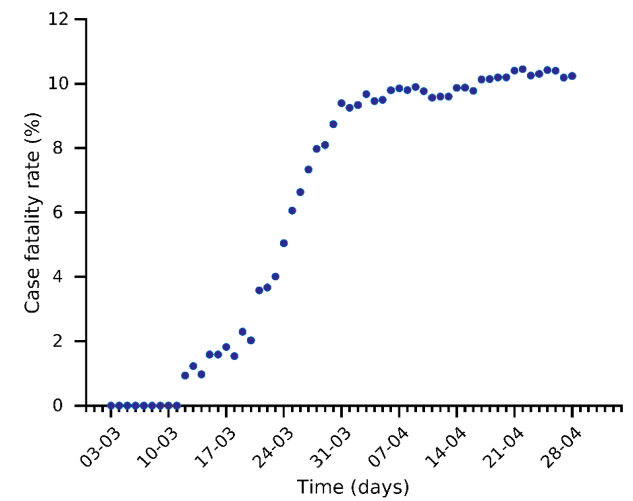
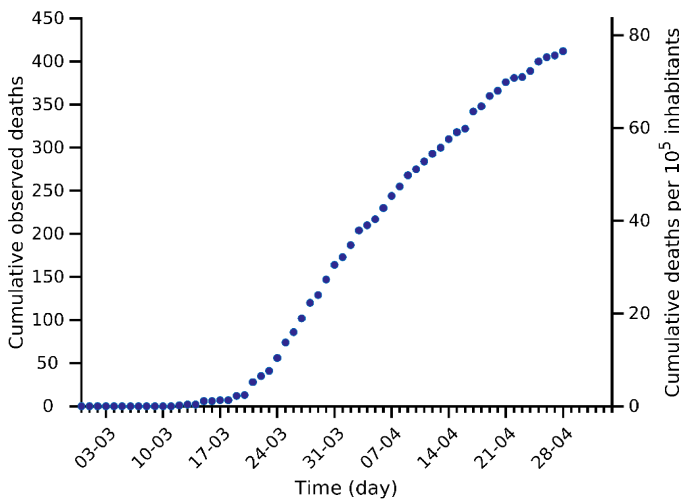
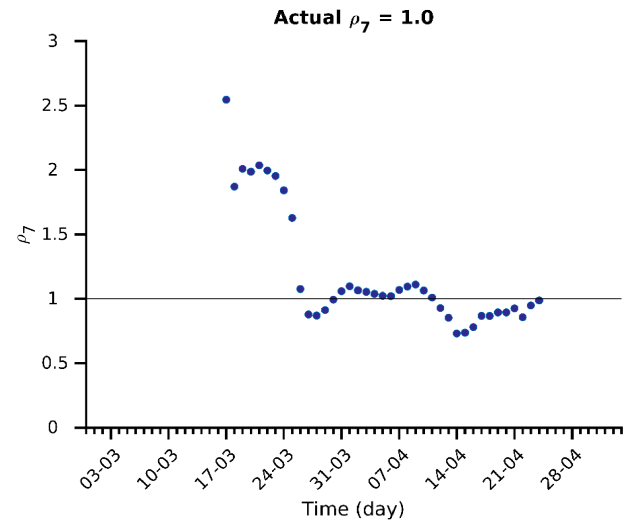
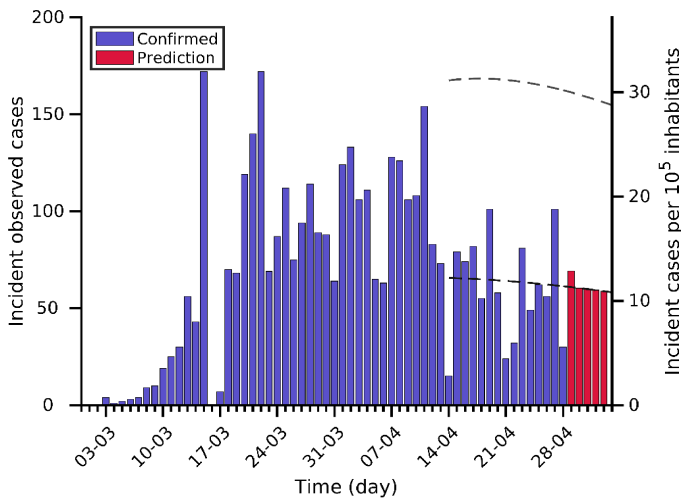
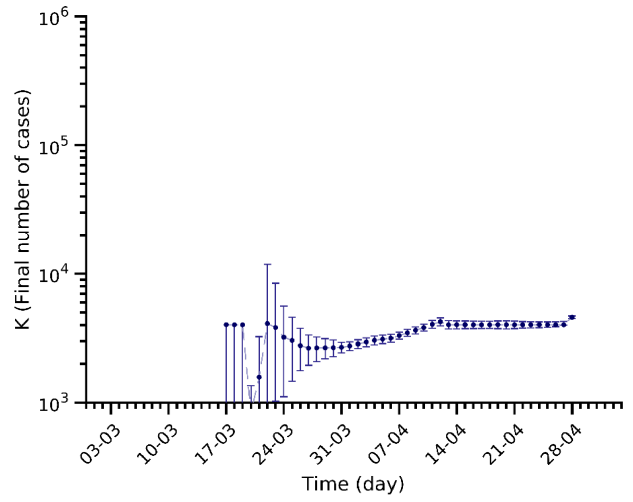
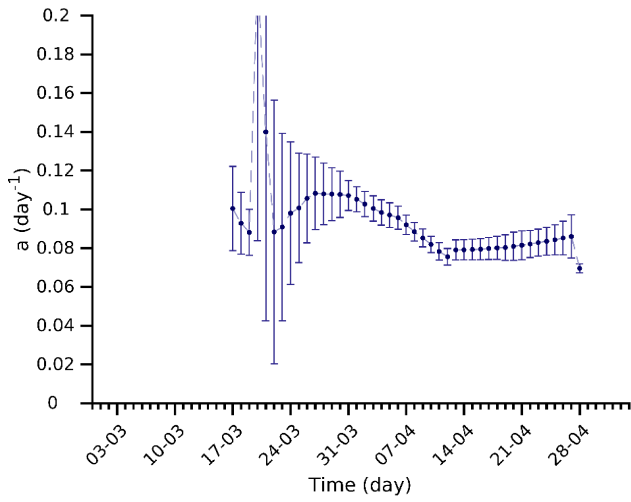
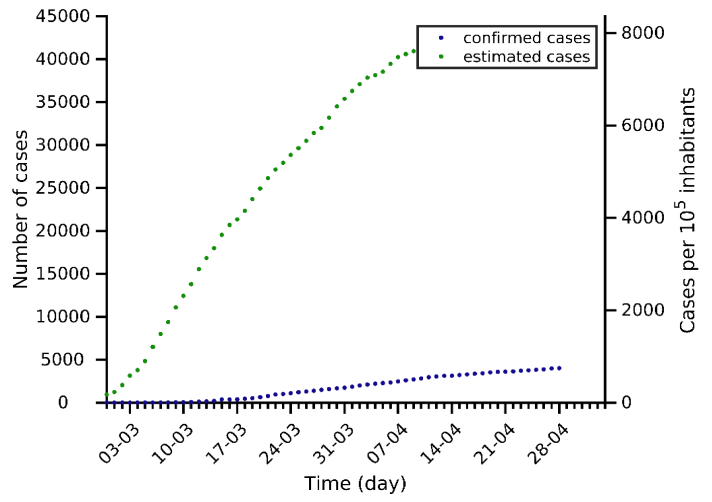
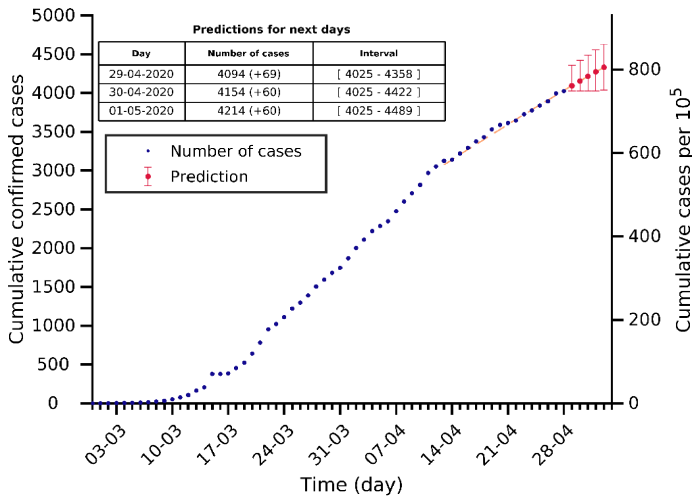




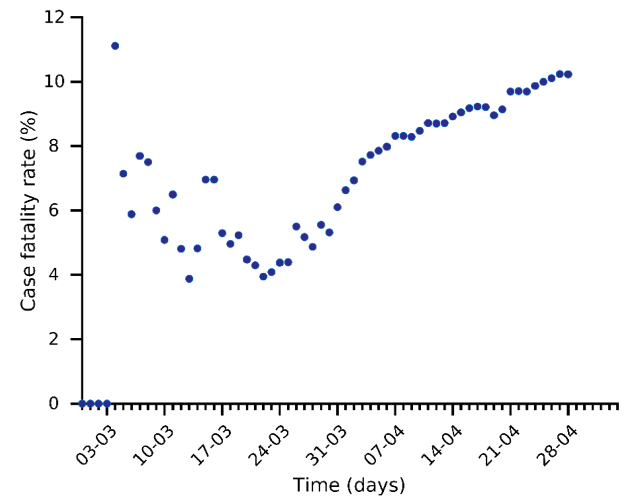
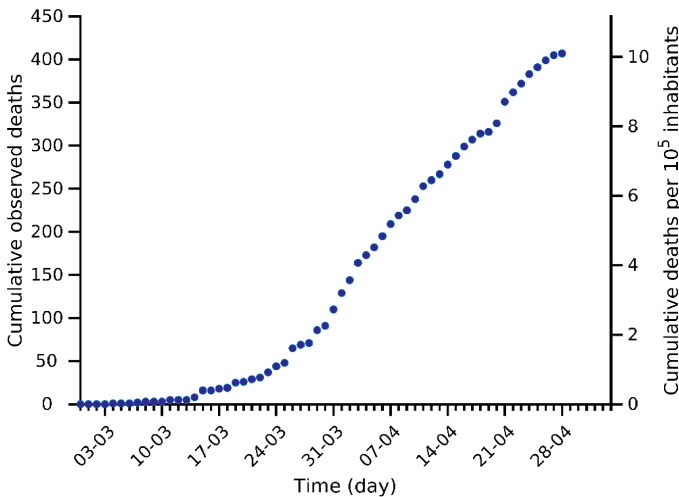
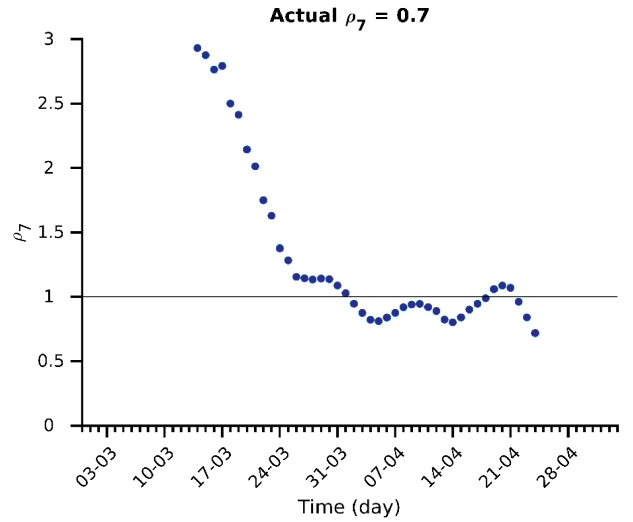
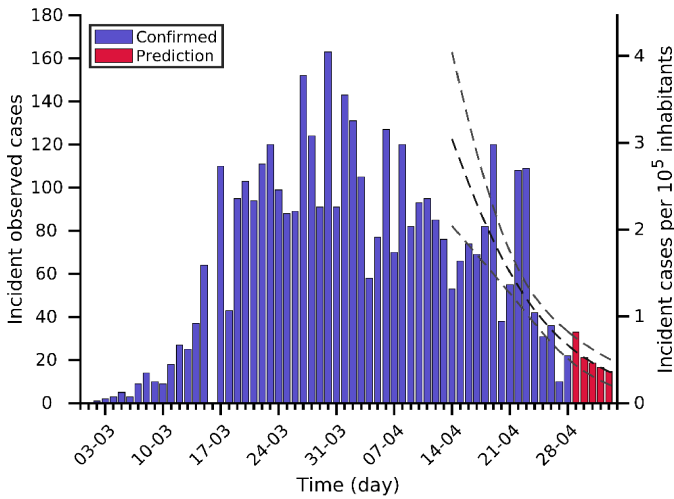
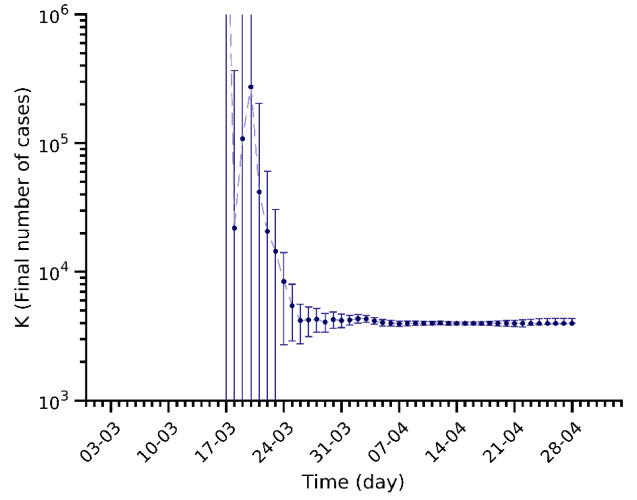
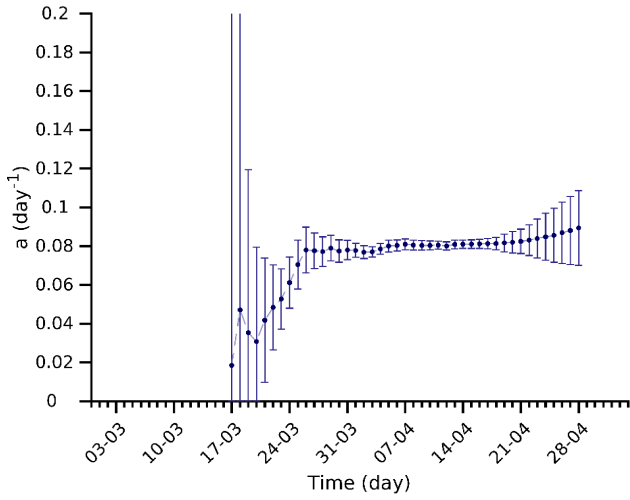
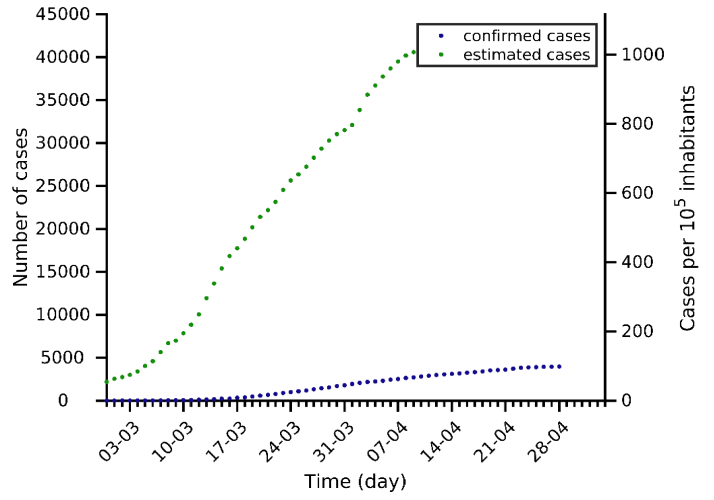
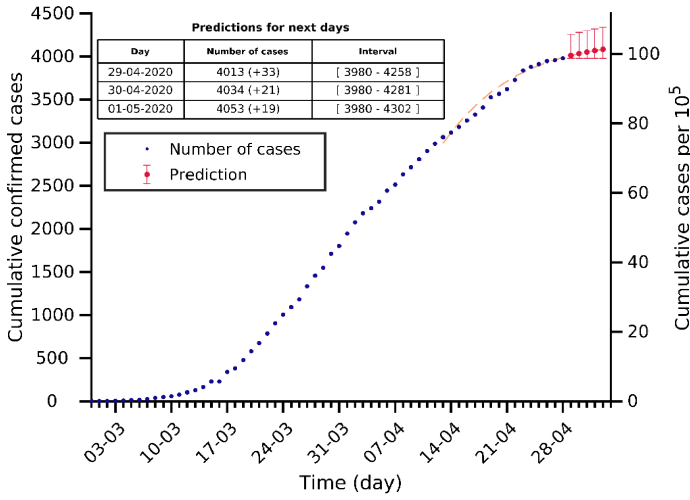
**Campania 28-04-2020. Population: 5.8M. Current cumulated incidence: 75/10<sup>5</sup>**



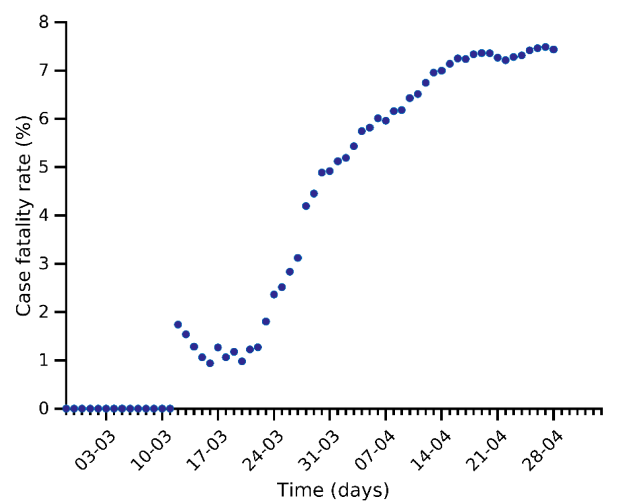
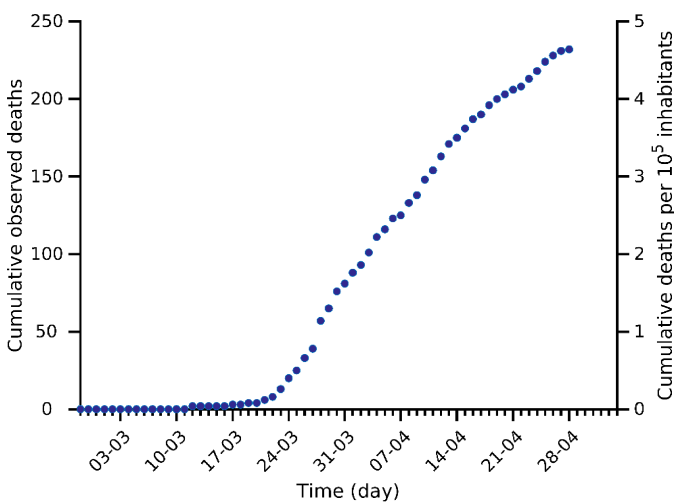
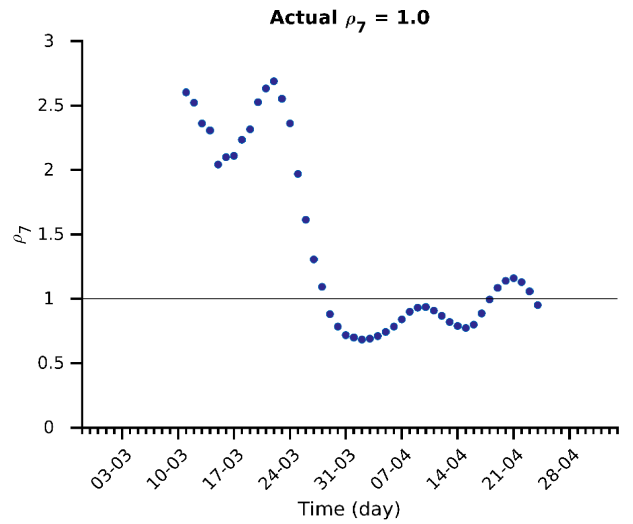
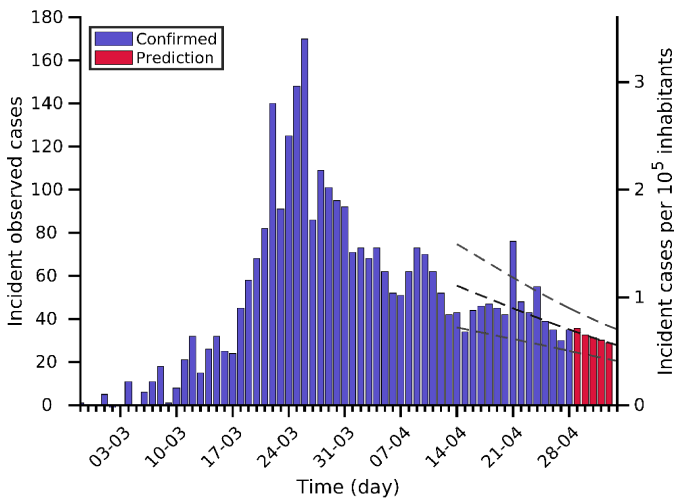
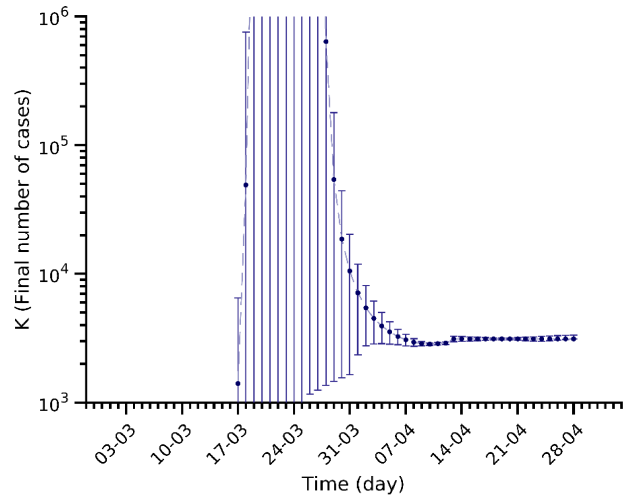
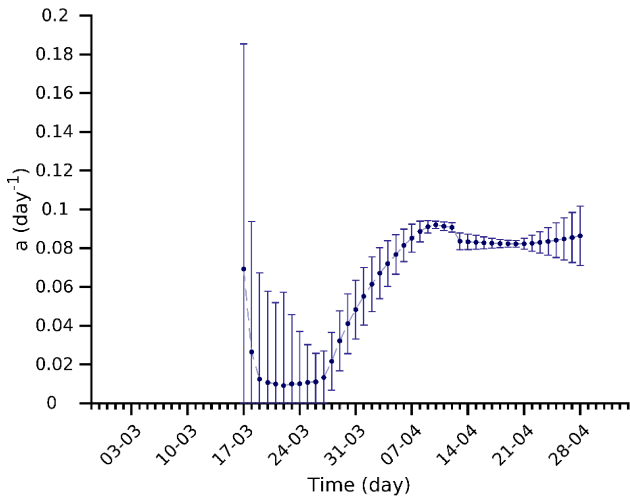
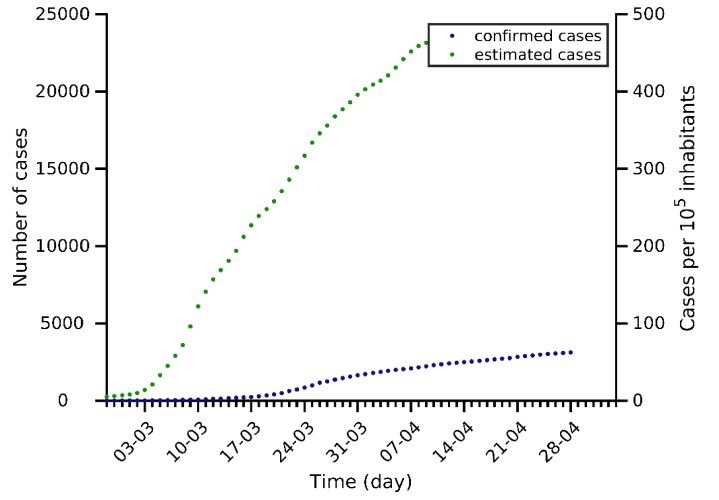
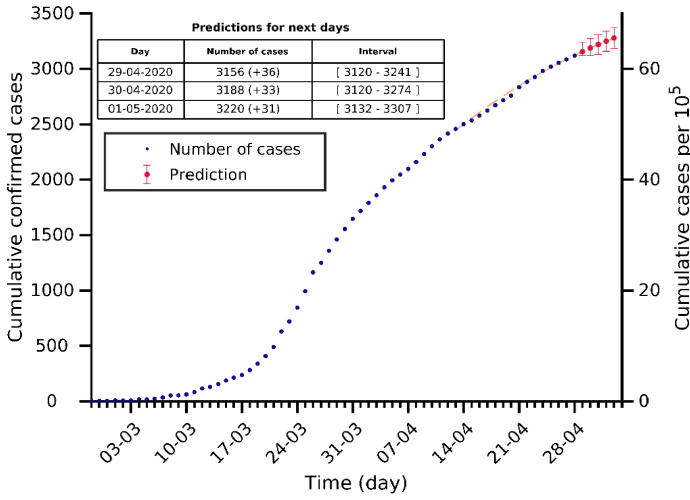
**Trento 28-04-2020. Population: 0.5M. Current cumulated incidence: 748/10<sup>5</sup>**



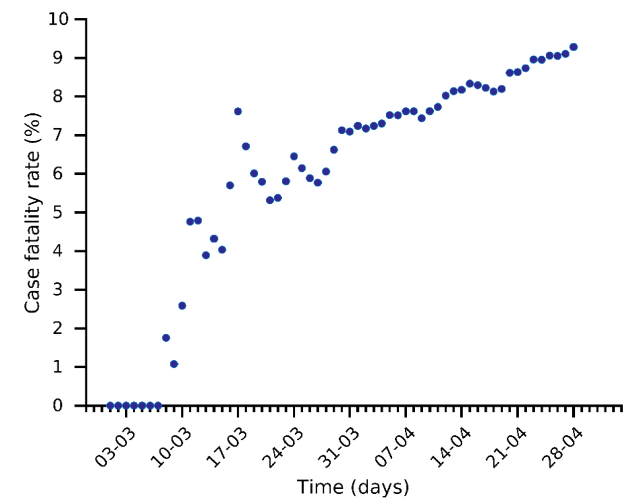
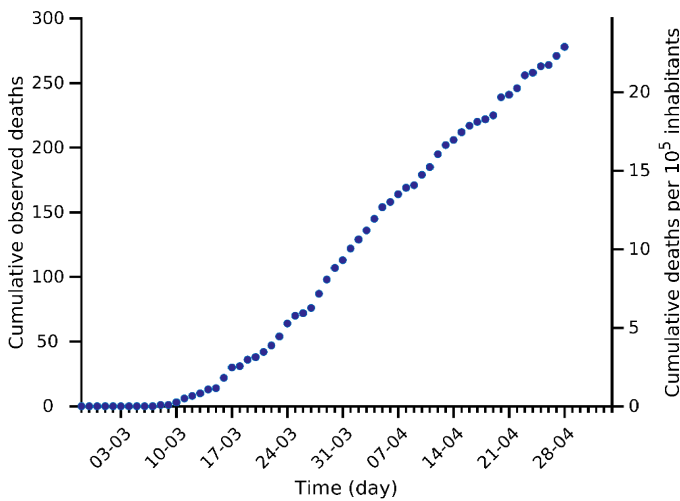
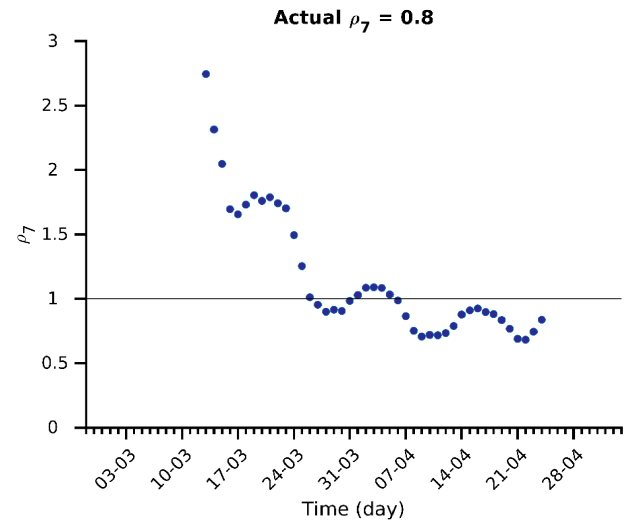
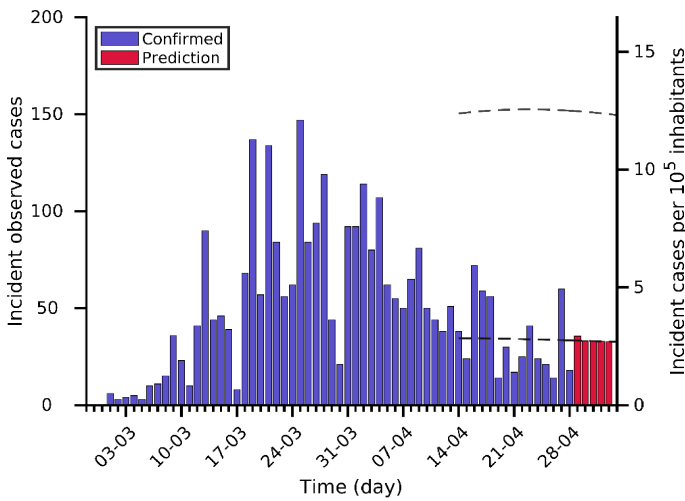
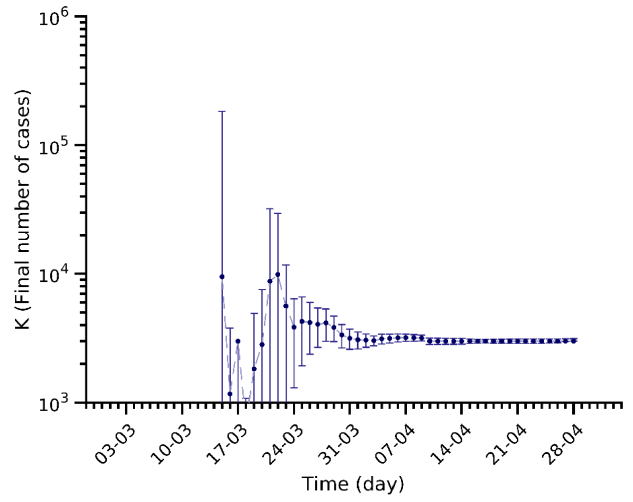
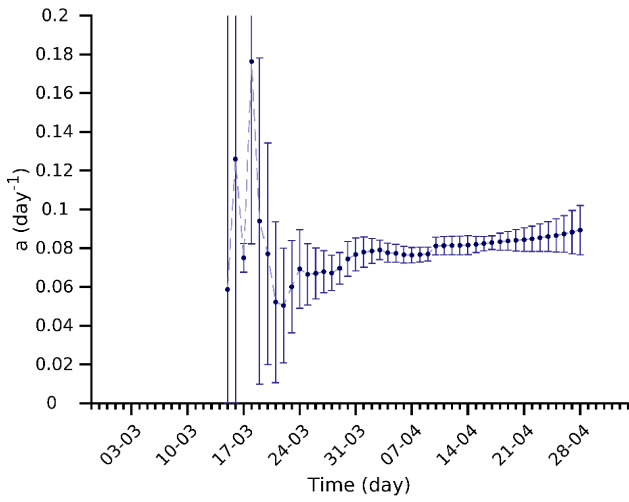
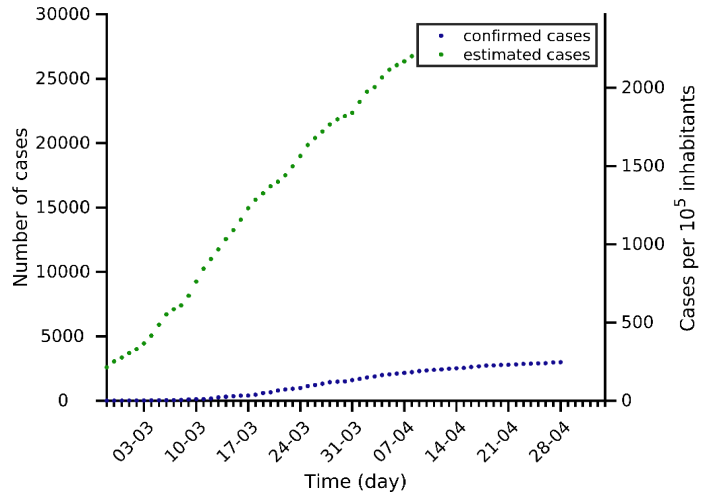
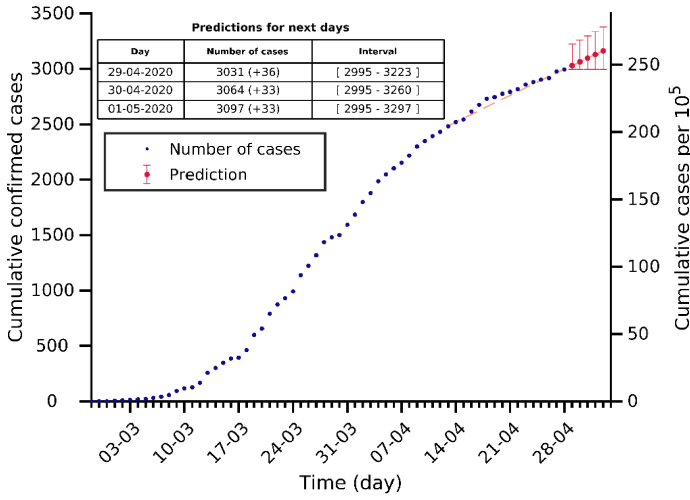
**Puglia 28-04-2020. Population: 4.0M. Current cumulated incidence: 99/10<sup>5</sup>**



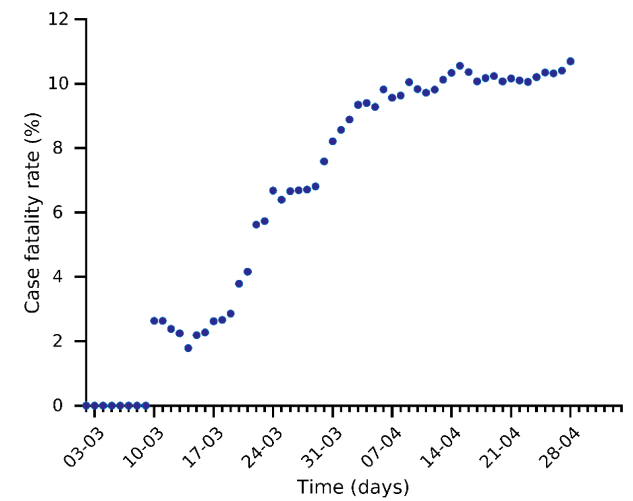
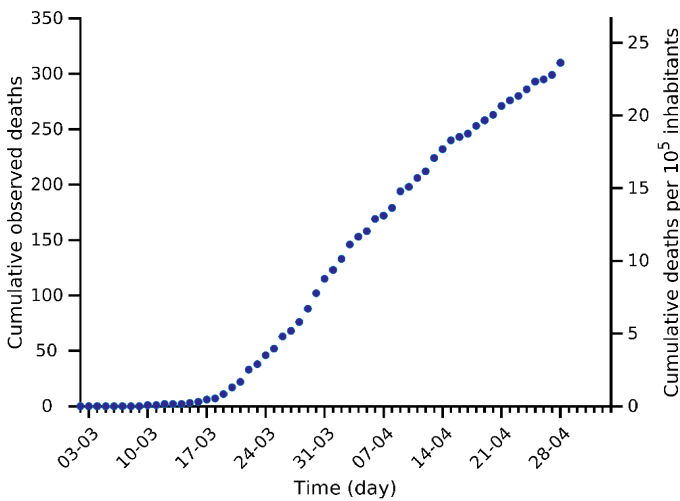
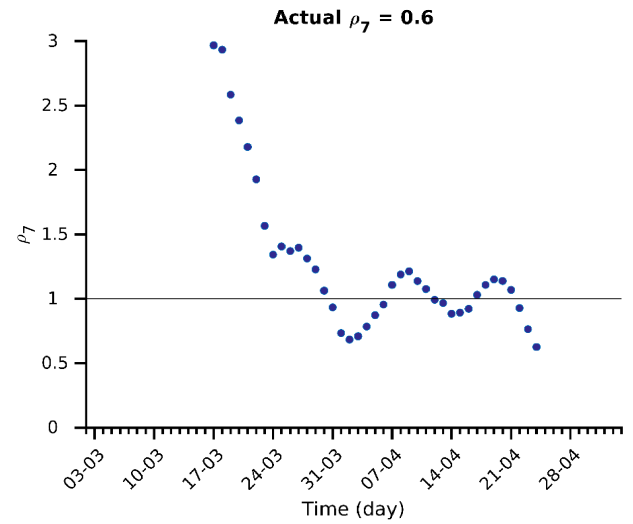
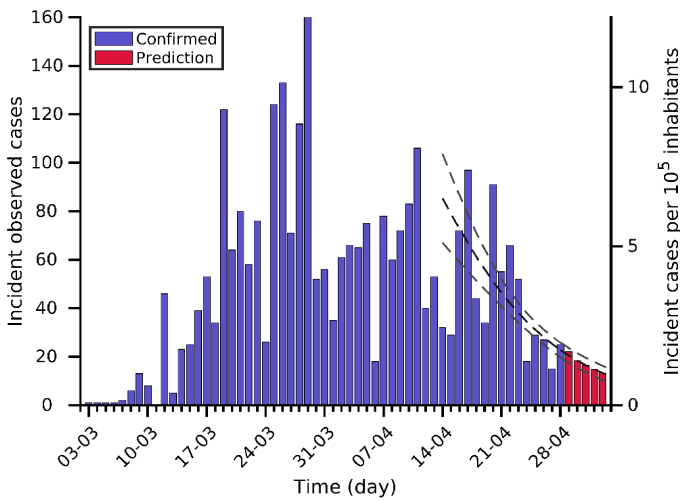
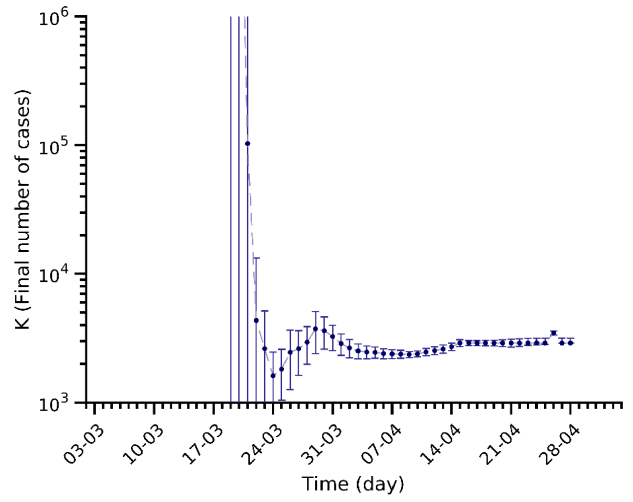
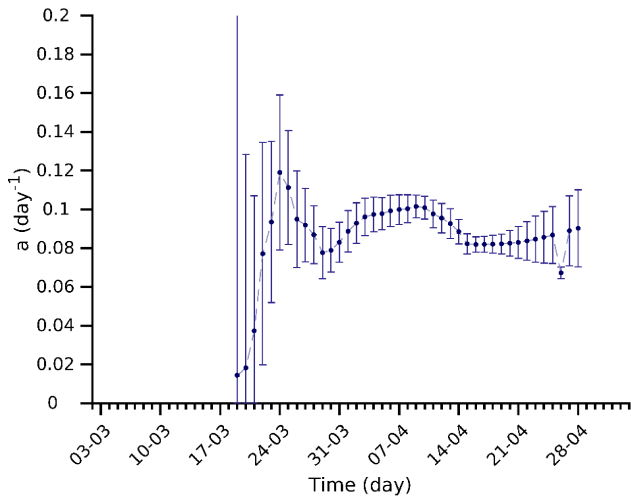
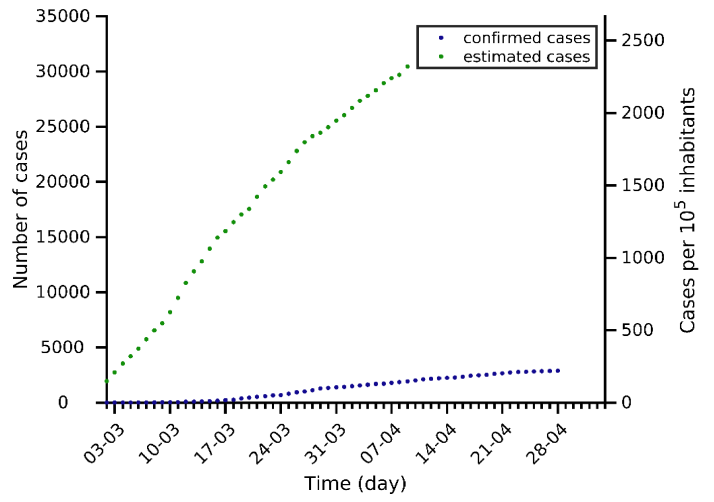
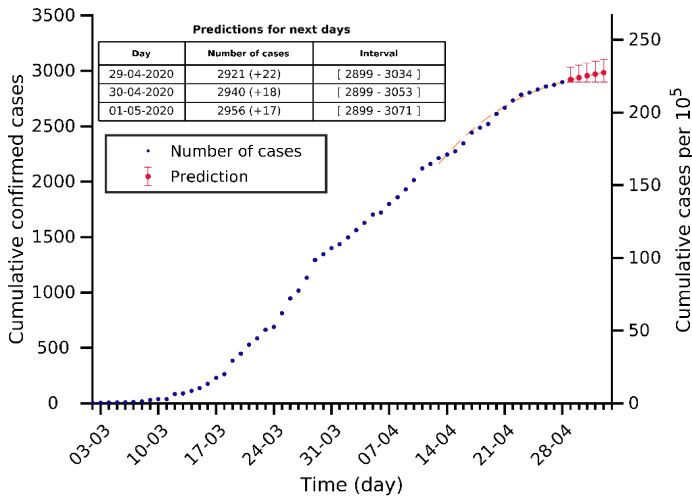
**Sicilia 28-04-2020. Population: 5.0M. Current cumulated incidence: 62/10<sup>5</sup>**



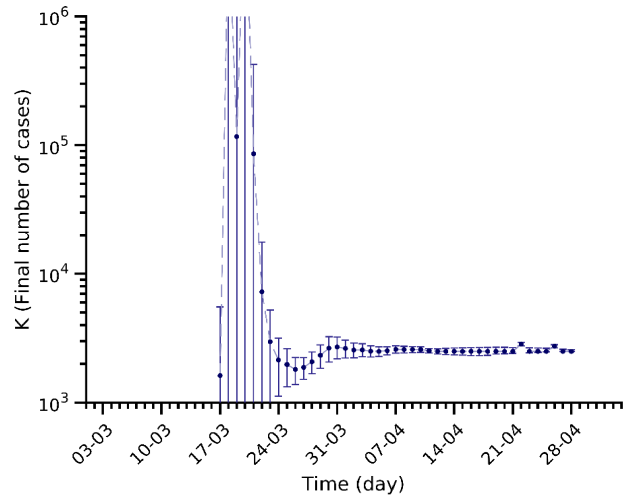
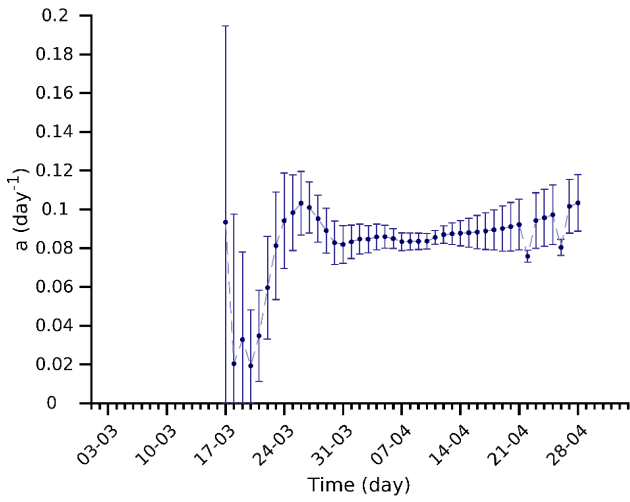
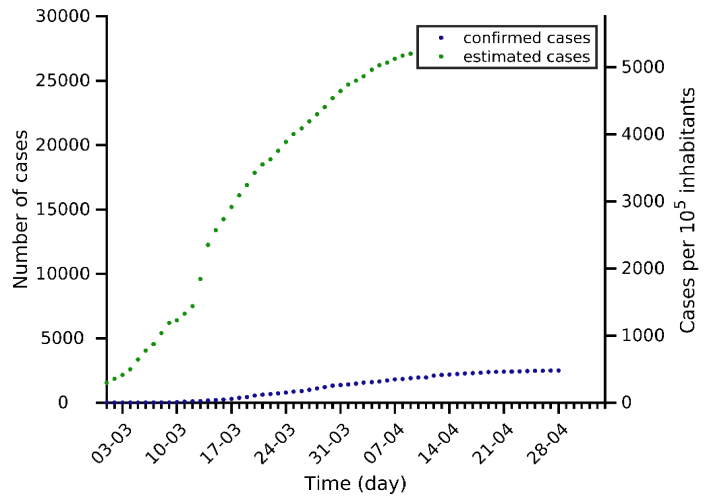
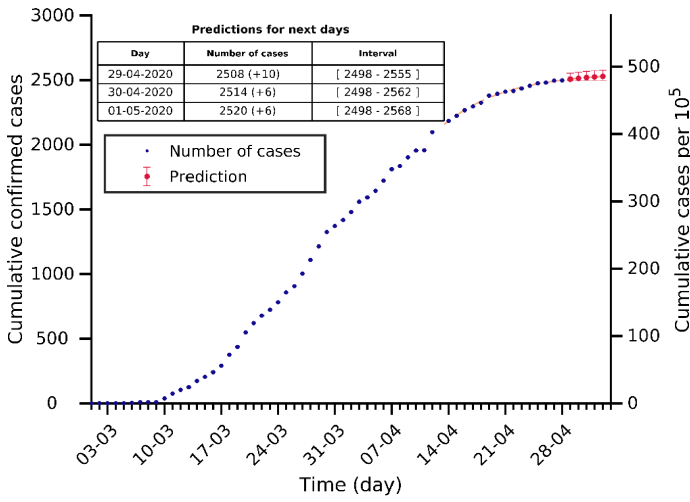
# Friuli Venezia Giulia 28-04-2020. Population: 1.2M. Current cumulated incidence: 2



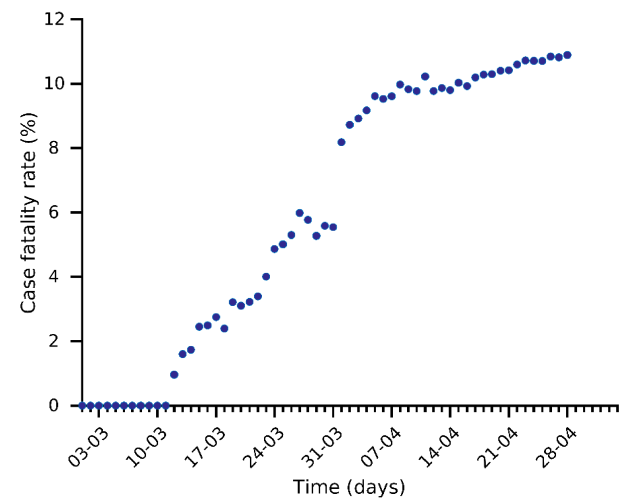
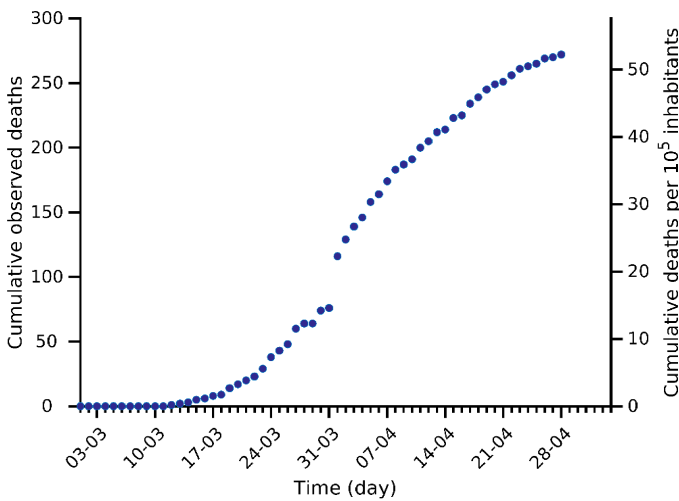
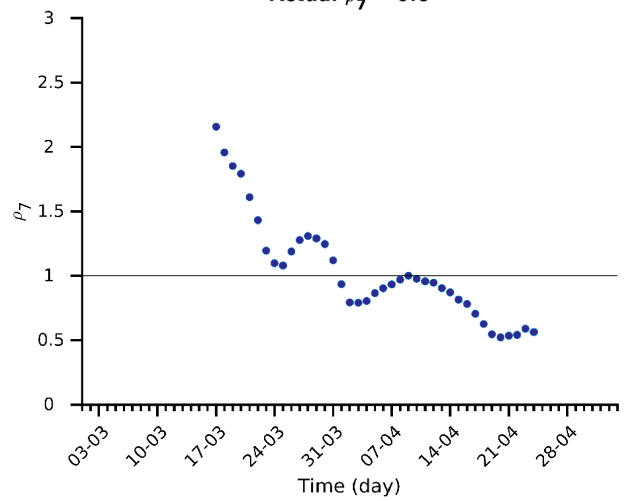
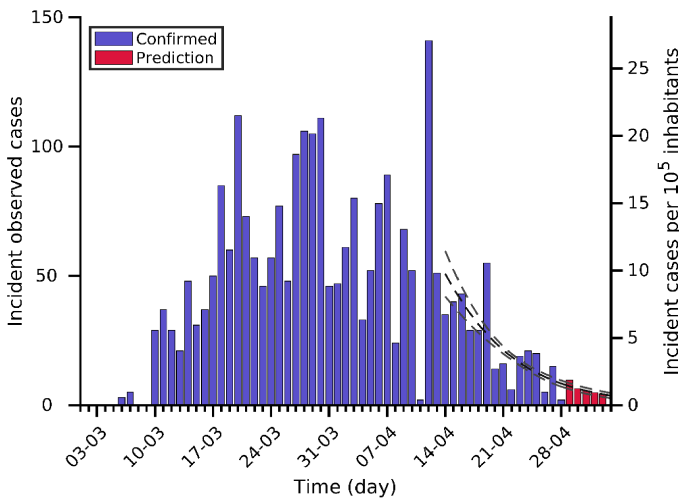
**Abruzzo 28-04-2020. Population: 1.3M. Current cumulated incidence: 221/10<sup>5</sup>**



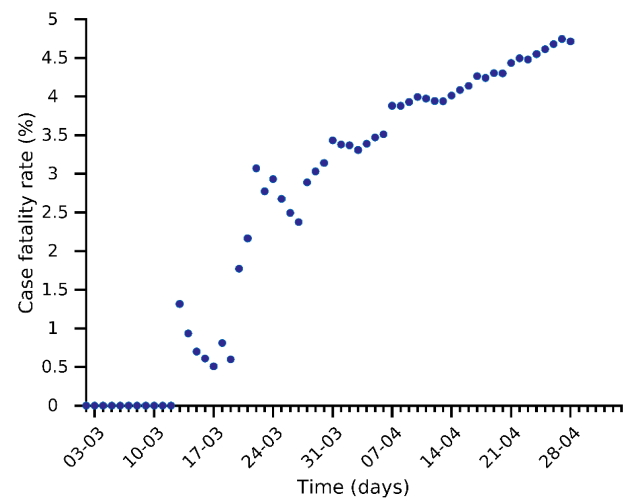
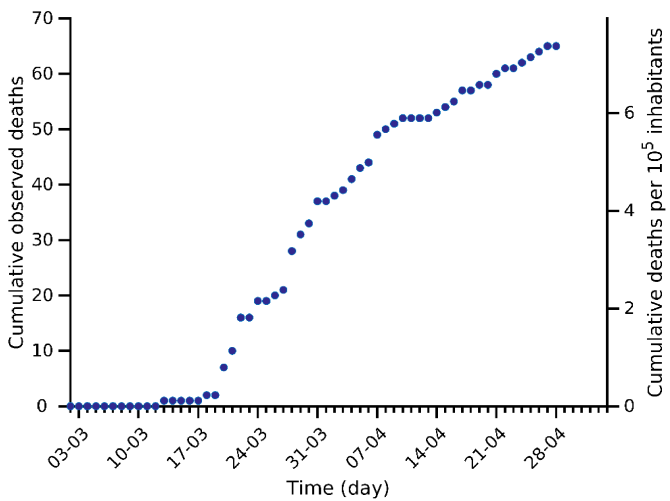
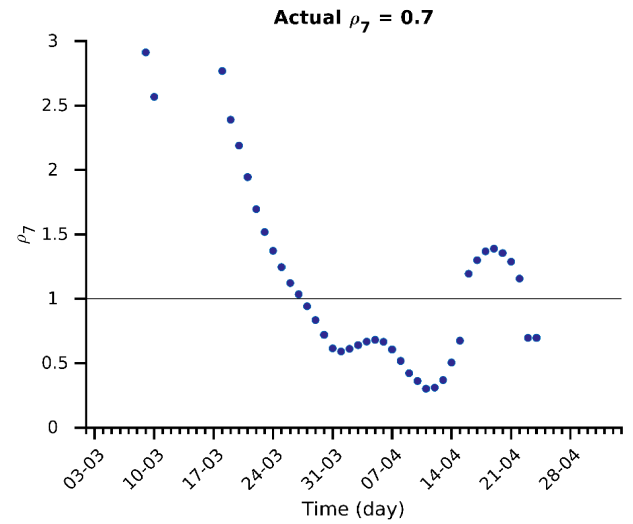
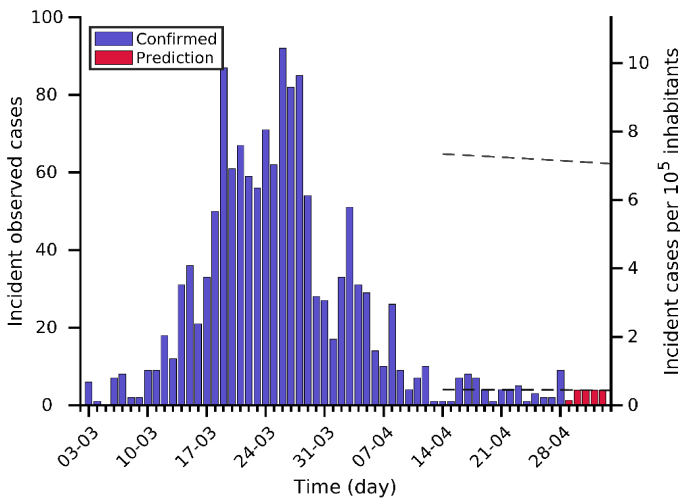
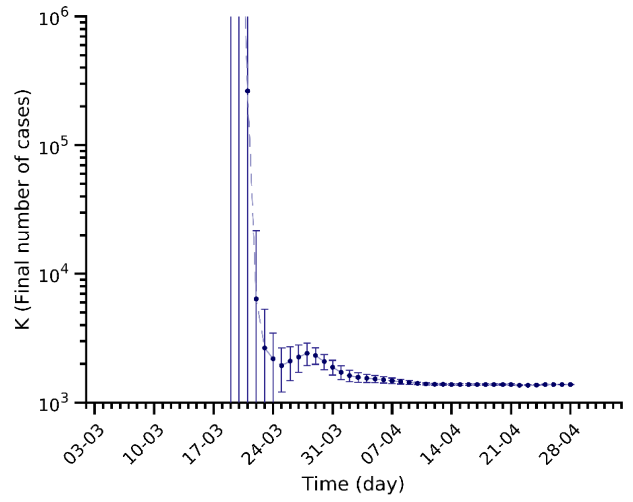
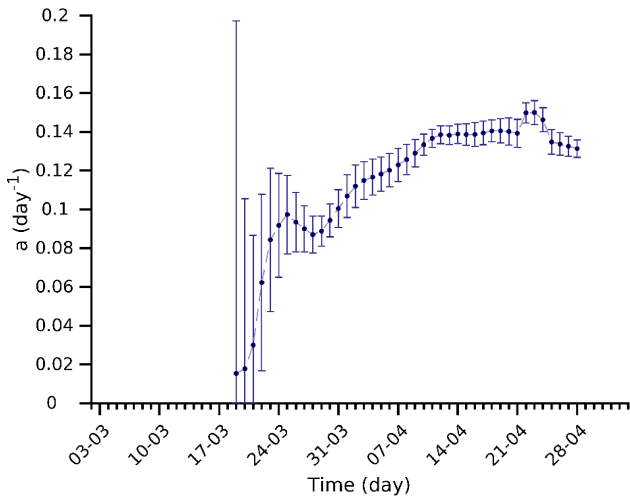
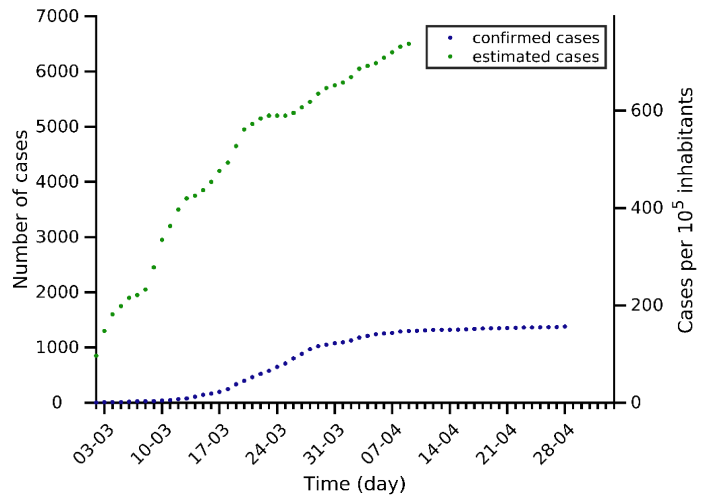
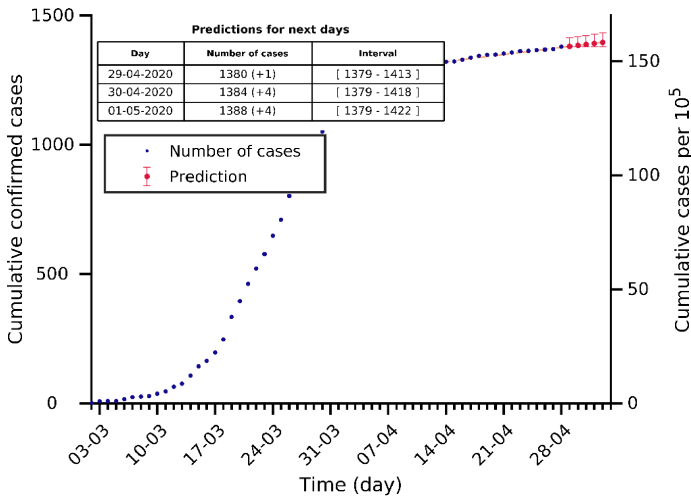
**Bolzano 28-04-2020. Population: 0.5M. Current cumulated incidence: 479/10<sup>5</sup>**



**Actual  $\rho_7 = 0.6$**

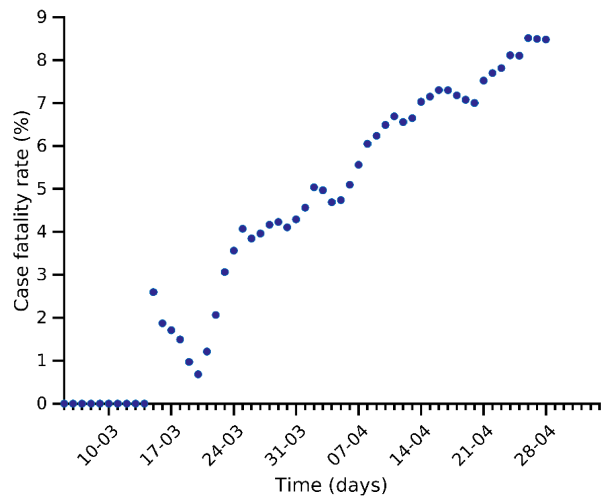
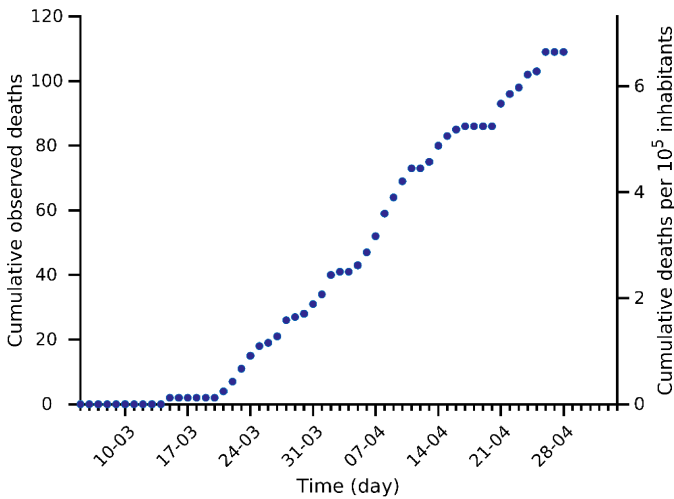
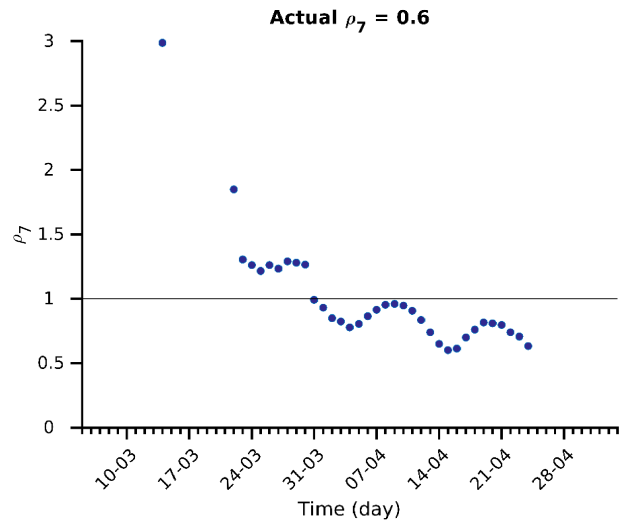
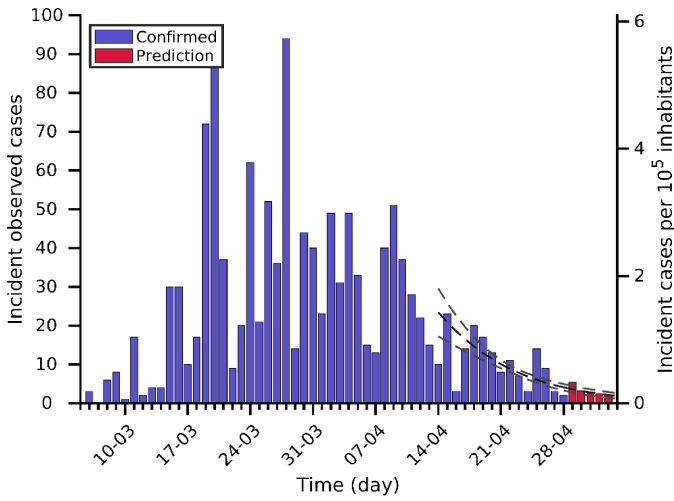
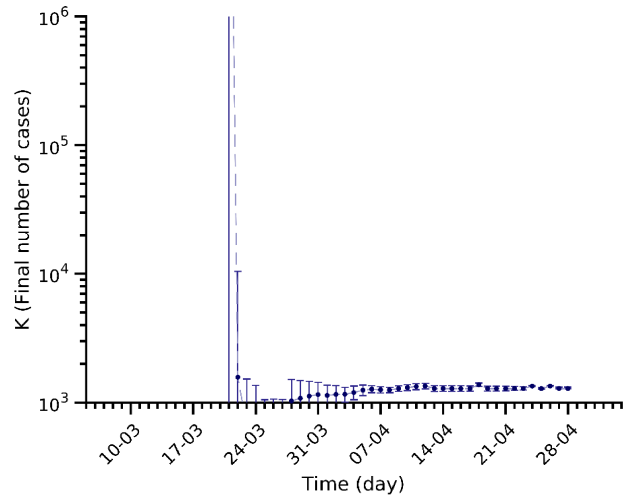
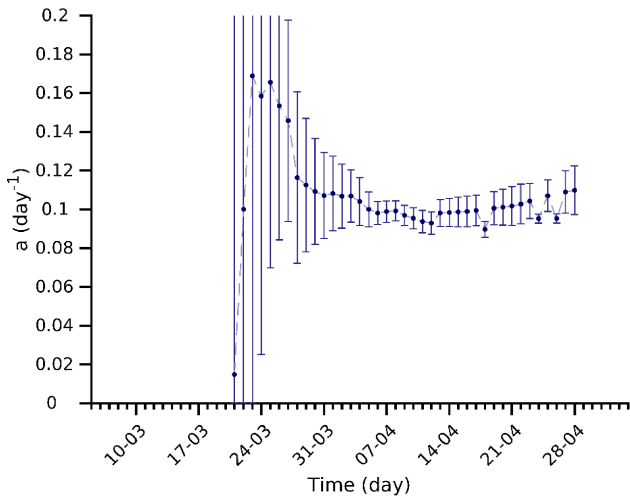
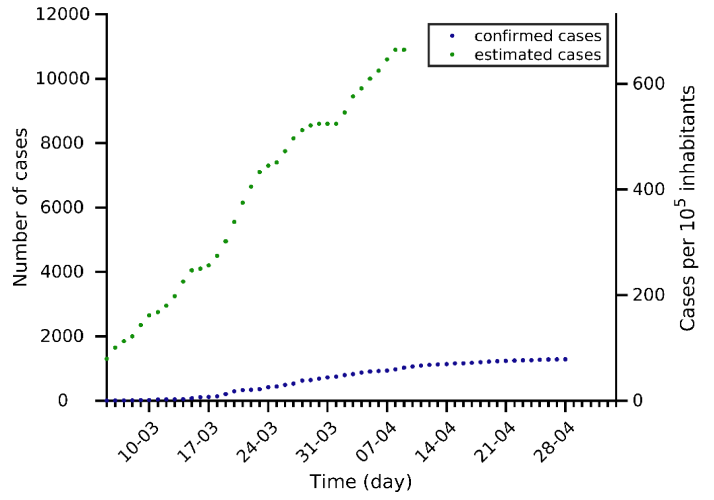
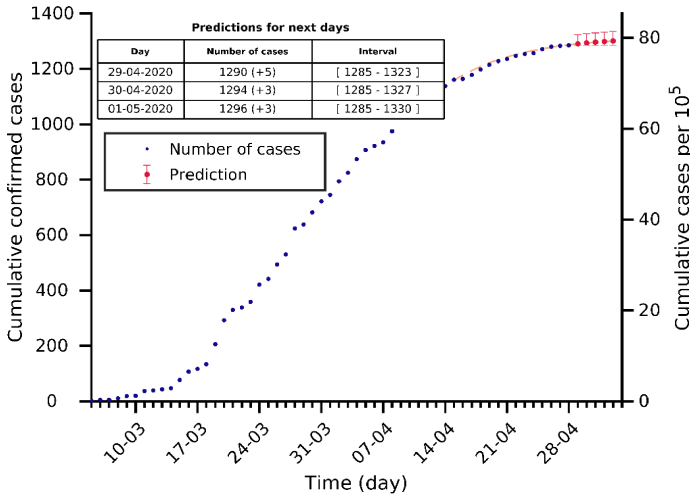


**Umbria 28-04-2020. Population: 0.9M. Current cumulated incidence: 156/10<sup>5</sup>**

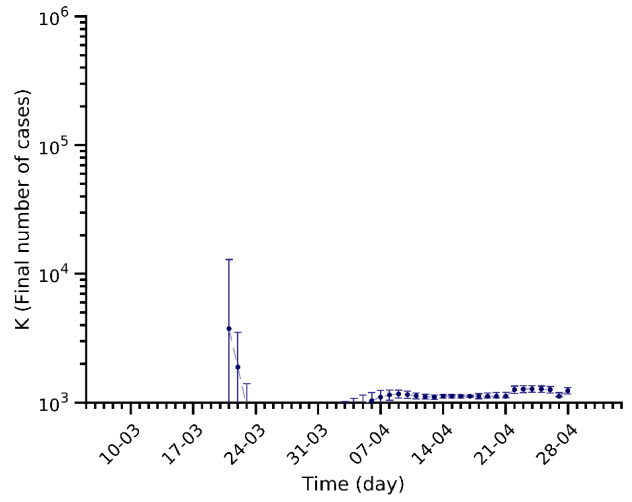
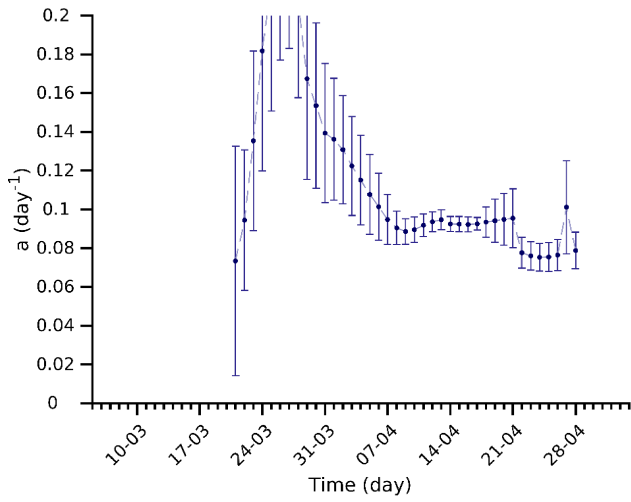
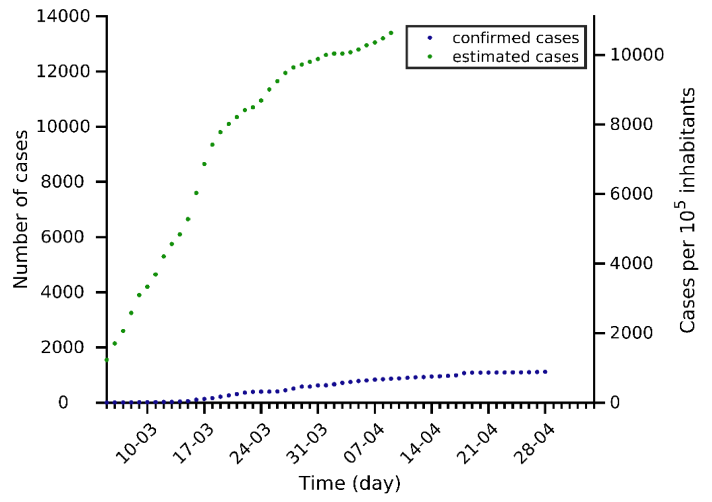
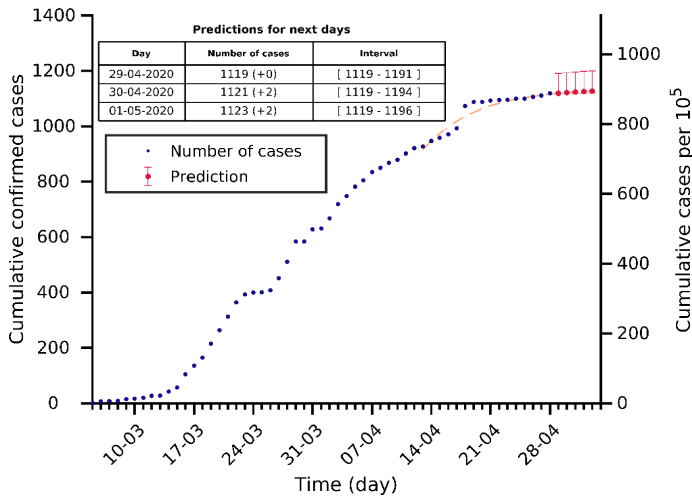




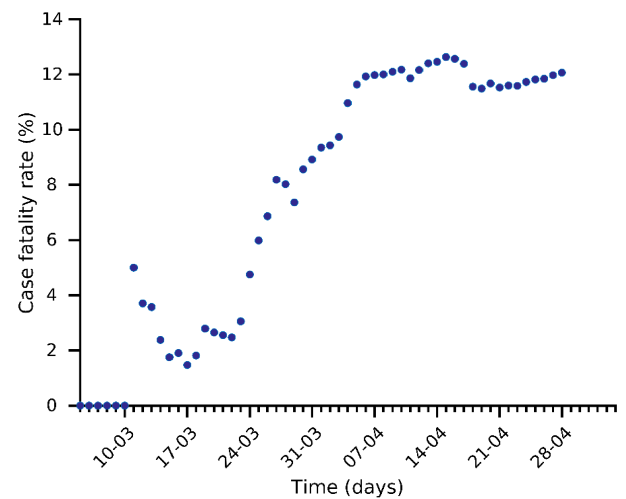
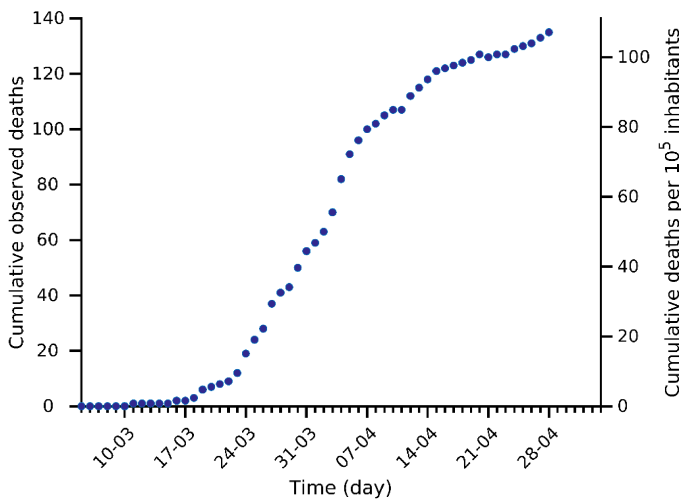
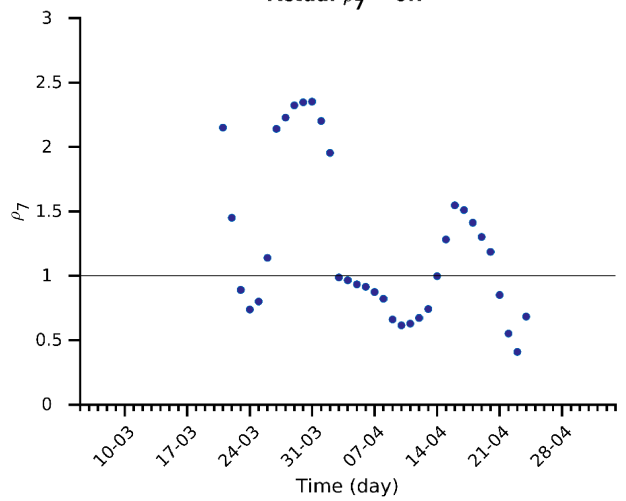
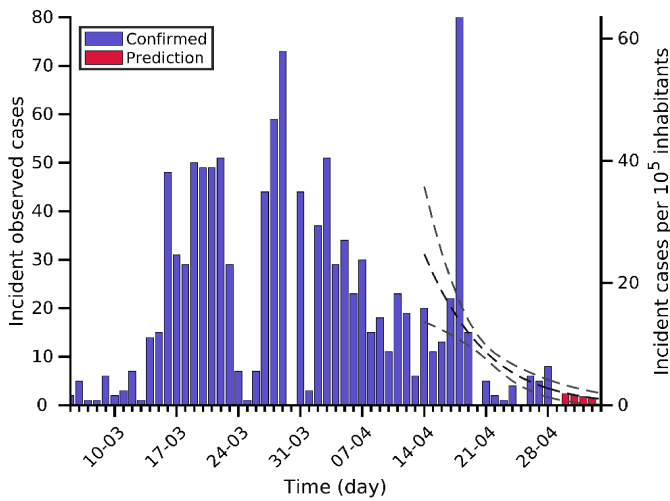
**Sardegna 28-04-2020. Population: 1.6M. Current cumulated incidence: 78/10<sup>5</sup>**



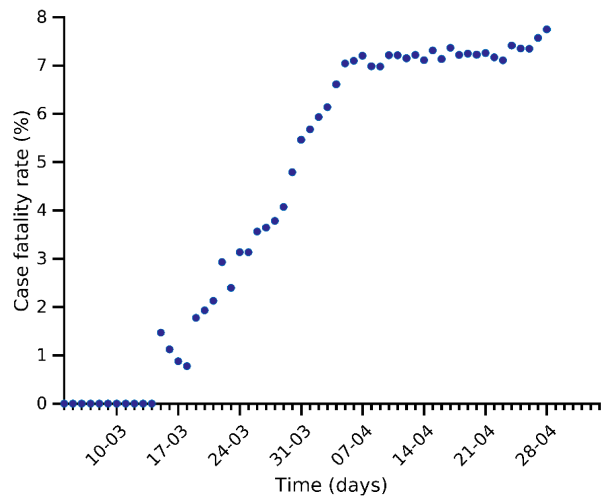
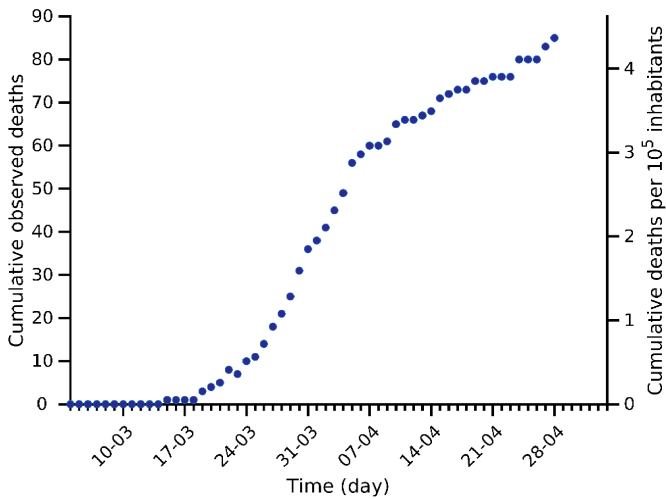
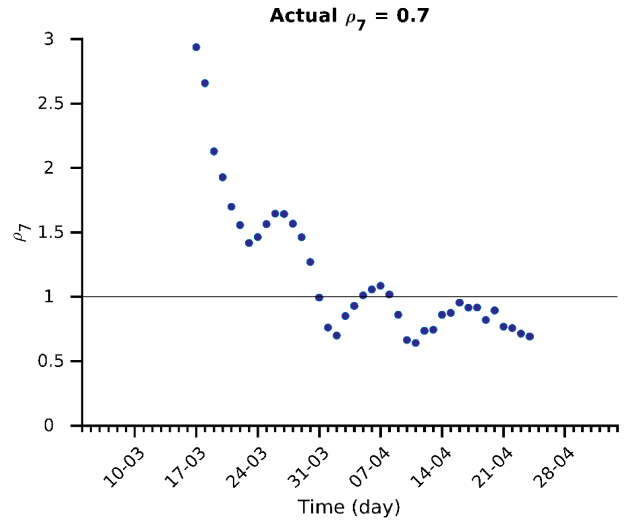
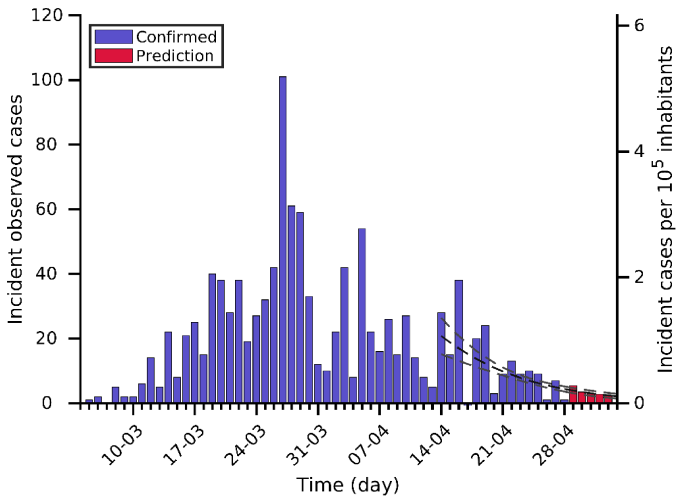
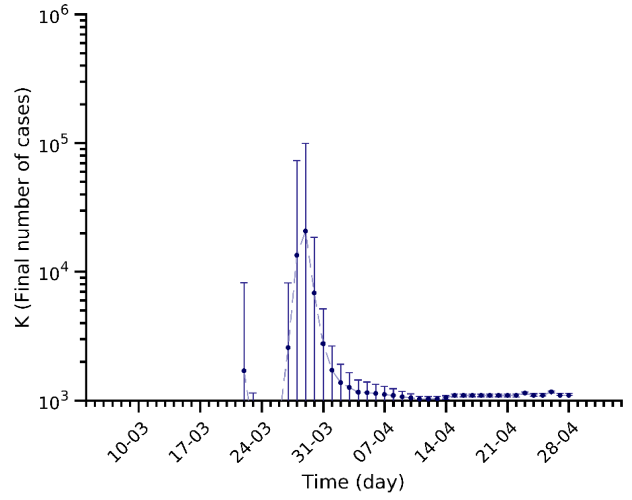
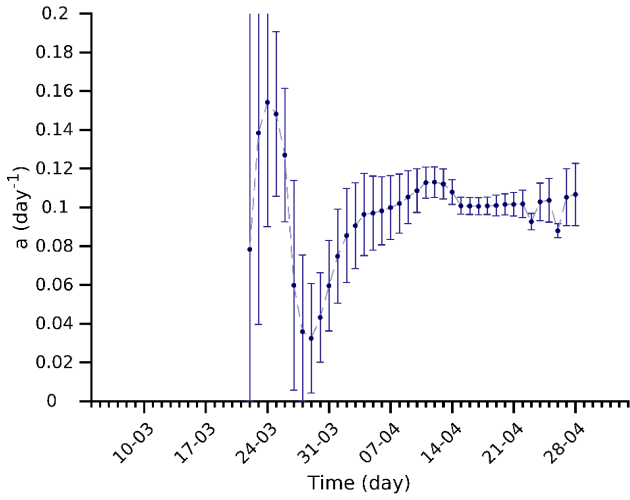
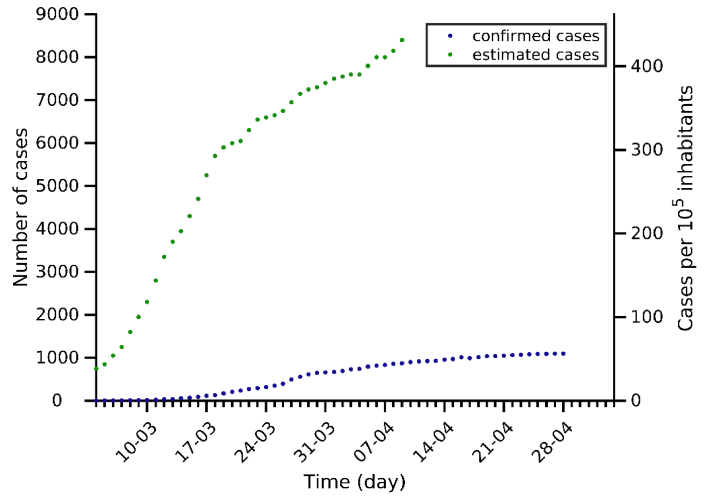
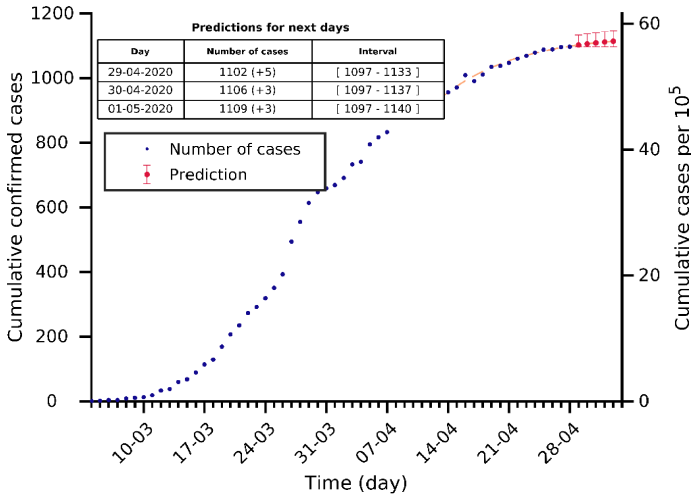
**Valle d'Aosta 28-04-2020. Population: 0.1M. Current cumulated incidence: 888/10<sup>5</sup>**



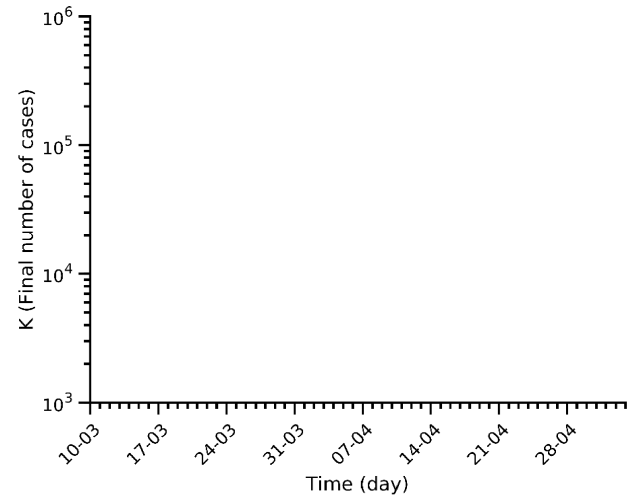
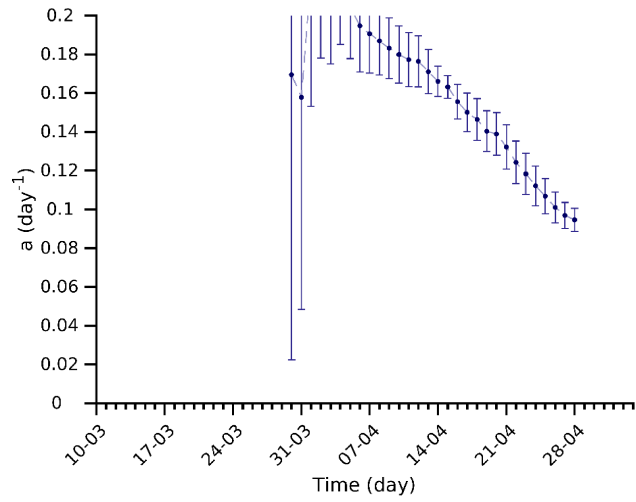
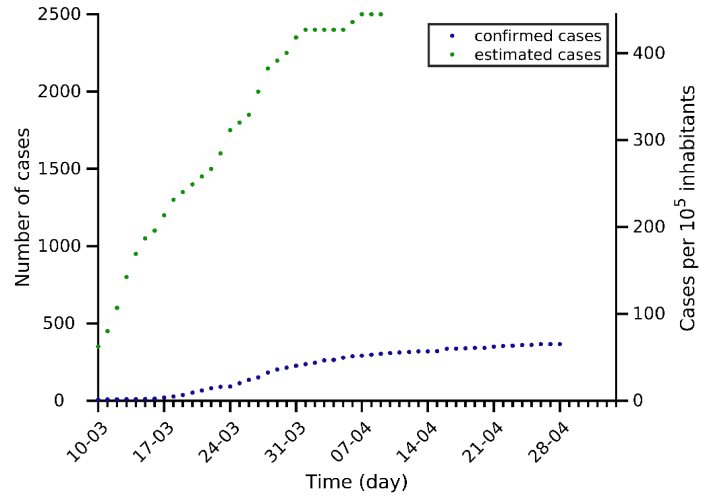
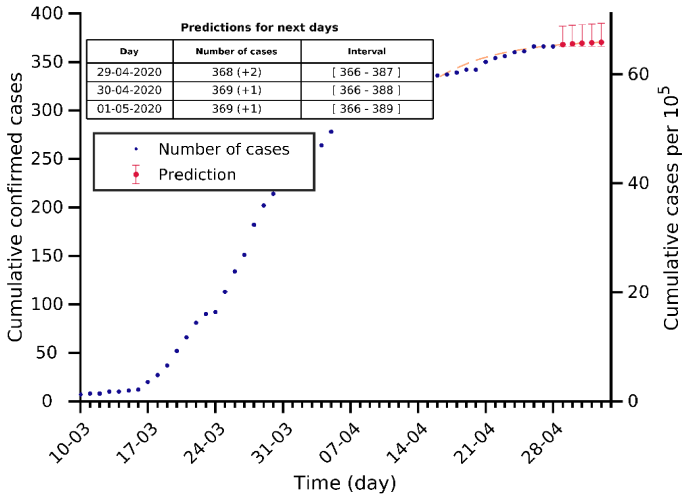
**Actual  $\rho_7 = 0.7$**



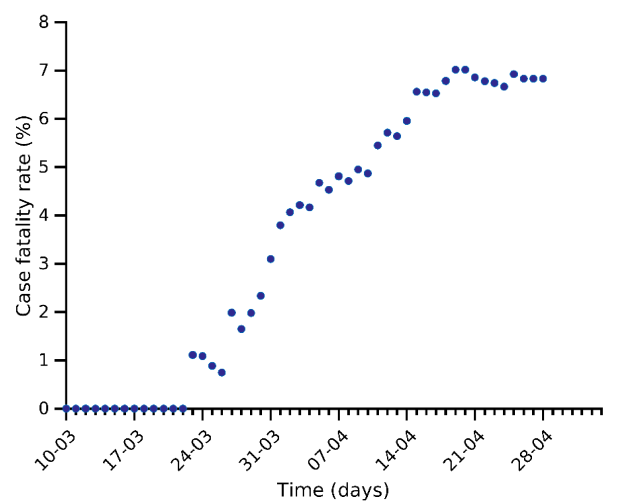
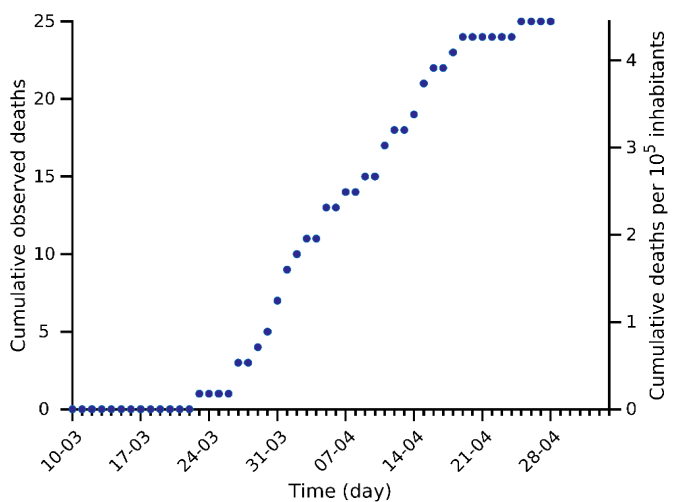
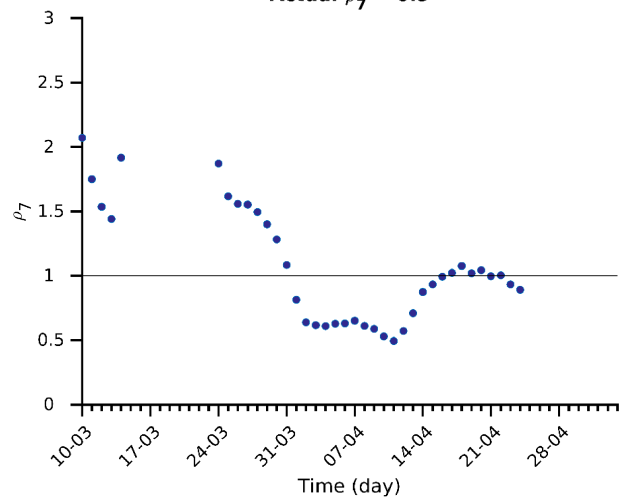
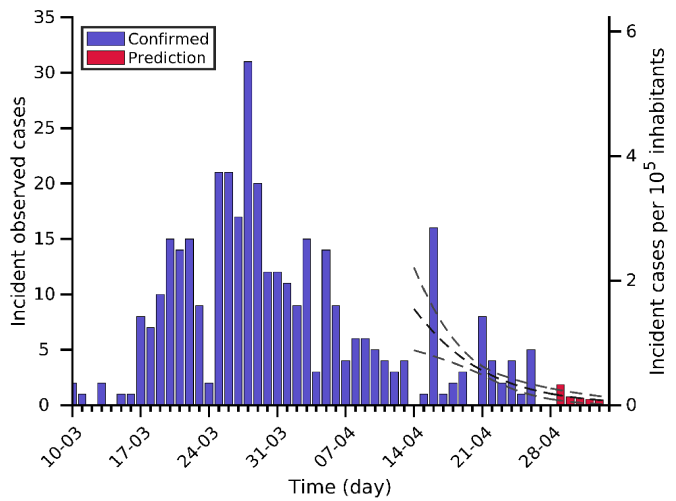
**Calabria 28-04-2020. Population: 1.9M. Current cumulated incidence: 56/10<sup>5</sup>**



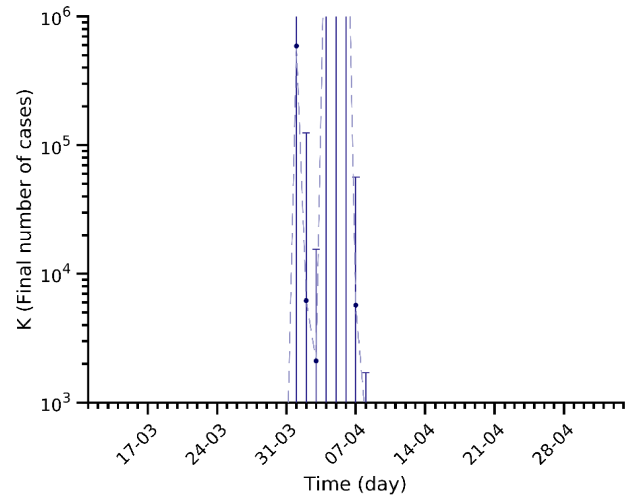
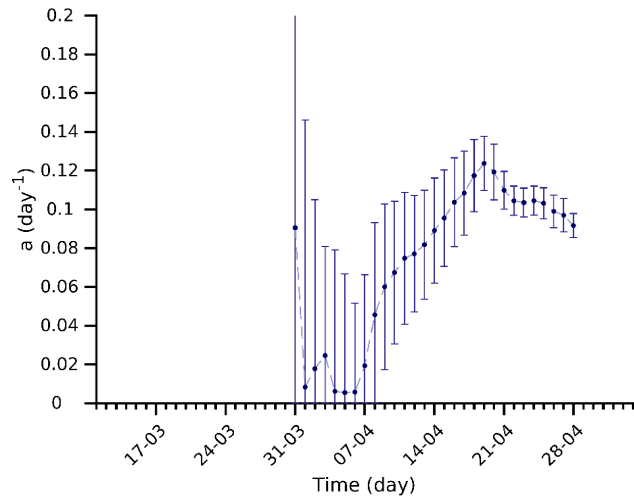
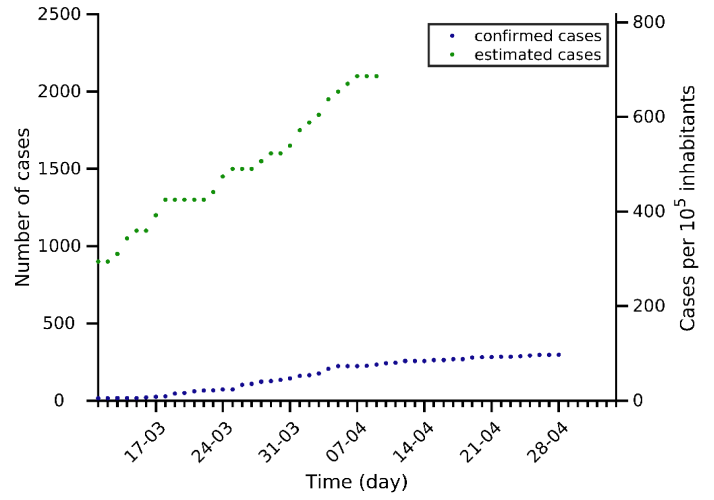
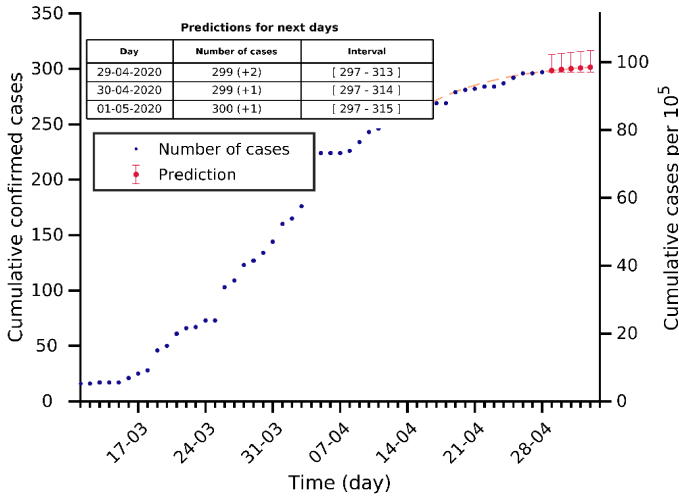
**Basilicata 28-04-2020. Population: 0.6M. Current cumulated incidence: 65/10<sup>5</sup>**



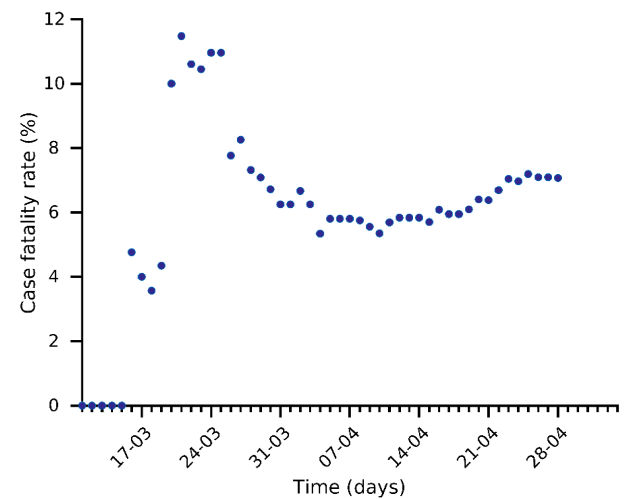
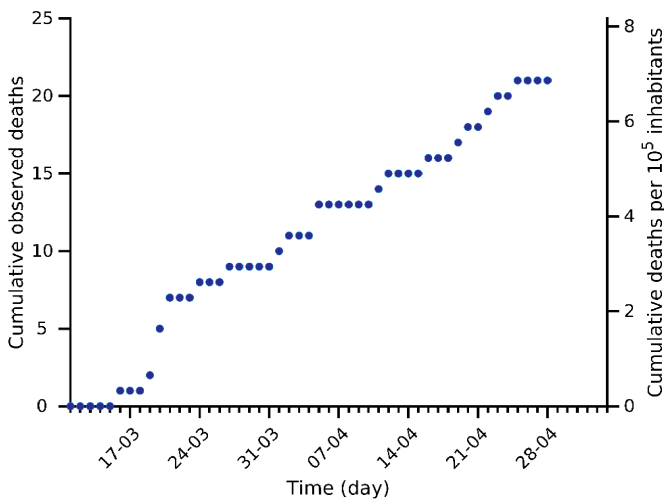
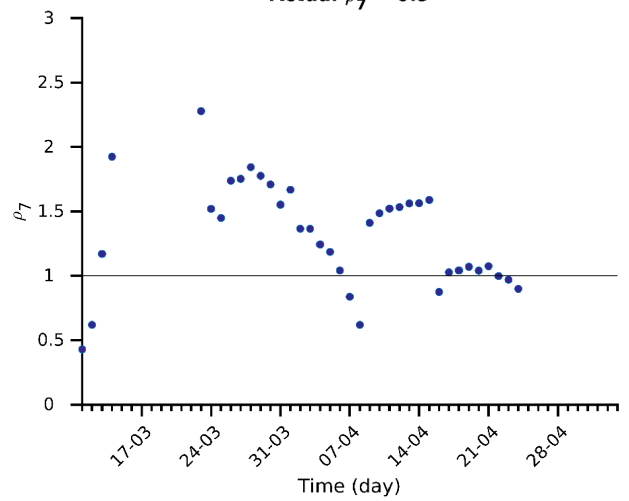
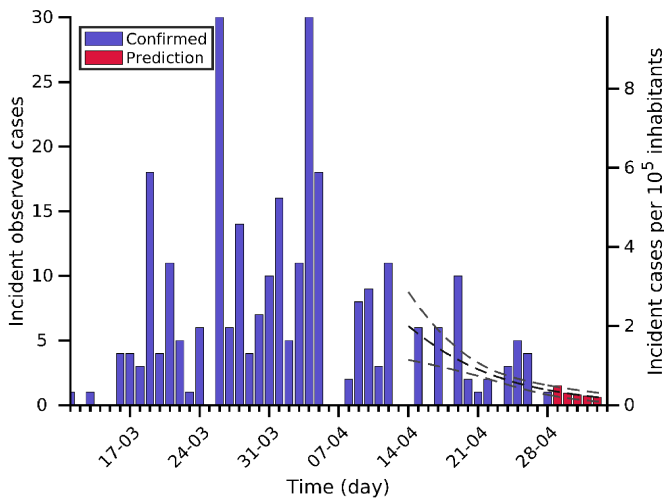
**Actual  $\rho_7 = 0.9$**



**Molise 28-04-2020. Population: 0.3M. Current cumulated incidence: 97/10<sup>5</sup>**



**Actual  $\rho_7 = 0.9$**



## Methods

## Methods

### (1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports<sup>1</sup>, from European Centre for Disease Prevention and Control (ECDC)<sup>2</sup> and from Ministerio de Sanidad<sup>3</sup>. 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.
- ✓  $\rho$ : 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.

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<sup>1</sup> <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

<sup>2</sup> <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

<sup>3</sup> <https://www.msbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>  
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

#### **(4) Fitting a mathematical model to data**

Previous studies have shown that Gompertz model<sup>4</sup> 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:

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<sup>4</sup> Madden LV. Quantification of disease progression. *Protection Ecology* 1980; **2**: 159-176.



- Group A: prediction of expected cumulated cases for the following 3-5 days<sup>5</sup>;
- 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-survivors<sup>6</sup> 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.

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<sup>5</sup> 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.

<sup>6</sup> 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