Daily report 21-05-2021

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

Full version

Situation report 233

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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 provide some figures and tables with several **indexes and indicators** as well as an **Analysis** section that discusses a specific topic related with the pandemic.

As for the predictions, 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 7-14 days later.

We show an individual report with several graphs and a summary table with the main indicators 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.

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Situation and highlights

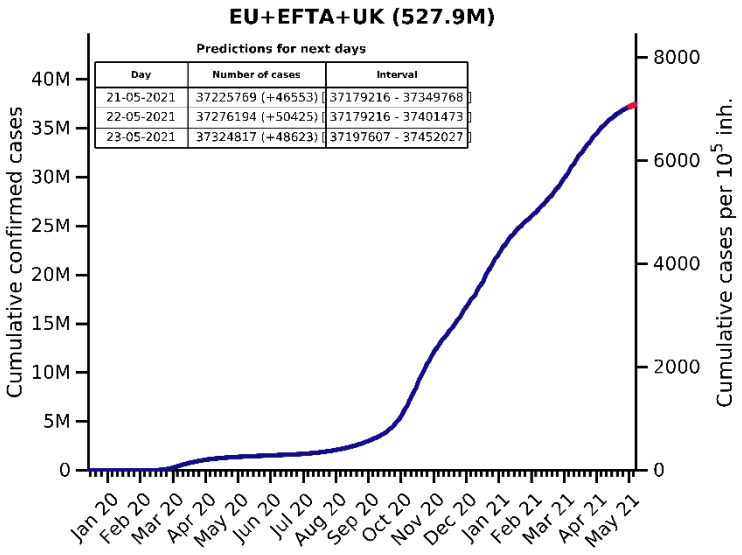
Global situation

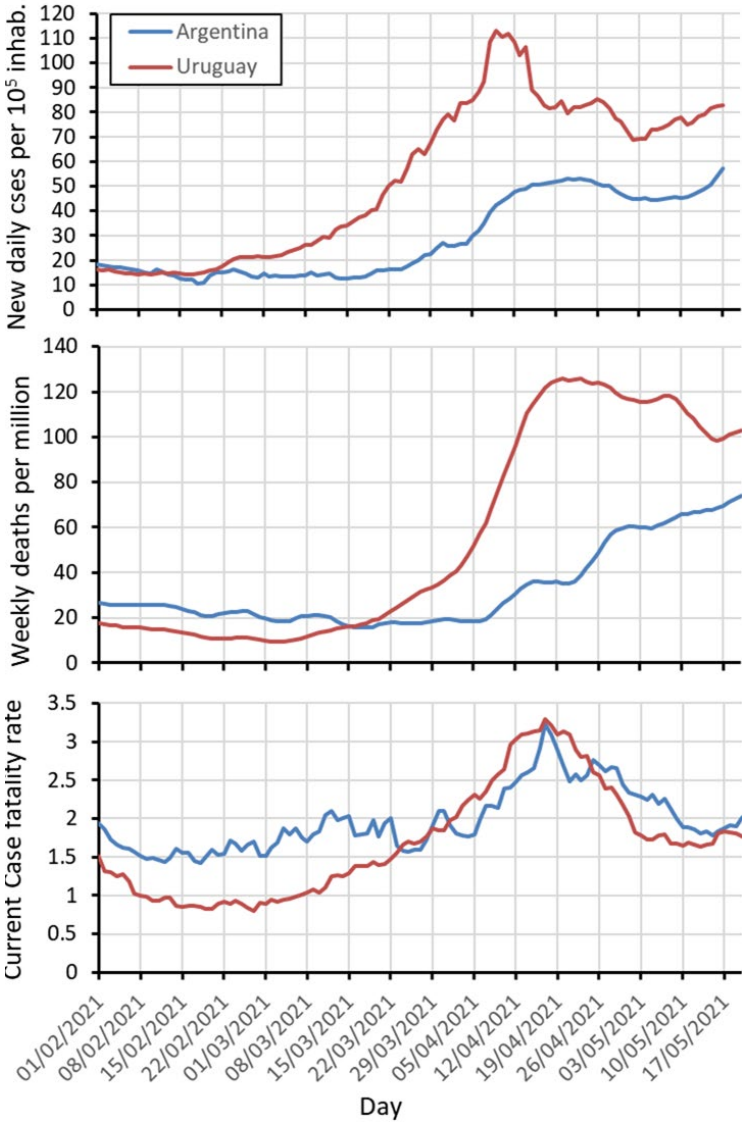
South America epidemiological situation is not clearly improving yet. Overall, they are in a complex situation with a tendency to stabilize the number of cases. We focus here on two countries, Uruguay and Argentina. The graphs highlight three important issues:

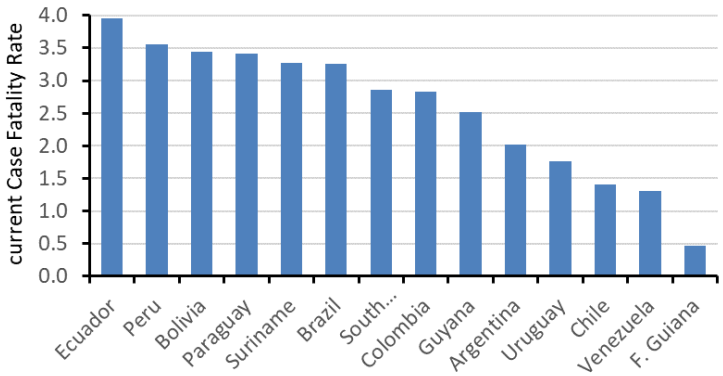
- Since the beginning of May, the number of daily new cases is increasing significantly. The value is especially high in Uruguay.
- The number of weekly deaths per million inhabitants in Argentina has been increasing since the beginning of April. Uruguay tends to improve slowly but is at a really high level.
- Despite the high mortality rate, the current Case Fatality Rate has improved since the end of April, the value is not excessively high.

In Uruguay, more than 70 doses have been distributed per 100 inhabitants, and it is surprising that there is not still a clear improvement in the situation. The difference in efficiency of the first dose could explain the situation. Other countries such as Bolivia are also deteriorating rapidly, however, the number of cases diagnosed daily is still low. The ability to make diagnoses must be much lower than in countries with higher HDI, so it is difficult to compare situations. If we look at the current Case Fatality Rate in all countries 8See next page), we see how Uruguay and Chile, the ones with the highest vaccination rate, have a rather low CFR within the set. Venezuela's very good values raise questions about its real situation.

The situation in Brazil does not seem as complicated as in Uruguay or Argentina, but since April 25, the number of new daily cases has been gradually increasing.







Highlights

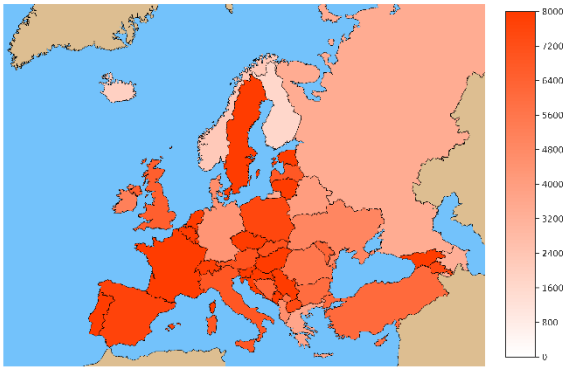
- The situation has improved in almost all countries, including Denmark, which is still growing but seems to be slowing down this trend ($\rho_t \approx 1.05$).
- Portugal is the only country with a growth rate above 1.1. Nevertheless, its low incidence keeps the country far from the risk zone (EPG=57).

Situation and trends per country

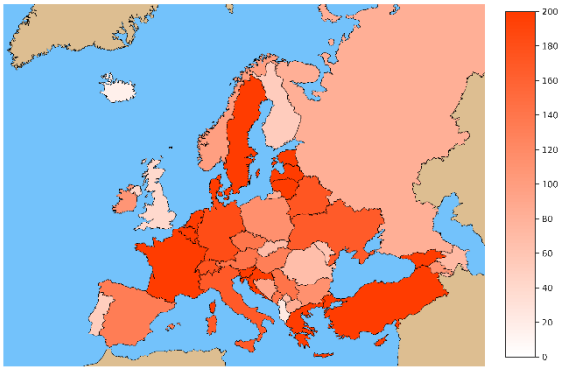
Maps of current situation in EU countries. Colour scale is indicated in each legend.

- Cumulative incidence: total number of reported cases per 100,000 inhabitants
- A_{14}: Cumulative incidence last 14 days per 100,000 inhabitants (active cases)
- ρ_7: Empiric reproduction number
- EPG: Effective Potential Growth ($EPG = A_{14} \cdot \rho_7$)

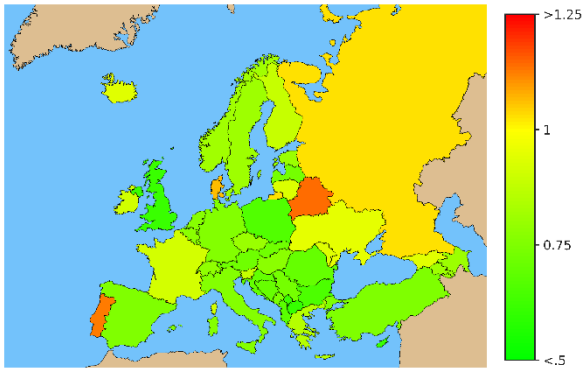
Cumulative incidence



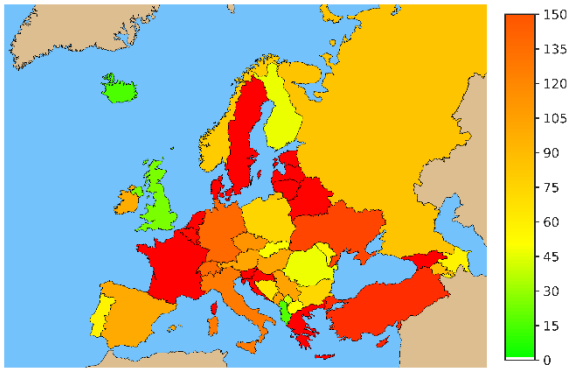
A_{14}



ρ_7



EPG



Tables of current situation in EU countries. Colour scale is indicated in each legend.

Incidence, mortality and epidemiological indexes.

	Reported data						Indexes		
Country	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality (last 14 days) /10^6 inh.	Mortality /10^5 inh.	ρ_7 [1]	EPG [2]	Biocom-Cov degree
Sweden	557.1	56,268	10,414.2	1,051,762	9.6	142.1	0.81	452	9
Lithuania	536.1	14,593	9,869.8	268,684	56.9	152.6	0.93	499	9
Netherlands	463.6	79,441	9,401.1	1,610,868	14.3	102.1	0.77	355	9
Latvia	453.9	8,561	6,854.9	129,297	70.0	121.8	0.73	331	9
Slovenia	321.0	6,673	12,047.2	250,453	19.2	224.2	0.89	285	9
France	313.7	204,738	8,917.7	5,820,918	38.1	164.5	0.91	287	9
Greece	302.5	31,531	3,679.9	383,558	79.0	111.2	0.86	259	9
Estonia	296.8	3,937	9,655.5	128,084	36.2	93.1	0.80	238	9
Cyprus	294.1	3,551	5,924.7	71,533	17.4	28.8	0.61	180	8
Croatia	283.5	11,640	8,591.2	352,692	115.2	190.7	0.70	197	9
Belgium	250.6	29,045	8,960.7	1,038,514	27.9	213.7	0.77	193	8
Luxembourg	247.3	1,548	11,086.4	69,398	12.8	129.1	0.79	195	9
Denmark	239.5	13,873	4,650.1	269,343	2.2	43.2	1.06	255	9
Germany	182.5	152,890	4,328.3	3,626,393	33.1	103.7	0.76	138	8
Switzerland	175.7	15,207	7,878.7	681,870	5.8	117.2	0.78	138	8
Italy	168.9	102,125	6,901.1	4,172,525	43.7	206.2	0.76	128	8
Austria	141.5	12,748	7,050.1	634,961	20.8	113.8	0.72	102	8
Czech Republic	140.8	15,082	15,465.5	1,656,202	41.6	279.8	0.80	113	8
Spain	133.2	62,654	7,697.5	3,619,848	10.1	169.1	0.75	100	7
Hungary	131.7	12,721	8,285.1	800,368	112.1	304.1	0.77	102	7
Poland	113.5	42,973	7,560.4	2,861,351	92.7	191.6	0.66	75	7
Bulgaria	113.1	7,860	5,982.4	415,687	92.5	250.6	0.65	73	7
Ireland	108.5	5,359	5,193.5	256,446	5.3	100.1	0.91	99	7
Norway	98.4	5,337	2,209.3	119,771	2.6	14.4	0.82	80	7
Liechtenstein	83.9	32	8,086.6	3,084	0.0	149.5	0.72	61	6
Slovakia	68.3	3,731	7,113.9	388,391	64.5	224.8	0.72	49	6
Romania	66.5	12,784	5,581.1	1,073,679	57.2	154.5	0.70	46	6
Finland	52.1	2,889	1,636.7	90,687	2.0	16.8	0.89	46	6
Portugal	50.8	5,176	8,270.1	843,278	2.9	166.8	1.13	57	6
United Kingdom	39.2	26,587	6,558.8	4,452,531	1.8	188.1	0.61	24	5
Malta	17.7	78	6,905.2	30,489	2.3	94.4	0.42	7	3
Iceland	15.8	54	1,919.7	6,551	0.0	8.5	0.94	15	3

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	Best	Best	0.5	0

Table of current situation in some EU provinces. Colour scale is indicated in each legend.

	Reported data						Indexes		
Province	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality (last 14 days) /10^6 inh.	Mortality /10^5 inh.	ρ_7 [1]	EPG [2]	Biocom-Cov degree
North Holland	359.4	10,253	9,438.2	269,271	NA	NA	0.71	256	9
Brussels	298.5	3,606	10,585.7	127,875	47.2	265.2	1.12	333	9
Madrid	227.6	15,115	10,616.0	704,979	21.2	229.2	0.80	181	8
Bern	170.2	1,762	6,276.4	64,961	7.7	102.5	1.12	190	8
Lazio	162.7	9,565	5,743.8	337,676	43.7	137.0	0.72	118	8
Berlin	148.9	5,612	4,689.7	176,753	48.0	90.8	0.92	137	8
Wien	139.2	2,641	7,166.2	135,942	38.5	121.5	1.87	260	8
Lisbon	64.2	1,819	11,249.8	318,707	3.9	254.5	1.32	85	7
London	52.0	4,659	8,077.8	723,849	NA	NA	0.90	47	6

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	Best	Best	0.5	0

[1] ρ_7 is the empiric reproduction number. [2] EPG stands for Effective Growth Potential, which is the product of reported cumulative incidence of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Situation of hospitalisations and ICUs in some EU countries. The analysis is done for those countries that report a historical series with current (active) number of patients in hospitals and ICUs[1]. We provide:

- Current active hospitalisations and patients in ICU per 100,000 inhabitants.
- Current absolute number of active hospitalisations and patients in ICU.
- Rate of occupation of curative care hospital beds by Covid-19 patients (data from Eurostat 2018[2]), only for hospitalisations.
- Current rate of occupation with regards to the maximum Covid-19 occupation reached in this pandemic.
- Weekly increase in Covid-19 patients in hospitals and ICUs.

	Hospitalisations					Intensive Care Units				
Country	Active /10^5 inh.	Active (total)	Occupation (Eurostat 2018) (%)	Occupation (historical maximum) (%)	Week-to-week Growth (%)	Active /10^5 inh.	Active (total)	Occupation (historical maximum) (%)	Week-to-week Growth (%)	Last available datapoint
Bulgaria	69.6	4839	11.0	45.4	-14.8	7.2	501	61.6	-11.3	16-May-21
France	35.2	22963	11.3	68.6	-10.1	6.5	4255	60.6	-12.7	16-May-21
Italy	23.0	13913	8.9	36.1	-16.7	2.9	1779	43.7	-14.9	16-May-21
Slovenia	21.6	450	5.2	34.0	-15.3	6.0	124	58.5	-10.1	13-May-21
Spain	18.1	8531	7.3	26.6	-9.2	4.5	2134	43.6	-5.1	10-May-21
Estonia	17.0	225	5.1	30.5	-20.0	2.4	32	42.1	-22.9	16-May-21
Belgium	15.5	1802	3.2	24.2	-15.7	5.3	619	42.0	-10.9	16-May-21
Sweden	14.9	1502	7.5	50.0	-9.3	3.0	305	55.4	-12.0	16-May-21
Cyprus	13.0	157	5.5	52.2	-27.3	2.6	31	79.5	-1.3	16-May-21
Czech Republic	12.3	1314	3.0	13.9	-24.4	2.3	251	12.2	-23.8	16-May-21
Luxembourg	10.1	63	2.8	25.5	-15.7	4.5	28	56.0	-8.1	16-May-21
Netherlands	8.6	1466	3.2	44.6	-8.7	4.0	686	48.2	-8.2	16-May-21
Austria	6.8	612	1.3	15.4	-25.0	3.2	285	40.2	-21.6	16-May-21
Denmark	2.8	164	1.2	17.0	3.3	0.6	32	22.7	-5.9	16-May-21
Portugal	2.4	245	0.7	3.6	-11.8	0.7	76	8.4	-7.2	16-May-21
Ireland	2.2	111	0.8	5.5	-11.3	0.8	39	17.6	-9.2	13-May-21

Colour scale
>20%
-20%

Colour scale
>20%
-20%

Vaccination rates in some EU countries[3].

Country	Total vaccinations	Daily vaccinations	People partially vaccinated	People fully vaccinated	Total vaccinations per hundred people	People partially vaccinated per hundred people	People fully vaccinated per hundred people
United Kingdom	58489834	527456	16010892	21239471	86.16	23.58	31.29
Hungary	7644400	91251	2014790	2814805	79.13	20.85	29.14
Cyprus	476020	10859	219660	128180	54.35	25.08	14.63
Germany	43549672	685010	21898498	10915832	51.98	26.14	13.03
Lithuania	1383714	15438	424436	479639	50.83	15.59	17.62
Spain	23503085	347306	8352555	7697288	50.27	17.87	16.46
Denmark	2878240	47858	630628	1123806	49.69	10.89	19.4
Belgium	5737676	98156	2659596	1560689	49.51	22.94	13.47
Austria	4393804	69848	2016722	1198446	48.79	22.39	13.31
Italy	29409913	484286	10728231	9500113	48.64	17.75	15.71
Portugal	4888521	85984	1933123	1477687	47.94	18.96	14.49
European Union	212495619	3198740	86352942	63872731	47.76	19.4	14.36
Estonia	617882	7400	229382	194250	46.58	17.3	14.64
France	30883216	480249	12155193	9451463	45.71	17.99	13.99
Poland	17254902	301447	7146808	5222430	45.59	18.88	13.8
Greece	4716739	91082	1301306	1743394	45.25	12.48	16.73
Netherlands	7600981	81120	3751369	1989047	44.36	21.89	11.61
Slovenia	921918	16005	295116	313401	44.35	14.19	15.08
Sweden	4437814	43345	2317980	1059917	43.94	22.96	10.49
Switzerland	3673576	63727	1199922	1236827	42.45	13.87	14.29
Czechia	4488482	69495	2184884	1165372	41.91	20.4	10.88
Norway	2271224	21123	909426	680899	41.89	16.78	12.56
Slovakia	2226477	35072	782303	722087	40.78	14.32	13.23
Ireland	1922913	38150	893847	514808	38.94	18.1	10.43
Romania	7026106	102894	987795	3041824	36.52	5.14	15.81
Croatia	1450169	31820	768153	341008	35.32	18.71	8.31
Latvia	574129	13639	266728	156823	30.44	14.15	8.31
World	1590731528	26482926	363034533	376173766	20.41	4.65	4.83
Bulgaria	1225601	21725	266649	479476	17.64	3.84	6.9

[1] https://github.com/ec-jrc/COVID-19

[2] https://ec.europa.eu/eurostat/databrowser/view/hlth_rs_bds/default/table?lang=en

[3] https://github.com/ec-jrc/COVID-19/tree/master/data-by-region

Situation and trends in some European regions[3]

Table of current situation in **Spain** by region. Colour scale is indicated in each legend.

	Reported data						Indexes		
Country	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality (last 14 days) /10^6 inh.	Mortality /10^5 inh.	ρ_7[(1)]	EPG[(2)]	Biocom-Cov degree
Euskadi	259.6	5,655	8,957.5	195,099	37.2	201.7	0.78	201	9
Melilla	233.7	198	10,605.1	8,984	94.4	114.5	0.68	159	8
Madrid	227.1	15,078	10,630.8	705,961	20.8	229.3	0.79	181	8
Aragon	200.0	2,641	9,153.4	120,897	33.3	262.7	0.82	163	8
Navarra	179.5	1,167	9,474.5	61,581	16.9	180.0	0.74	133	8
Andalucia	160.8	13,553	6,708.7	565,306	15.8	115.9	0.89	143	8
La Rioja	152.1	477	9,666.4	30,312	25.5	245.2	0.85	129	8
Castilla y Leon	135.6	3,266	9,121.0	219,642	17.0	281.2	0.90	123	8
Castilla-La Mancha	127.2	2,590	9,171.5	186,687	9.8	288.2	0.58	74	7
Cantabria	112.4	654	5,121.7	29,792	6.9	96.4	0.71	79	7
Catalunya	99.7	7,544	7,261.2	549,320	10.2	189.2	0.67	66	7
Galicia	86.5	2,337	4,626.0	124,917	5.6	88.5	0.81	70	7
Extremadura	80.3	855	6,953.1	74,076	4.7	167.0	1.17	94	7
Canarias	78.0	1,721	2,433.8	53,719	9.1	34.0	0.95	74	7
Asturias	71.5	731	5,068.0	51,810	11.7	191.6	0.97	70	7
Murcia	67.4	1,003	7,515.2	111,804	2.0	107.1	0.98	66	6
Baleares	48.1	571	5,045.2	59,927	3.4	70.4	0.65	31	5
Comunitat Valenciana	29.3	1,457	7,854.7	390,729	2.8	147.5	0.89	26	4
Ceuta	13.0	11	6,799.6	5,769	94.3	134.4	1.37	18	3

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	Best	Best	0.5	0

Table of current situation in **Italy** by region. Colour scale is indicated in each legend.

	Reported data						Indexes		
Country	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality (last 14 days) /10^6 inh.	Mortality /10^5 inh.	ρ_7[(1)]	EPG[(2)]	Biocom-Cov degree
Valle d'Aosta	275.4	347	9,067.5	11,425	87.3	374	0.78	214	9
Campania	251.4	14,587	7,125.4	413,418	63.9	119	0.75	189	9
Basilicata	229.5	1,290	4,589.9	25,795	46.3	101	0.91	208	9
Toscana	201.0	7,499	6,374.9	237,783	71.6	176	0.81	163	8
Puglia	199.0	8,019	6,138.8	247,334	75.0	157	0.70	140	8
Piemonte	185.1	8,065	8,194.9	356,969	45.2	265	0.76	141	8
Calabria	181.2	3,528	3,340.5	65,039	39.0	58	0.69	126	8
Marche	176.1	2,685	6,644.1	101,322	28.2	196	0.83	146	8
Emilia-Romagna	173.9	7,752	8,534.9	380,569	35.7	294	0.76	132	8
Sicilia	173.8	8,691	4,427.4	221,368	41.4	114	0.75	130	8
Bolzano	165.5	862	13,893.1	72,383	3.8	224	0.95	157	8
Lazio	162.7	9,565	5,743.8	337,676	43.7	137	0.72	118	8
Lombardia	160.1	16,104	8,226.8	827,698	36.8	332	0.83	132	8
Trento	137.9	742	8,368.8	45,024	14.9	252	0.96	133	8
Veneto	122.7	6,018	8,581.1	420,990	22.4	235	0.73	90	7
Umbria	121.1	1,068	6,341.8	55,935	19.3	157	0.76	92	7
Abruzzo	110.5	1,450	5,591.9	73,366	32.8	188	0.75	82	7
Liguria	107.7	1,671	6,576.3	101,998	49.6	277	0.72	77	7
Friuli Venezia Giulia	70.6	858	8,775.2	106,619	41.2	311	0.68	48	6
Sardegna	69.5	1,139	3,432.0	56,285	23.8	88	0.69	48	6
Molise	60.5	185	4,421.2	13,529	29.4	159	0.65	39	5

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	Best	Best	0.5	0

Table of current situation in **Belgium** by region. Colour scale is indicated in each legend.

	Reported data						Indexes		
Country	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality (last 14 days) /10^6 inh.	Mortality /10^5 inh.	ρ_7[(1)]	EPG[(2)]	Biocom-Cov degree
Wallonia	342.0	12,464	11,190.2	407,770	44.7	248	0.96	327	9
Brussels	298.5	3,606	10,585.7	127,875	47.2	265	1.12	333	9
Flanders	269.3	17,743	7,379.4	486,230	19.7	190	0.98	265	9

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	Best	Best	0.5	0

[3] https://github.com/ec-jrc/COVID-19/tree/master/data-by-region

Table of current situation in **Sweden** by region. Colour scale is indicated in each legend.

Country	Reported data				Indexes		
	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	ρ_7 [1]	EPG [2]	Biocom-Cov degree
Norrbotten	798.0	1,995	9,565.2	23,913	1.19	950	9
Kronoberg	756.0	1,512	10,713.5	21,427	0.69	522	9
Kalmar	636.2	1,546	9,644.9	23,437	0.80	508	9
Östergötland	582.5	2,691	8,907.8	41,154	0.73	428	9
Örebro	578.2	1,723	10,481.5	31,235	0.95	548	9
Jämtland	576.9	750	9,366.2	12,176	0.97	557	9
Södermanland	530.5	1,358	9,819.5	25,138	0.87	460	9
Västra Götaland	521.3	8,915	10,816.1	184,956	1.07	559	9
Västernorrland	520.0	1,274	10,689.0	26,188	0.74	385	9
Skåne	515.3	7,019	11,181.9	152,297	0.93	481	9
Dalarna	489.9	1,406	9,136.2	26,221	0.84	411	9
Västmanland	479.9	1,315	9,817.5	26,900	0.75	360	9
Jönköping	467.7	1,651	11,911.3	42,047	0.82	383	9
Gävleborg	455.1	1,306	12,277.4	35,236	0.89	407	9
Stockholm	452.7	10,761	10,496.2	249,494	0.81	365	9
Uppsala	413.6	1,555	10,488.6	39,437	0.86	354	9
Västerbotten	383.9	1,052	8,263.1	22,641	0.85	328	9
Blekinge	348.1	557	7,745.6	12,393	0.85	296	9
Halland	346.5	1,140	12,124.0	39,888	1.06	368	9
Gotland	310.2	183	6,606.8	3,898	0.87	270	9
Värmland	298.9	840	6,500.0	18,265	0.89	265	9

Colour scale					
>150.0	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	0.5	0

Situation and trends in other countries

Country	Reported data						Indexes		
	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality (last 14 days) /10^6 inh.	Mortality /10^5 inh.	ρ_7 [1]	EPG [2]	Biocom-Cov degree
Argentina	717.1	324,091	7,459.8	3,371,508	145.3	158.8	1.20	861	9
Colombia	441.7	224,742	6,180.0	3,144,547	131.0	161.7	1.00	444	9
Brazil	412.1	875,948	7,401.6	15,732,836	129.2	206.6	1.05	432	9
Chile	406.4	77,680	6,803.8	1,300,629	66.5	146.5	1.05	428	9
India	340.2	4,695,030	1,867.6	25,772,440	41.3	20.8	0.84	286	9
Peru	240.2	79,211	5,756.1	1,897,900	124.2	202.5	0.99	238	9
Iran	238.8	200,595	3,324.3	2,792,204	50.0	92.6	0.79	188	9
Canada	233.7	88,191	3,545.5	1,338,141	16.5	66.3	0.83	194	9
Turkey	231.7	195,444	6,107.5	5,151,038	41.9	53.9	0.75	173	8
Qatar	183.0	5,273	7,433.0	214,150	17.0	18.7	0.71	129	8
Belarus	173.1	16,357	4,022.4	380,089	14.8	28.9	1.14	198	8
Ukraine	167.8	73,374	4,962.8	2,170,398	78.8	111.8	0.95	160	8
Iraq	148.2	59,603	2,863.0	1,151,557	10.7	40.0	0.71	105	8
United States of America	142.9	472,922	9,872.1	32,676,954	25.6	175.7	0.88	125	8
Ecuador	112.6	19,859	2,340.3	412,907	60.8	113.2	0.73	82	7
Russia	82.1	119,780	3,409.0	4,974,908	35.0	80.4	1.03	85	7
Philippines	78.0	85,520	1,057.7	1,159,055	15.6	17.8	0.93	72	7
Saudi Arabia	40.0	13,924	1,253.1	436,240	5.3	20.7	0.95	38	5
Mexico	25.2	32,548	1,850.2	2,385,512	23.3	171.2	1.05	27	4
Indonesia	22.5	61,443	640.9	1,753,101	8.5	17.8	0.73	16	4
Pakistan	20.2	44,548	401.2	886,184	6.5	9.0	0.76	15	3
Israel	5.1	440	9,695.1	839,162	2.8	73.9	0.40	2	2

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>1.25	>150
0.0	Best	Best	Best	Best	Best	0.5	0

[1] ρ_7 is the empiric reproduction number. [2] EPG stands for Effective Growth Potential, which is the product of reported cumulative incidence of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Analysis: On the B.1.1.7 variant substitution dynamics of SARS-CoV-2 in Catalonia (Spain).

Viruses are constantly changing through mutations that bring on small genetic differences. The great expansion of the coronavirus causes coexistence of different genetic variants of the same virus. Mutations in this virus can have a major impact if they increase its transmissibility, virulence, mortality, or escape the effect of antibodies acquired through a natural infection or vaccination[1]. On December 2020 – March 2021 period, Catalonia (7.6 million inhabitants) has suffered the pandemic third wave (Figure 1).

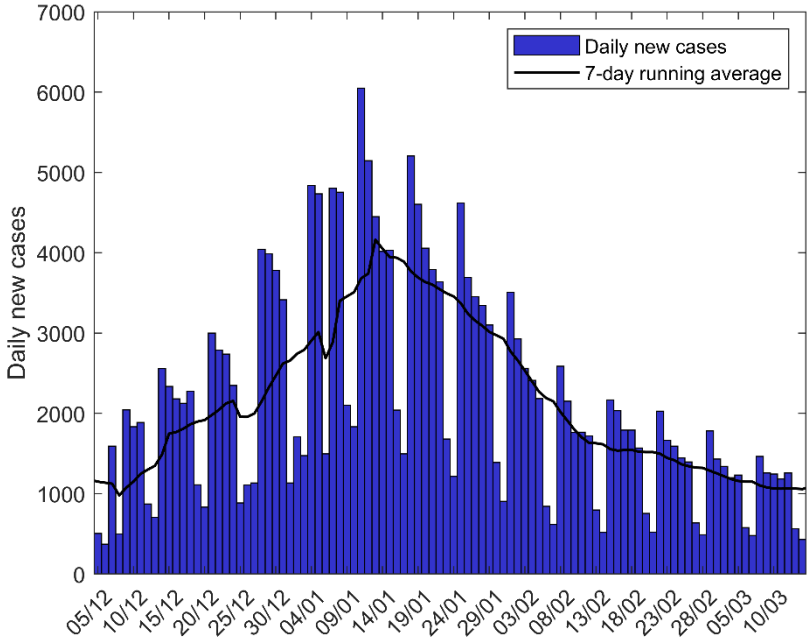


Figure 1. *Daily new cases in Catalonia (Spain) during the period December 2020 – March 2021 (third wave). Data from DadesCovid[2].*

During this wave, a substitution process of the multiple variants by a new variant began, the so-called British variant (B.1.1.7 or 20I/501 Y.V1). This process of replacement almost caused the disappearance of not only the majority variant that existed (20E (EU1)), but of all the others.

In order to better understand the dynamics of the epidemic from the period mentioned below**, we present a model that describes this substitution process**. The data used in this report comes from Can Ruti Sequencing Hub, where a protocol to track the existence of new variants in the North Metropolitan Area of Barcelona (2 million inhabitants, around 25 % of Catalan population) was established by January 2021. Each week, around 100 (January) or 200 (March) PCR positive samples are processed in order to obtain their sequence and determine the variant. These samples are randomly chosen between those positive cases diagnosed in the health area. Given that the objective is to track the spreading of the B.1.1.7 variant, in this report we are going to distinguish those that belong to the B.1.1.7 variant from those that belong to other variants.

The B.1.1.7 variant of the virus started being systematically detected in Catalonia in mid-December 2020, during the rising phase of the third wave. Since then, the analysis of the infections origins by sequencing has increased. At first it was noticed that the B.1.1.7 variant was replacing, not only the previous majority variant,

[1] https://upcommons.upc.edu/handle/2117/335882
[2] https://dadescovid.cat/descarregues?lang=eng

but all the other variants that already existed then. The period which has been observed a clearer replacement by the B.1.1.7 variant lasted approximately from mid-February to mid-March.

Theoretical framework of the substitution process

The theoretical analysis was described previously in a previous report[1] and consists of an exponential growth model based on some previous considerations. It assumes that changes in the effective reproductive coefficient due to higher transmission are reproduced in a way that specific increase in secondary attack rates measured in the UK will lead to the same increase in the reproductive coefficient of this variant anywhere. This presupposition says that non-pharmaceutical interventions (NPIs) do not affect the relative increase in the reproductive coefficient R_t. Also, another assumption is that both variants have the same incubation time.

Briefly, the theoretical framework assumes the evolution of two independent epidemic: one caused by the B.1.1.7 variant, and the other one caused by older variants. This assumption results on a sigmoid model that correctly reproduces the substitution process provided by observations. The basic parameters and variables of the model are:

- $N_{B.1.1.7}$ and N_{other}: daily new cases corresponding to each variant.
- $R_{B.1.1.7}$ and R_{other}: effective reproduction numbers corresponding to both epidemic curves.
- $\xi = N_{B.1.1.7}/N_{other}$: ratio between number of cases of each variant – when $\xi \ll 1$, the B.1.1.7 variant is residual; when $\xi = 1$, both variants are equally present among new cases; when $\xi \gg 1$, the variant B.1.1.7 represents the majority of the cases.
- $\chi_{B.1.1.7}$ and χ_{other}: percentage of new cases that correspond to each variant – this percentages can vary from 0 % to 100 %, depending on the prevalence of each variant.
- η: increase in transmissibility of the B.1.1.7 variant with regards to the previous ones – if η = 1.5 it means that the new variant is 50% more transmissible than the original one.

Analysis of the substitution using the fraction of cases between variants

First we analyse the evolution of the variant percentage respect to the B.1.1.7 variant and all other variants existing during the studied period. The definition of the B.1.1.7 variant percentage is the following:

$$\chi_{B.1.1.7} = \frac{N_{B.1.1.7}}{N_{other}+N_{B.1.1.7}} = \frac{\xi_0 e^{\delta t}}{1+\xi_0 e^{\delta t}}, \quad (1)$$

$$\chi_{other} = \frac{N_{other}}{N_{other}+N_{B.1.1.7}} = \frac{\xi_0 e^{-\delta t}}{1+\xi_0 e^{-\delta t}}; \quad (2)$$

For the details of the calculation of the sigmoid function, see the previous report[1].

In Figure 2 we have plotted the evolution of the percentage of cases for each variant obtained from random sequencing (χ_{other} and $\chi_{B.1.1.7}$) together with the fitted substitution model. We can see in Figure 2 that the substitution process started by mid-December, and ended in mid-April, when almost all SARS-CoV-2 infections come from the B.1.1.7 variant.

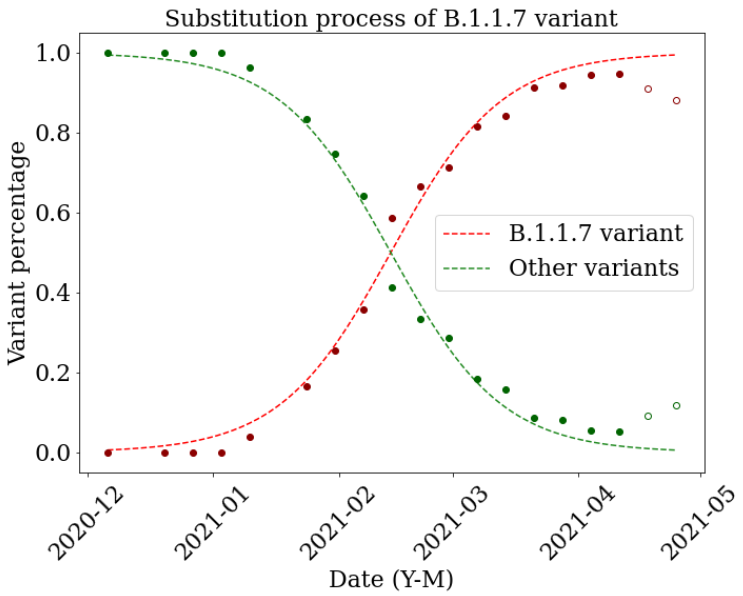


Figure 2: *Evolution of the percentage of B.1.1.7 variant and the other variants obtained from Sequencing measurements with a sigmoid fit only for the colour-filled markers. The quality parameters of the fitting are Reduced χ^2 = 0.00134112, AIC = -110,570018, and BIC = -108,903592).*

In the previous figure, we have adjusted a sigmoid function[1] that describes the evolution of the fraction of cases originated for each variant, see eqs. (1-2). The model consists of two parameters: the initial ratio, $\xi_0 = \frac{N_{0,B.1.1.7}}{N_{0,others}}$, and the increase in contagiousness of the new variant with respect to the original variants, δ, which relates the increase in transmissibility (η) with the incubation time (τ) ($\delta = ln\,\eta/\tau$). The parameters resulting from the fittings are ξ_0 = 0.006 ± 0.003 and δ = 0.073 ± 0.006 d^{-1}, collected from Figure 2. The former is the initial fraction.

The time when both variants have the same number of cases is when $\xi_t = N_2(t)/N_1(t) = 1$. This corresponds to the intersection points of the two curves in Figures 1, when the percentage of the B.1.1.7 variant and the other variants is 50 %. Also, we can use the previous equations (1) and (2) to find the intersection time with the parameters ξ_0 and δ found with the fitting.

$$\frac{N_2(t)}{N_1(t)} = \frac{\xi_0 e^{\beta_1 t} e^{\delta t}}{e^{\beta_1}} = \xi_0 e^{\delta t} = 1 \qquad (3)$$

Then, the intersection time t, in days, when both percentages are 50% is:

$$t = \frac{-ln(\xi_0)}{\delta} \qquad (4)$$

We have collected the intersection time for *Sequencing* data. According to these results, the intersection point (50 % each variant) would have been achieved around the 14th February 2021. On the other hand, with the parameter δ we can compute the **increase in transmissibility, η**. Assuming an incubation time (τ) of 5 days, the increase in transmissibility η that given by the next relation:

$$\delta = \frac{ln(\eta)}{\tau} \rightarrow \eta = e^{\delta\tau} \qquad (5)$$

giving rise to the value **η = 1,44 ± 0.04**. This last result tells us that once the substitution process will have taken place completely, with 100% of infections coming from the B.1.1.7 variant, **the reproduction number will be around 44% higher than on the previous months**, when almost all cases came from other variants.

Analysis of the number of cases

We now present an analysis of the absolute number of cases which came from B.1.1.7 variant or of the old variants. To do so, we have used the sigmoid fit introduced before to estimate, at every point of time, what the fraction of the total cases that were originated by the B.1.1.7 variant or by the old variants was. The data of the total number of detected cases in Northern Metropolitan region and in Catalunya were obtained from open data from Catalonia Government[3]. These data series were first smoothed by applying a 7-day running average, using data from three days before to three days after each point. Then, using the fitted sigmoid, we split the cases of each day between those that correspond to B.1.1.7 variant and those that correspond to other variants.

The plot of the number of estimated cases that correspond to each variant over time during the studied period is given by Figure 3. We can see in the figure that, before the intersection points of the substitution (mid-February), the evolution curve of the total cases (black curve) followed the dynamics of the old variants (green). Then, after the substitution, the curve of the total number of cases (in black) resembles the dynamics of the B.1.1.7 variant (in red). Also, we can see a decrease in cases corresponding to the end of the third wave (Figure 3), when the percentage of B.1.1.7 variant with respect to all cases was below 30%, i.e., the European variant 20E (EU1) was majority with respect to the B.1.1.7.

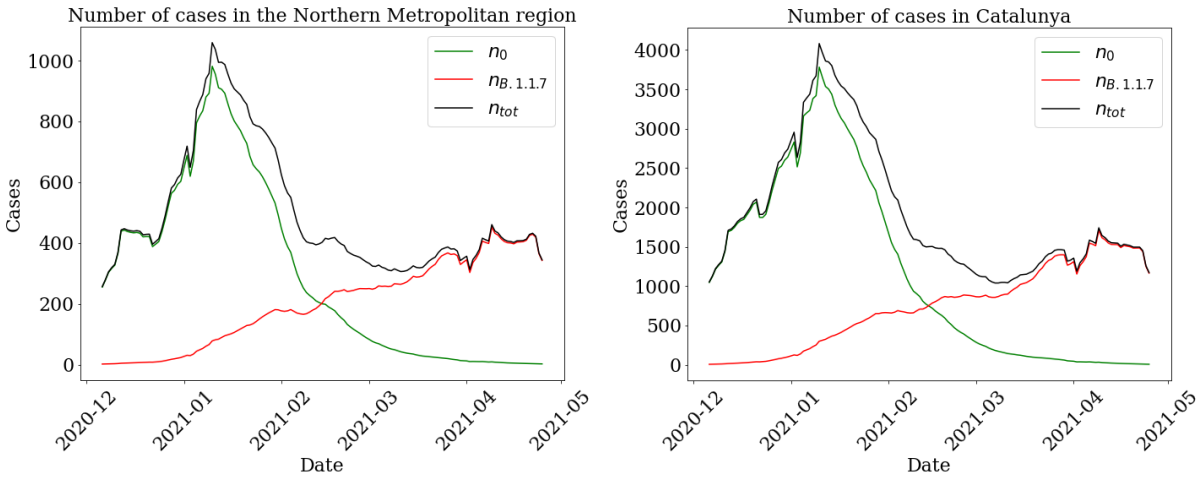


Figure 3. *Evolution of the number of cases in Northern Metropolitan region (left) and in Catalunya (right). Total number of cases are obtained from official databases, while green (old variants) and red (B.1.1.7) curves are estimations using the model fitted to the Sequencing data.*

Analysis of the effective reproduction numbers

Effective reproduction number is used to measure the rate at which an epidemic spread. It is a measure of the average number of people infected by an infectious person. It is often referred to as R_0 (basic reproductive number), which is the value of before propagation begins, while R_t denotes the effective value of the reproduction number with time. Mathematical models such as SIR or SEIR are usually used to calculate this reproductive rate. An empirical alternative to assess an equivalent indicator (ρ) was defined previously[4]. The ρ_t is defined as the quotient between the average of those infected in the last three days and those infected five days ago, also as an average of three days:

$$R_t \approx \rho_t = \frac{N(t-1)+N(t)+N(t-1)}{N(t-6)+N(t-5)+N(t-4)} \qquad (6)$$

3 https://dadescovid.cat/descarregues?lang=eng

4 https://biocomsc.upc.edu/en/shared/methods.pdf

We present an analysis of the evolution of the empiric reproductive number during the substitution period, computed as detailed above (Eq. (3)). From the sigmoid fit that was made with smoothed data, we obtained a curve that estimates the number of cases that corresponded weather to the B.1.1.7 variant or to the other old variants. Then, using the total number of daily infections in Catalunya and in the Northern Metropolitan region, we have computed the empiric reproduction number that corresponded to the old variants, to the B.1.1.7 variant o to the whole series. The result is shown in Figure 4, using data from *Sequencing*. These results show that **the decreasing phase of the third wave would have been a combination of the old variants decreasing with an R_t around 0.7 with the B.1.1.7 variant increasing with an R_t around 1.1.**

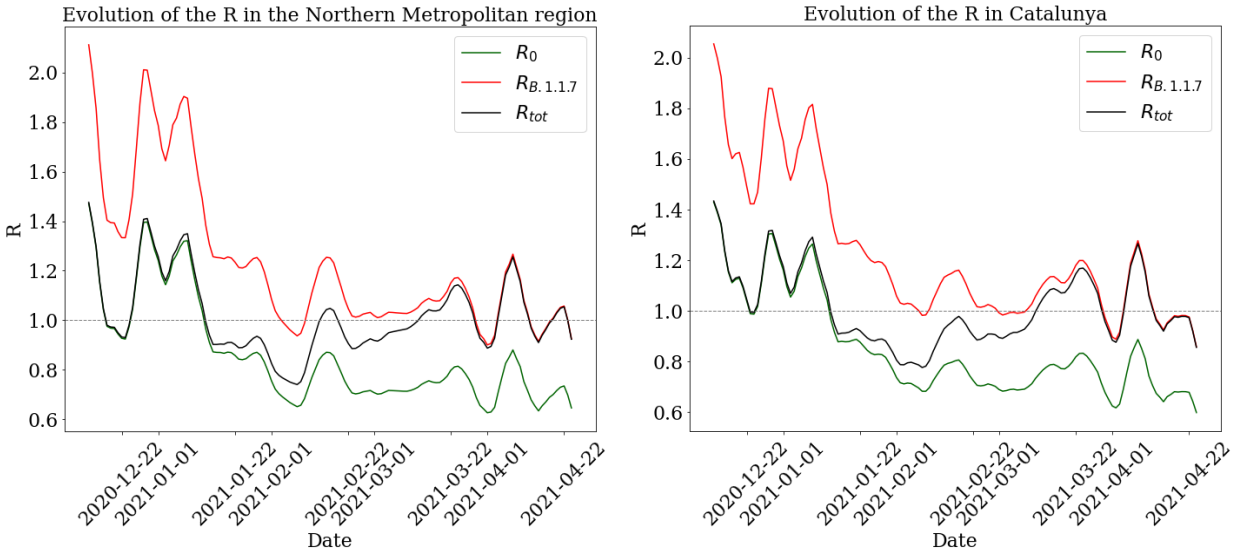


Figure 4. *Evolution of the R_t for sequencing data of Northern Metropolitan region (left) and Catalunya (right).*

In Figure 5 we show the ratio between both reproduction numbers, one for the original variant and the other for the new variant, as a function of time ($R_{t,B.1.1.7}/R_{t,other}$). We see that the **ratio between both reproduction numbers is almost constant over time**, as expected from the theoretical model. In addition, we obtained very similar results between the Northern Metropolitan region and Catalonia. In both cases we see that the new variant is approximately a 44% more transmissible, as we found in previous calculations (i.e., $R_{t,B.1.1.7}/R_{t,other} \approx 1.44$). This constant behaviour of the reproductive coefficient quotients determines that the infections follow the sigmoid dynamics described before independently on the conditions, or in other words, it indicates that **the process of substitution took place independently on the NPIs**.

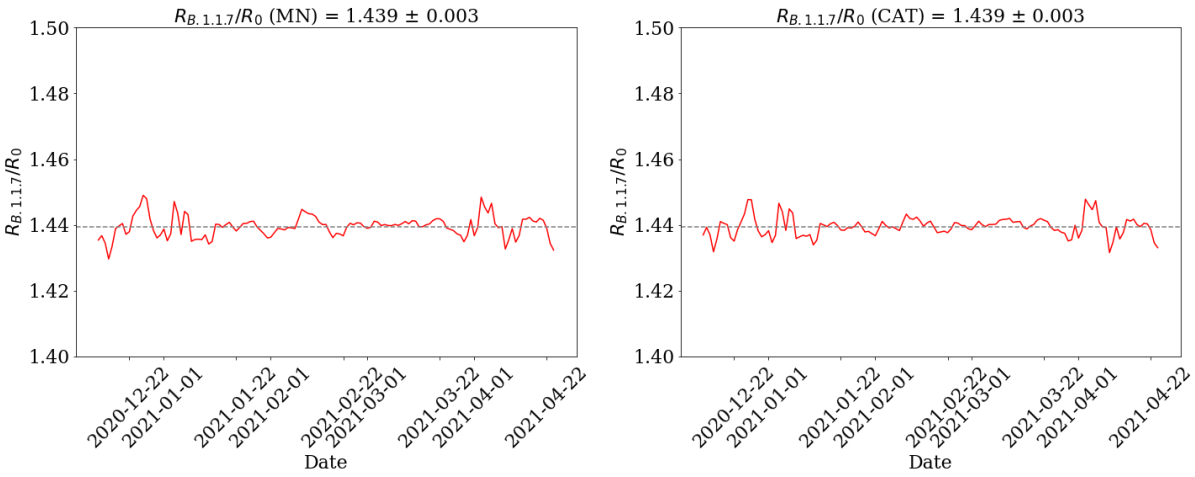


Figure 5. *Evolution of the ratio between the reproductive number of the B.1.1.7 estimated series and that of the other variants series, $R_{t,B.1.1.7}/R_{t,other}$. Cases estimated from the model fitted to Sequencing data of Northern Metropolitan region (left) and Catalunya (right).*

Conclusions

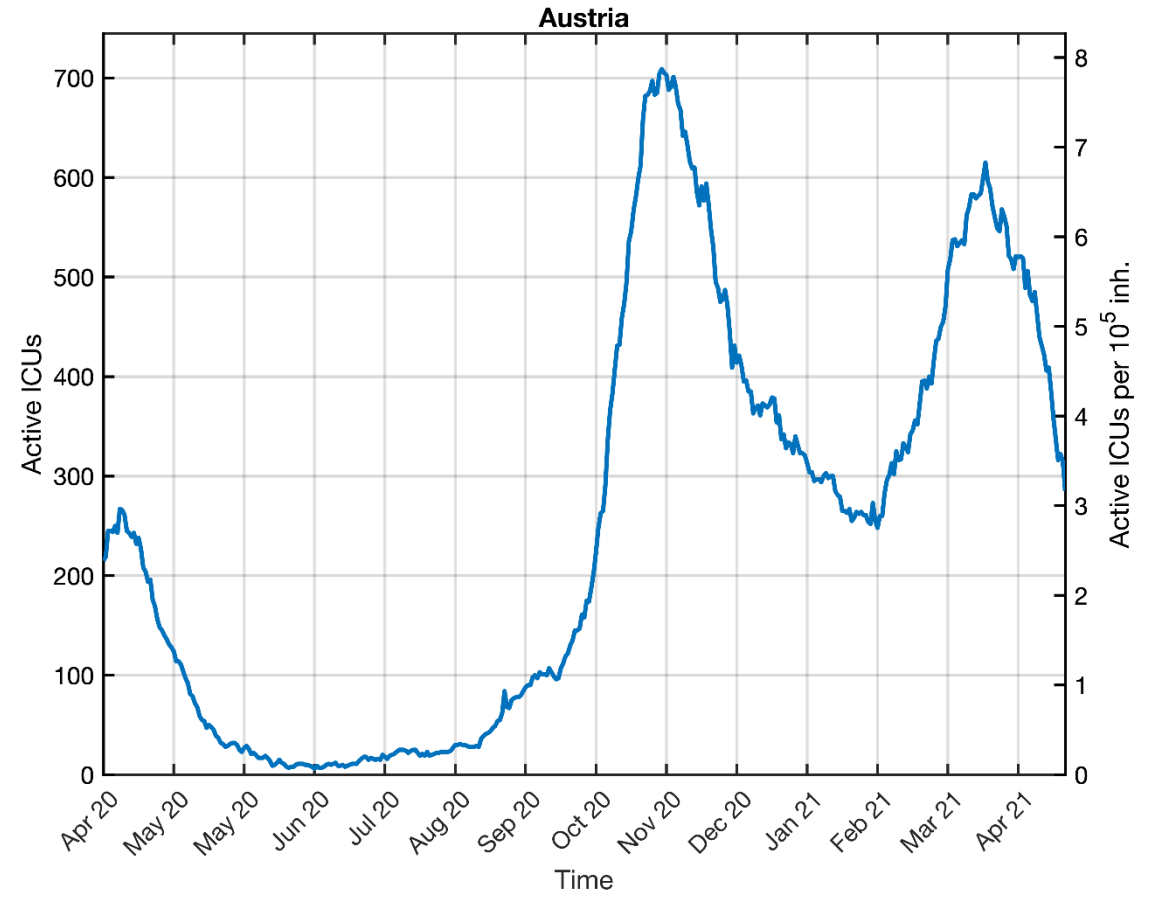
We have analysed the evolution of the B.1.1.7 variant with respect the rest of the variants using the data from the *Sequencing* measurements. **The results are coherent with the substitution process described in the previous theoretical report[1] and gives rise to sigmoid dynamics for the rise of B.1.1.7 variant.** From the fitting we obtain an increase in transmissibility of around 44% with respect to the previous variants.

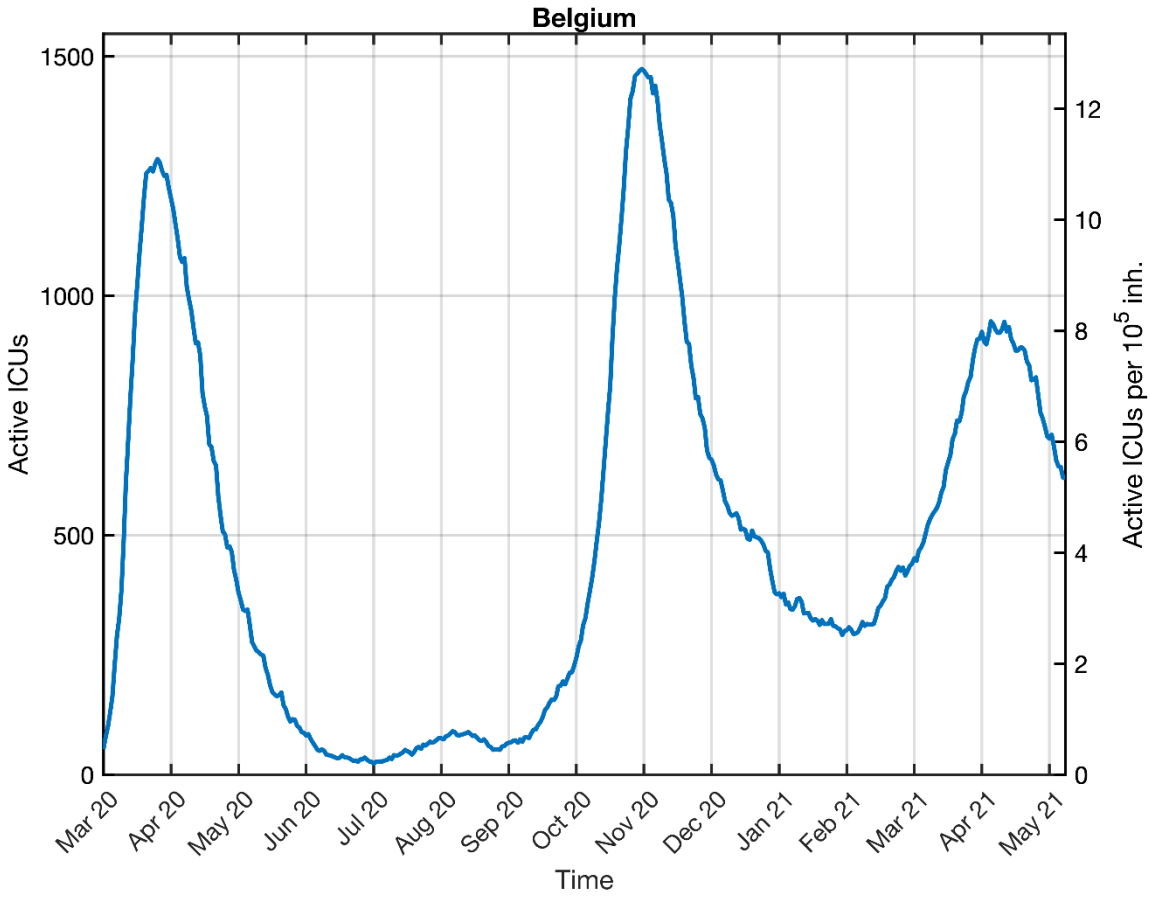
We have employed the resulting sigmoid substitution in combination to the data series of cases in Northern Metropolitan region and whole Catalunya in order to quantify the estimated cases associated to each variant and to calculate the evolution of the reproductive number of the B.1.1.7 variant and the other during the beginning of 2021.

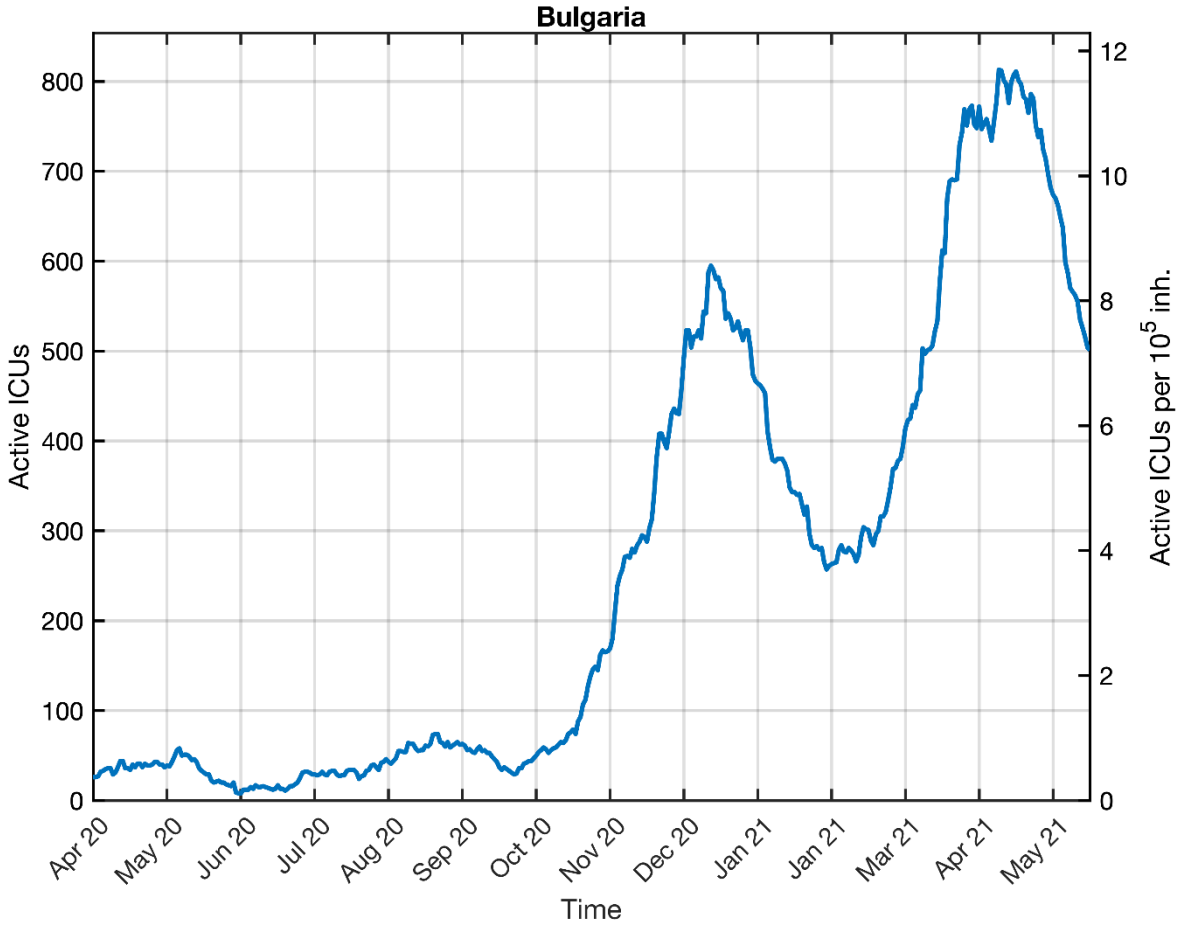
Finally, we have evaluated the changes on the transmissibility observed in the data to evaluate the dependence of the increase in transmissibility on the particular situation of the pandemic, note that data is obtained during different states of the third wave in Catalonia. We have seen that the decreasing phase of the third wave, which occurred with an R_t around 0.9, would have been a combination of the old variants decreasing with an R_t around 0.7 and the B.1.1.7 increasing in a range of R_t between 1.0 and 1.1. **We conclude that the fitting is satisfactory, independently of the state of the pandemic, and, therefore, it indicates that the increase in transmissibility is independent on the non-pharmaceutical interventions.**

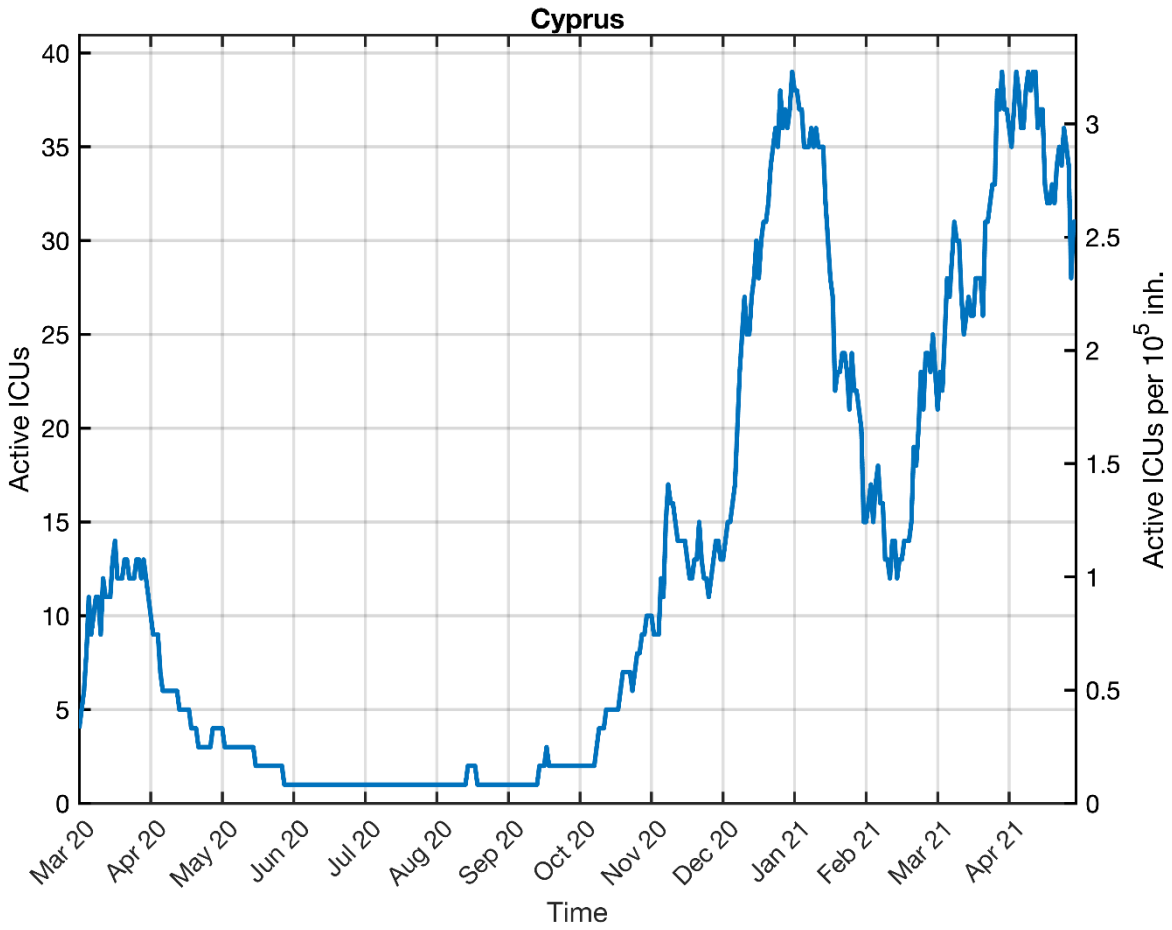
A final question mark in this analysis is whether, without the presence of the B.1.1.7, the other variants would have decreased exactly at the same rate that they did. In other words, if there is competition for resources like in an ecological habitat this would not be the case. Given the low level of immunization, it seems difficult to imagine that both variants would compete for hosts. However, we cannot disregard the possibility that society is formed by quite closed groups with different levels of risk behaviour. The penetration and spread in one of the groups with a higher risk of one variant prevent the other from taking a member of this group as a host easily if there is local herd immunity. An interesting future line of works is to analyse other substitution processes and the hierarchical nature of the different contacts to check if this competition is minimal or relevant.

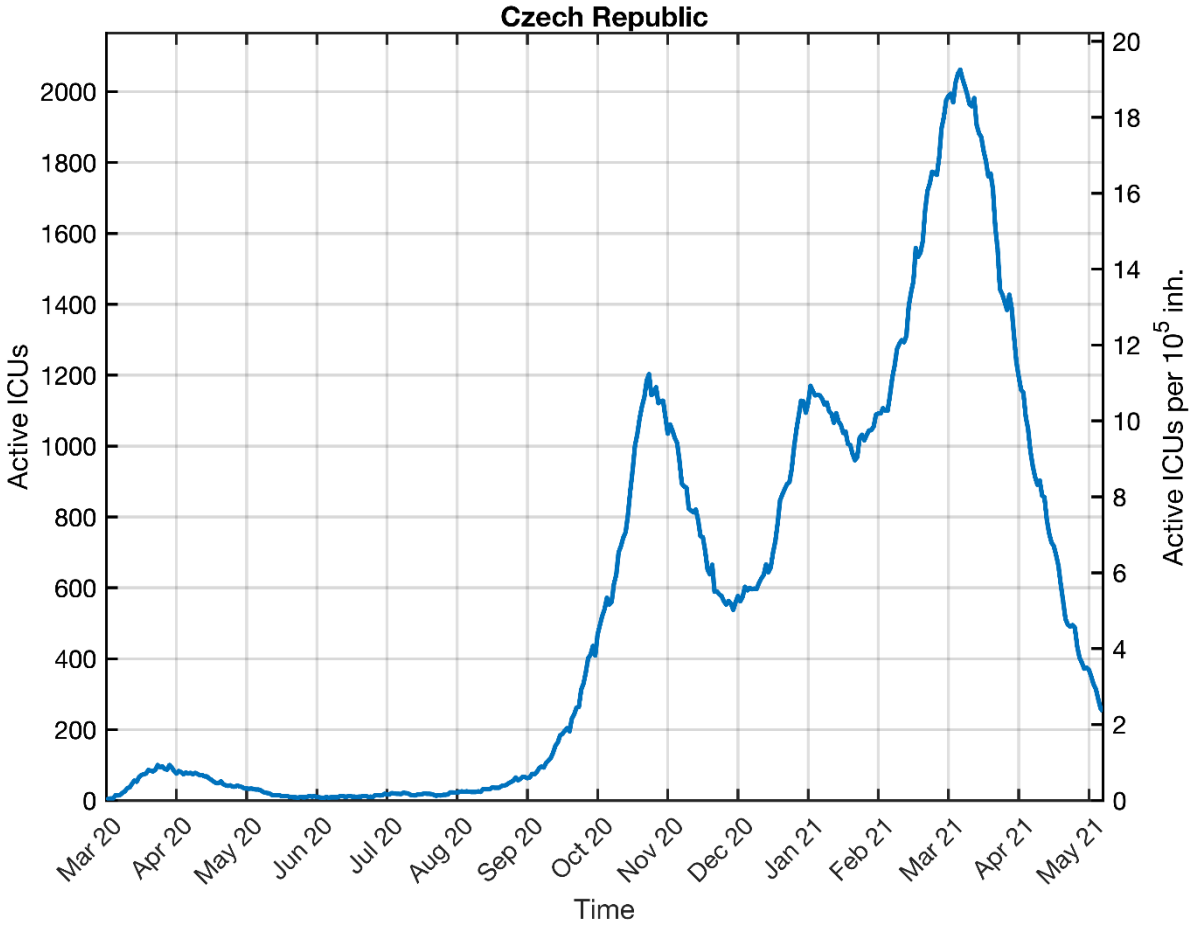
Evolution of active ICUs in some EU countries

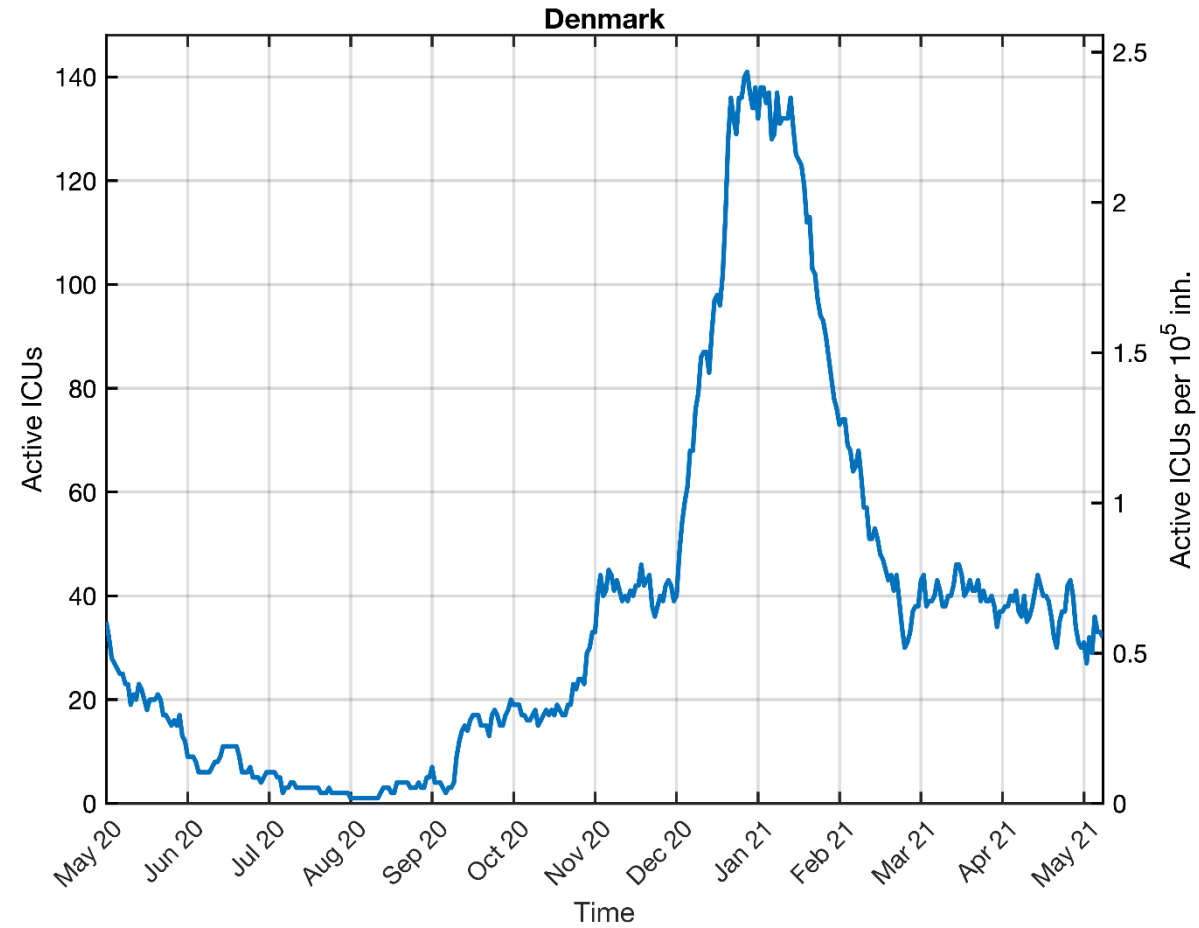


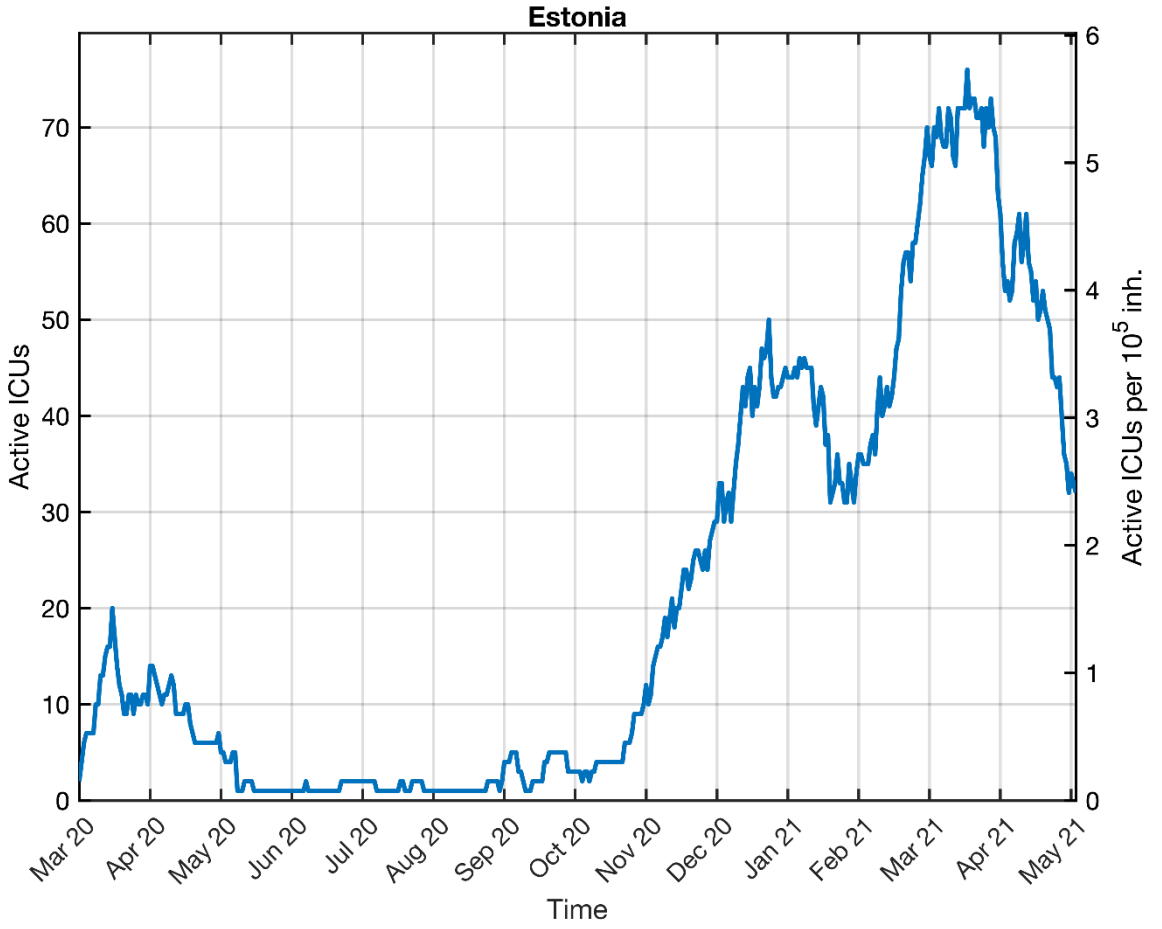



Bulgaria
Active ICUs
Active ICUs per 10^5 inh.
Time
0
100
200
300
400
500
600
700
800
0
2
4
6
8
10
12
Apr 20
May 20
Jun 20
Jul 20
Aug 20
Sep 20
Oct 20
Nov 20
Dec 20
Jan 21
Jan 21
Mar 21
Apr 21
May 21


Cyprus
Active ICUs
Active ICUs per 10^5 inh.
Time
0
5
10
15
20
25
30
35
40
0
0.5
1
1.5
2
2.5
3
Mar 20
Apr 20
May 20
Jun 20
Jul 20
Aug 20
Sep 20
Oct 20
Nov 20
Dec 20
Jan 21
Feb 21
Mar 21
Apr 21


Czech Republic
Active ICUs
Active ICUs per 10^5 inh.
Time
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
2
4
6
8
10
12
14
16
18
20
Mar 20
Apr 20
May 20
Jun 20
Jul 20
Aug 20
Sep 20
Oct 20
Nov 20
Dec 20
Jan 21
Feb 21
Mar 21
Apr 21
May 21


Denmark
Active ICUs
Active ICUs per 10^5 inh.
Time
0
20
40
60
80
100
120
140
0
0.5
1
1.5
2
2.5
May 20
Jun 20
Jul 20
Aug 20
Sep 20
Oct 20
Nov 20
Dec 20
Jan 21
Feb 21
Mar 21
Apr 21
May 21


Estonia
Active ICUs
Active ICUs per 10^5 inh.
Time
0
10
20
30
40
50
60
70
0
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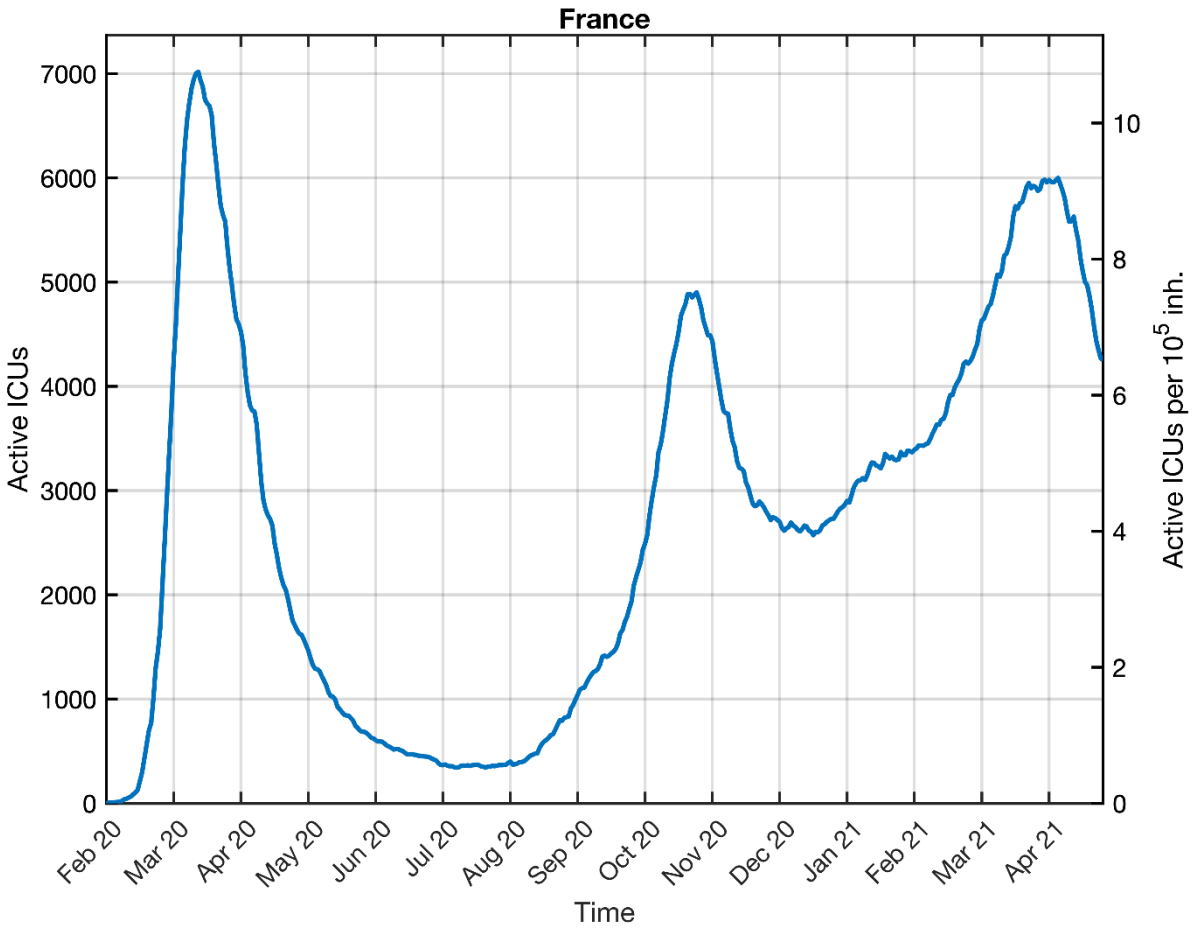
France
Active ICUs
Active ICUs per 10^5 inh.
Time
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1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
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Feb 20
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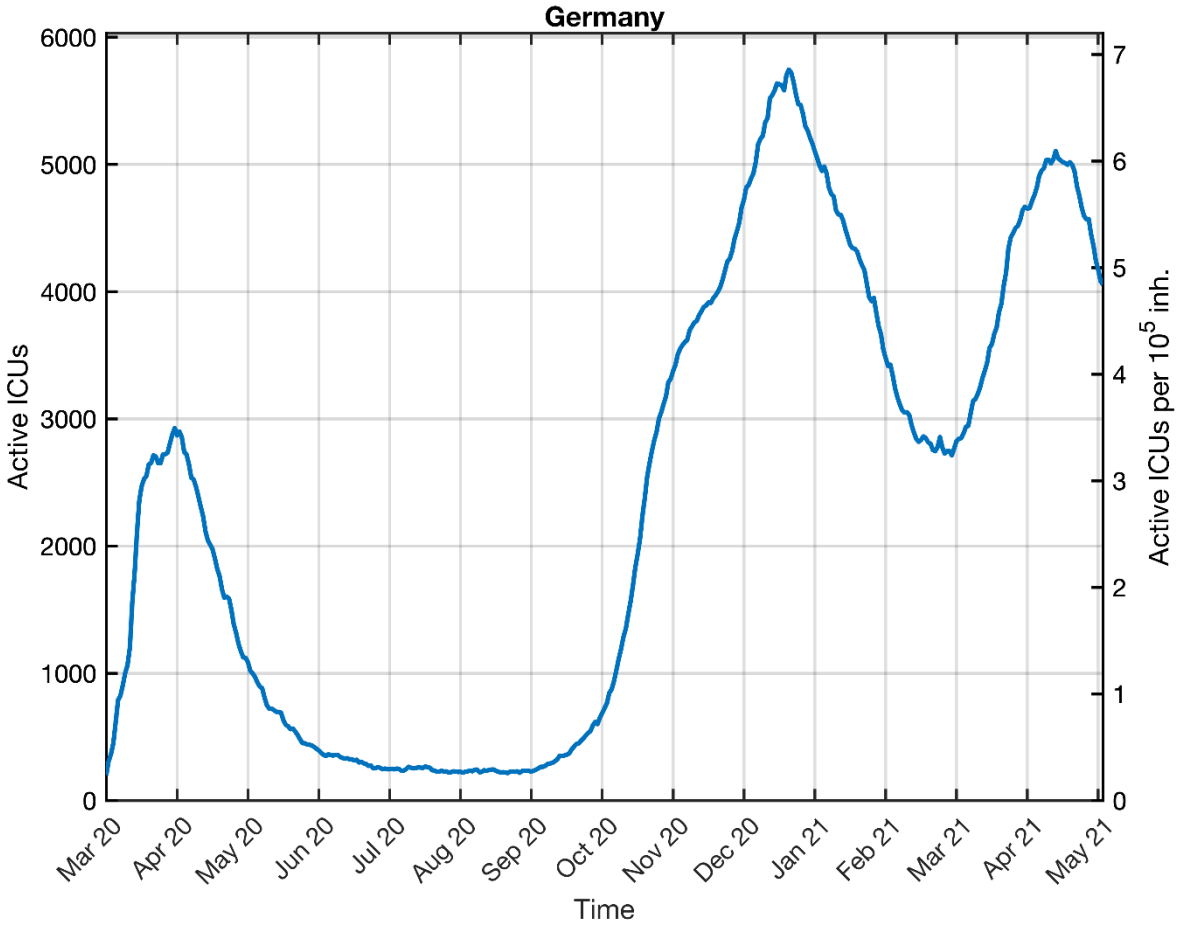
Germany
Active ICUs
Active ICUs per 10^5 inh.
Time
0
1000
2000
3000
4000
5000
6000
0
1
2
3
4
5
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Mar 20
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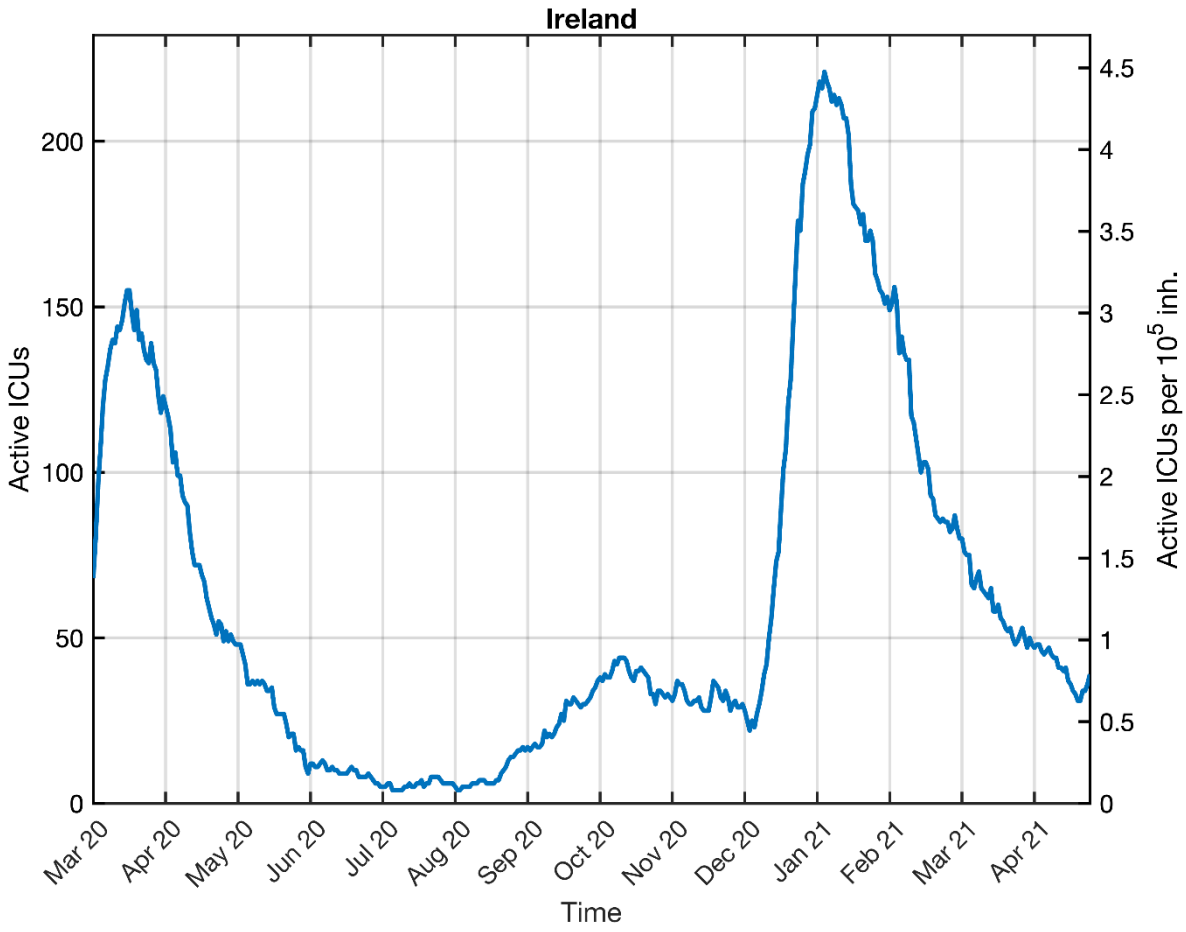
Ireland
Active ICUs
Active ICUs per 10^5 inh.
Time
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50
100
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200
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1.5
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3
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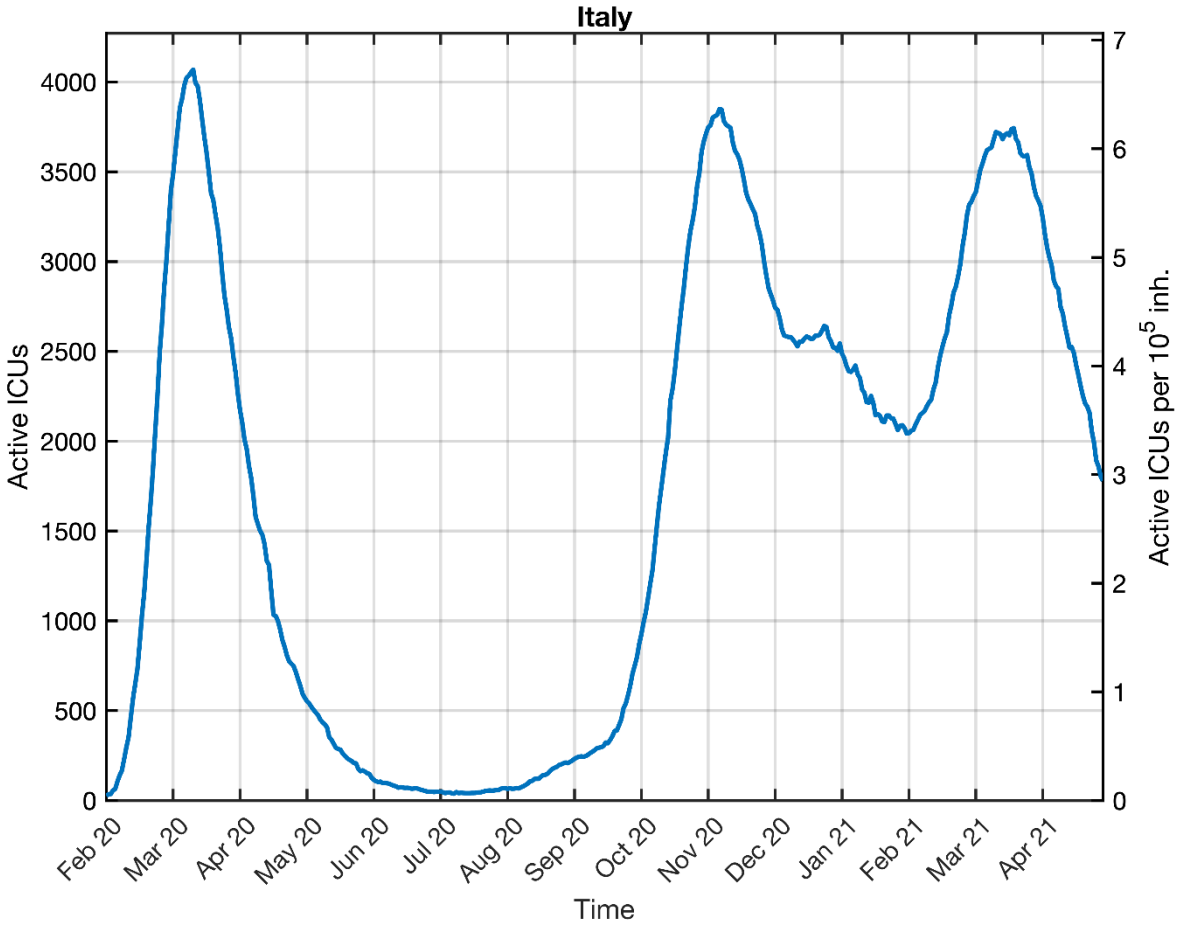
Italy
Active ICUs
Active ICUs per 10^5 inh.
Time
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1000
1500
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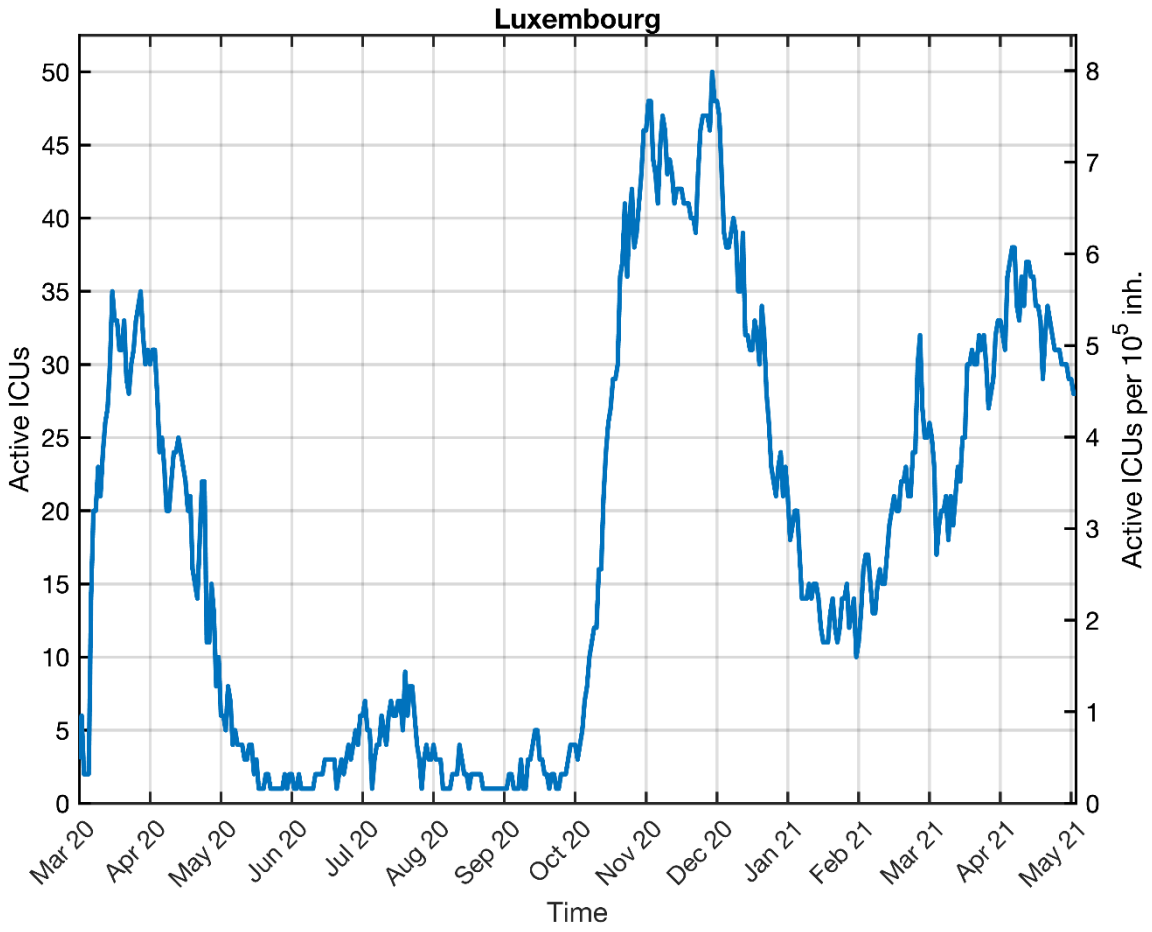
Luxembourg
Active ICUs
Active ICUs per 10^5 inh.
Time
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5
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15
20
25
30
35
40
45
50
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2
3
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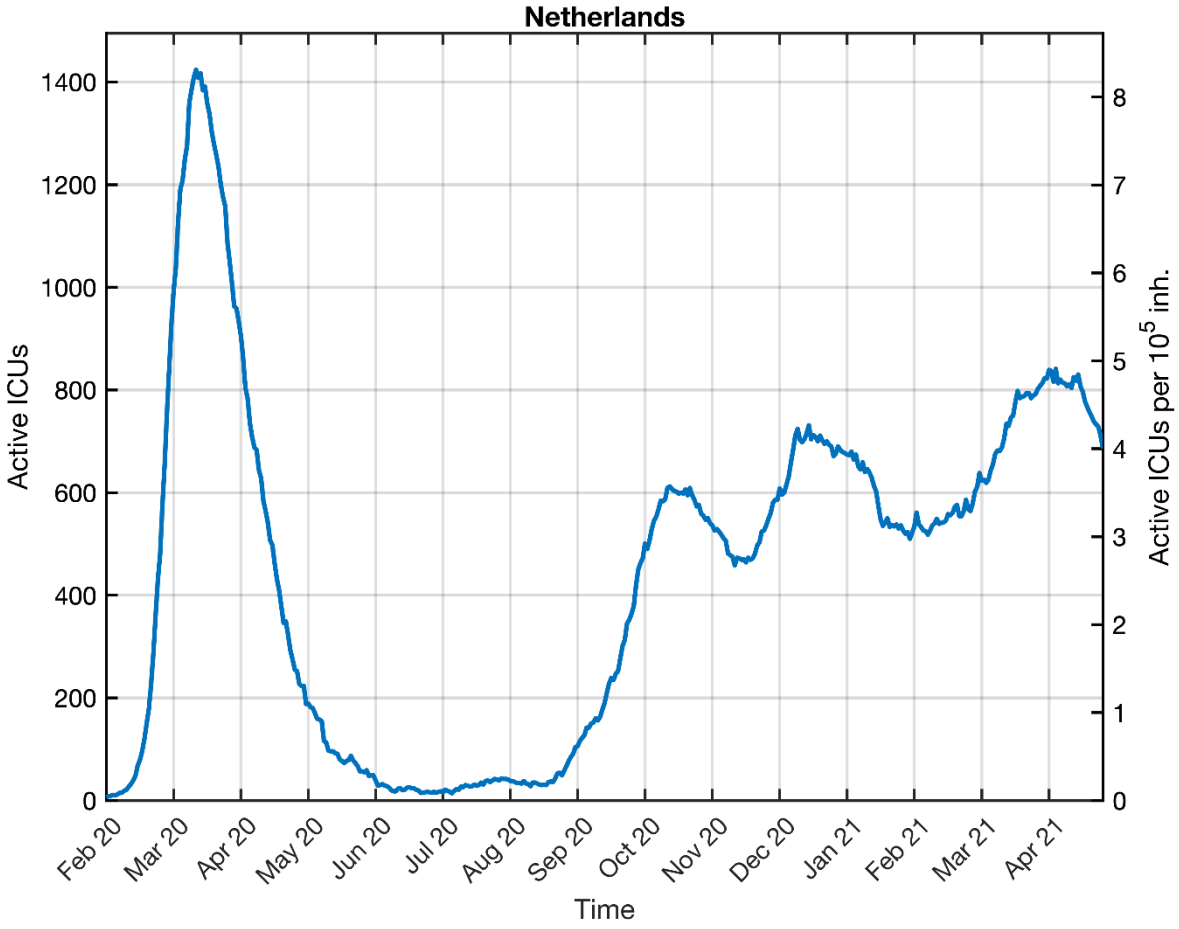
Netherlands
Active ICUs
Active ICUs per 10^5 inh.
Time
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400
600
800
1000
1200
1400
0
1
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5
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Feb 20
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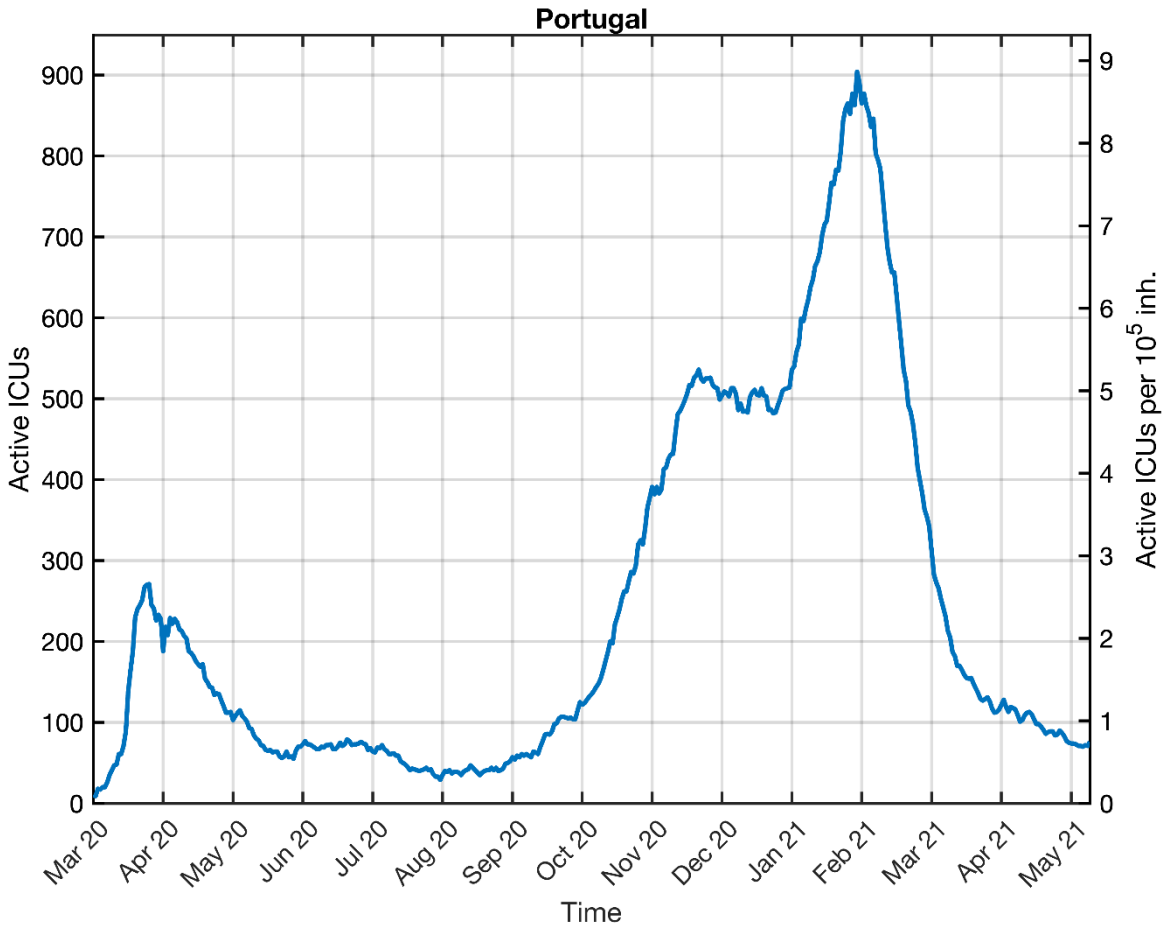
Portugal
Active ICUs
Active ICUs per 10^5 inh.
Time
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100
200
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700
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900
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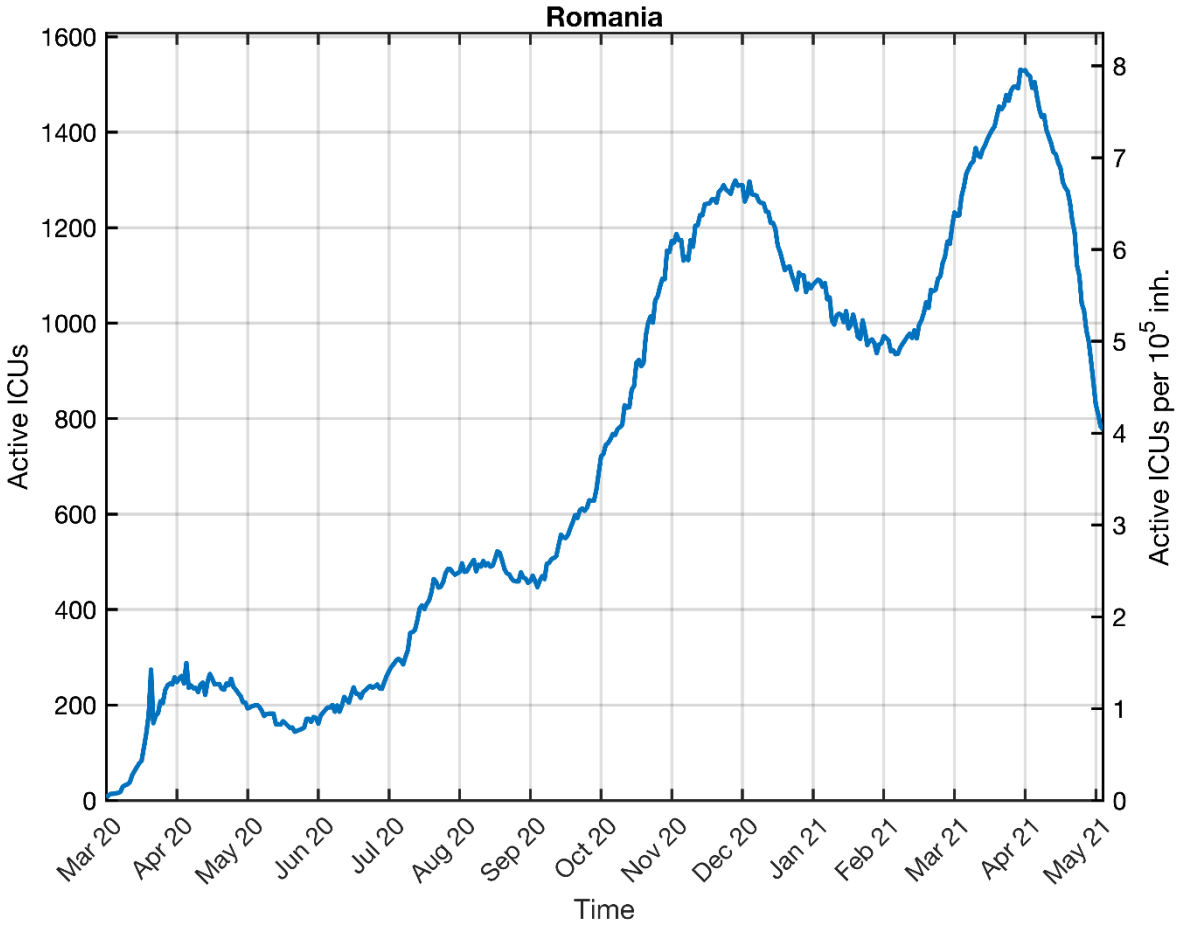
Romania
Active ICUs
Active ICUs per 10^5 inh.
Time
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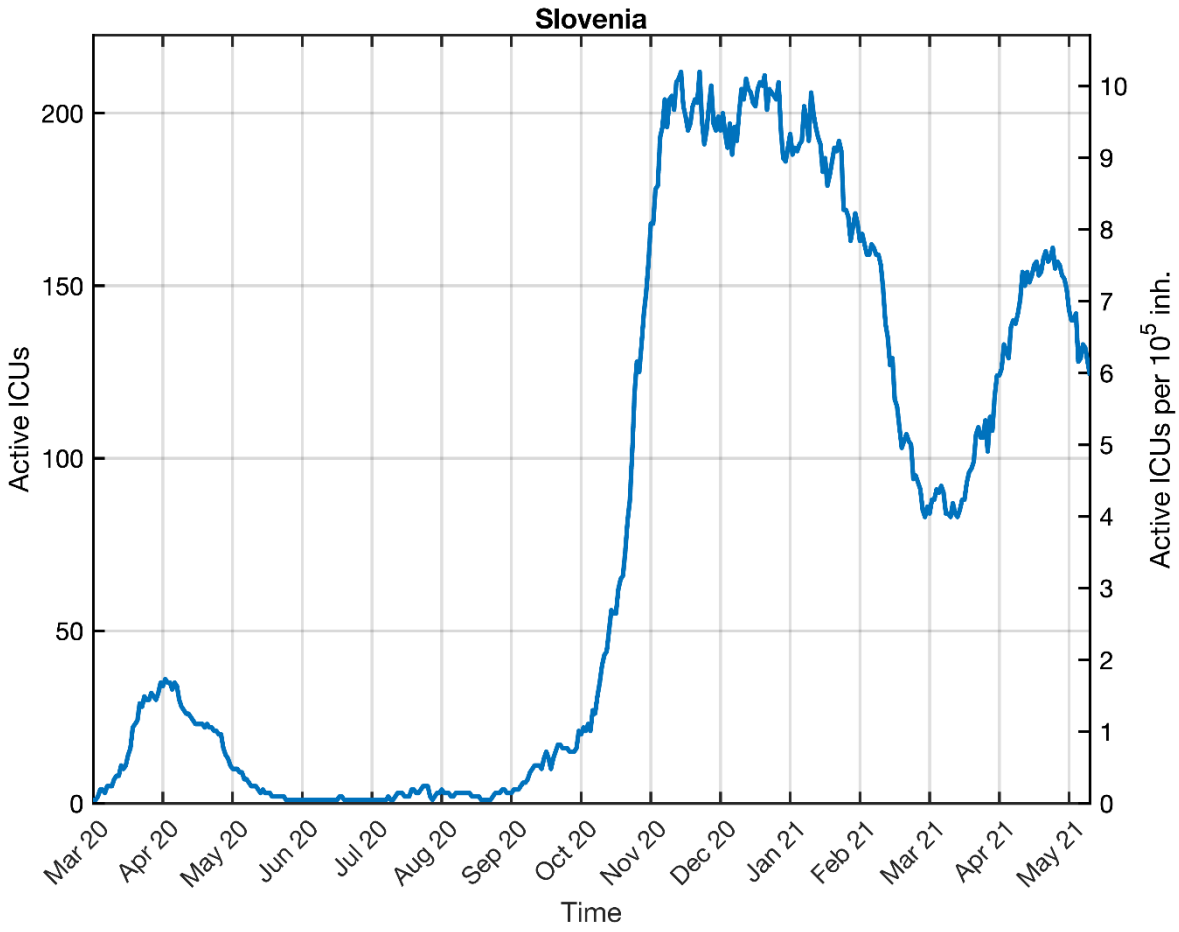
Slovenia
Active ICUs
Active ICUs per 10^5 inh.
Time
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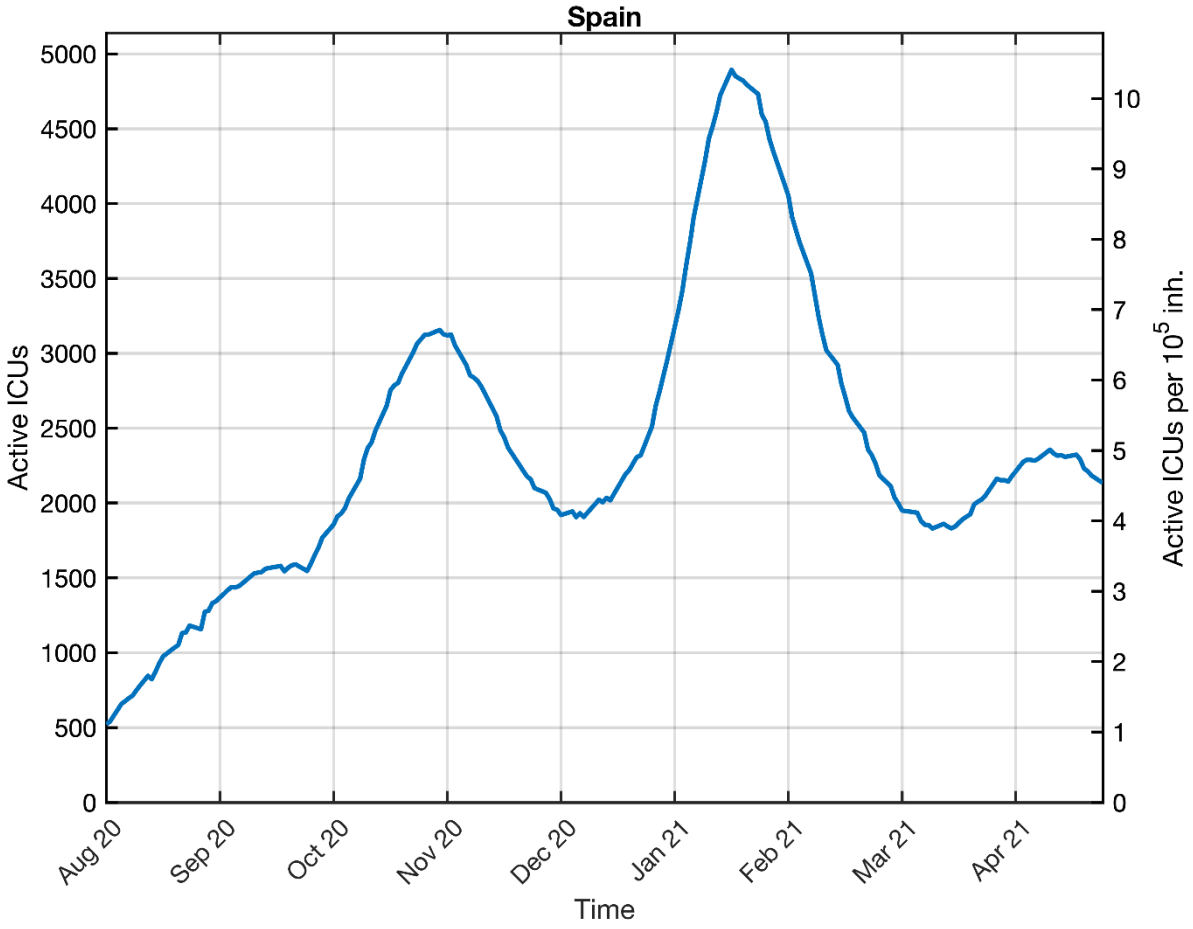
Spain
Active ICUs
Active ICUs per 10^5 inh.
Time
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500
1000
1500
2000
2500
3000
3500
4000
4500
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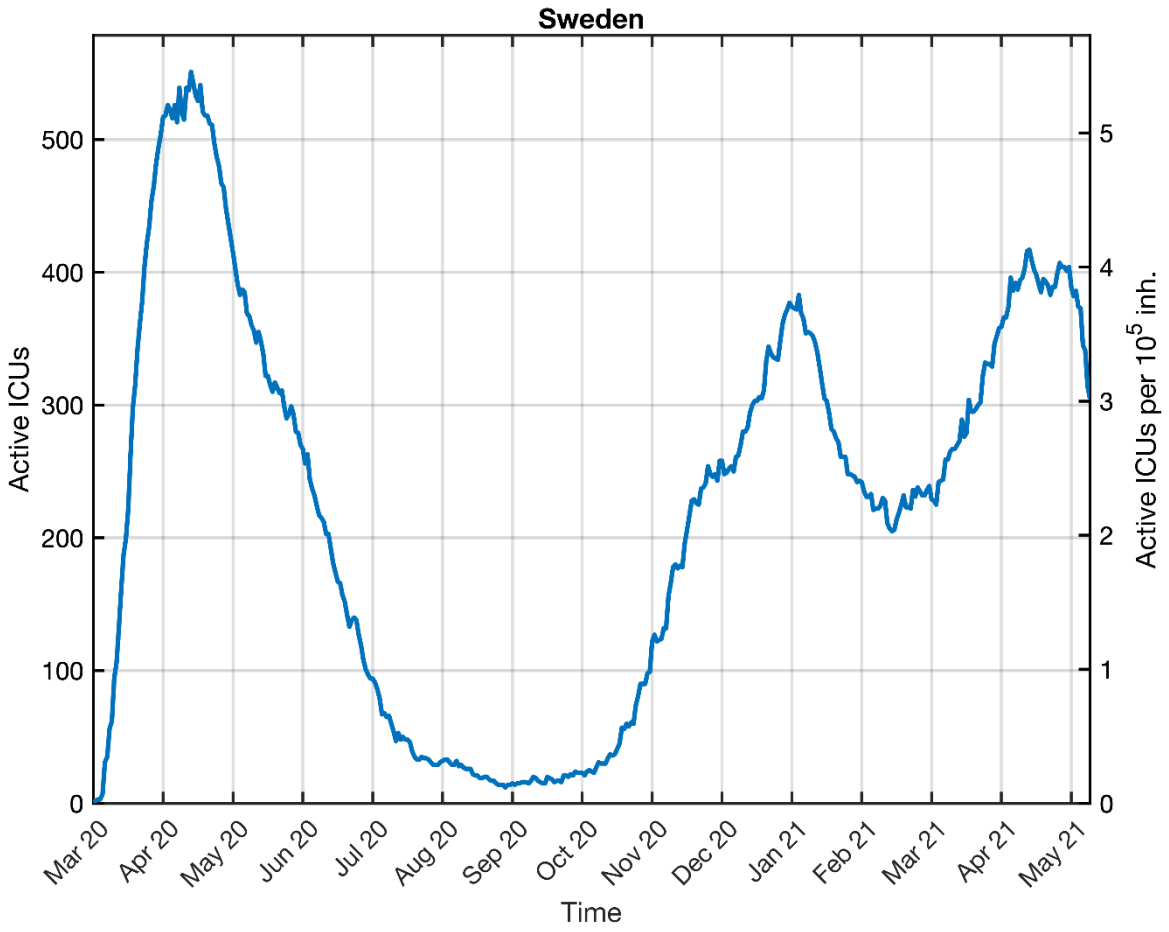
Sweden
Active ICUs
Active ICUs per 10^5 inh.
Time
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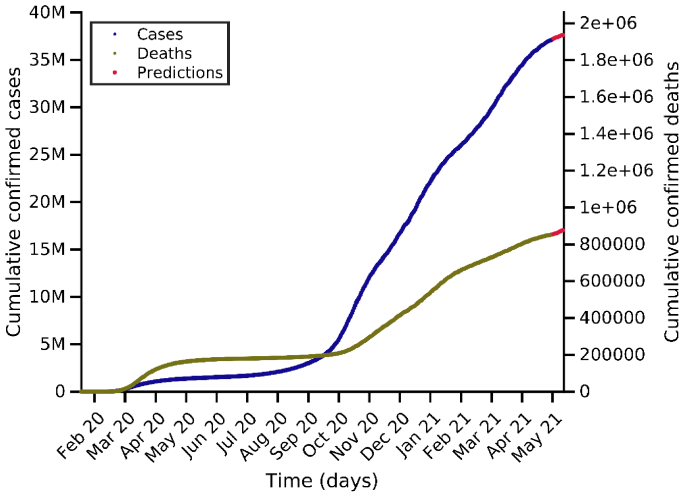
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

EU+EFTA+UK 19-05-2021. Pop: 527.9M. Cumulative incidence: 7043/10^5

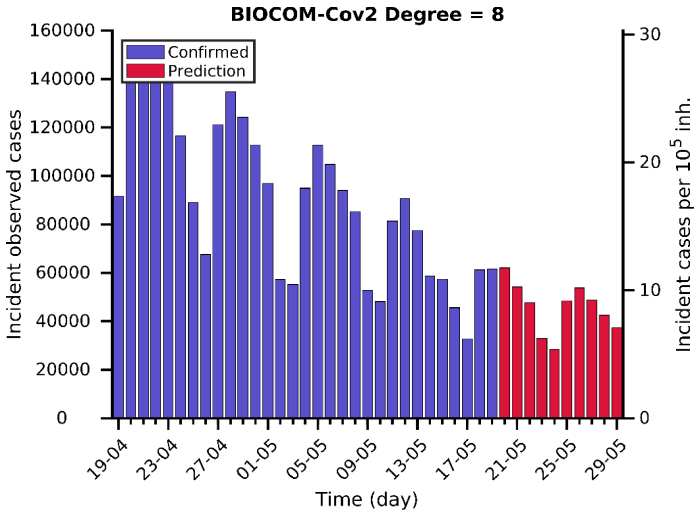


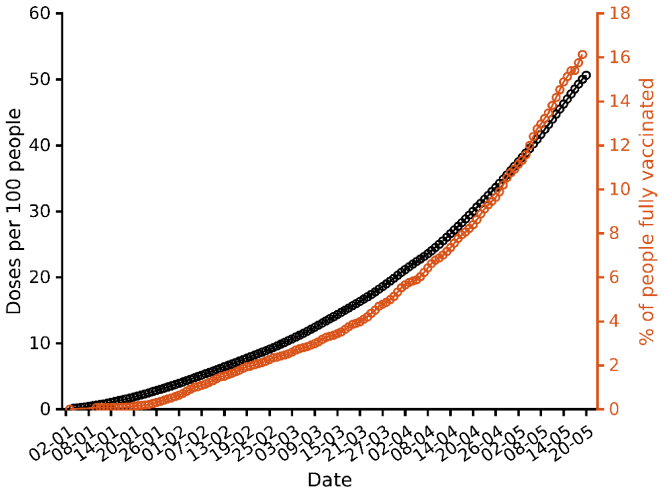
Predictions for next days

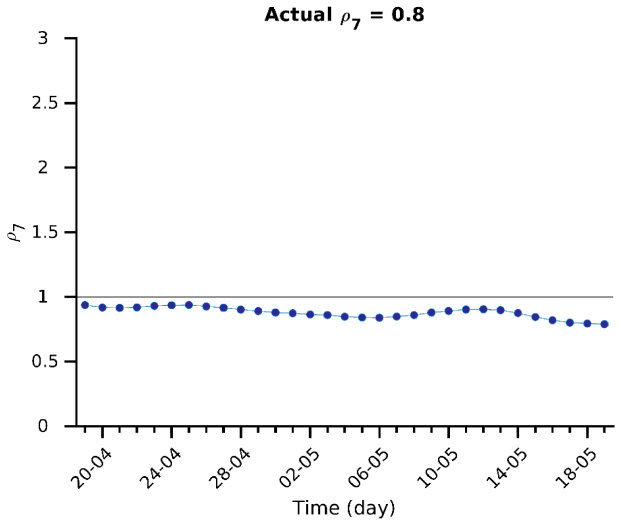
Day	Number of cases
22-05-2021	37343141 (+163925)
26-05-2021	37506536 (+327320)
29-05-2021	37635107 (+455891)

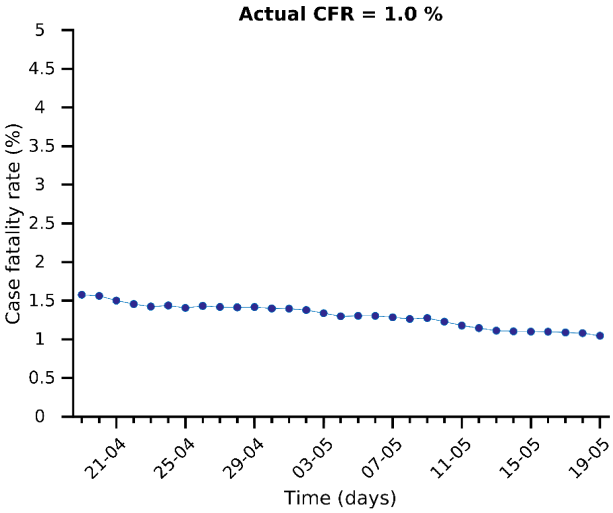
Current indicators

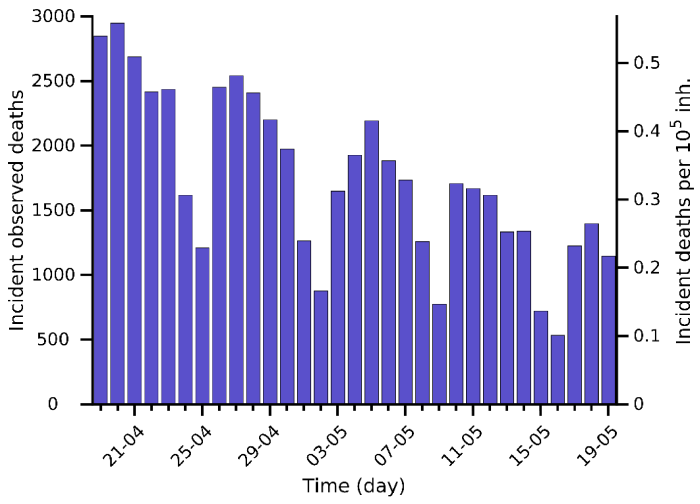
	A14	EPG	CFR	N7	D7
Today	180	142	1.05 %	56396	1099
A Week ago	229	208	1.15 %	79559	1520
Maximum	618	667	4.95 %	245465	4833

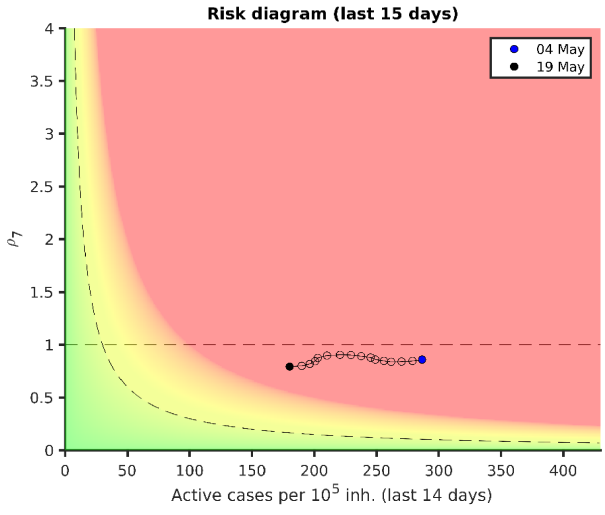




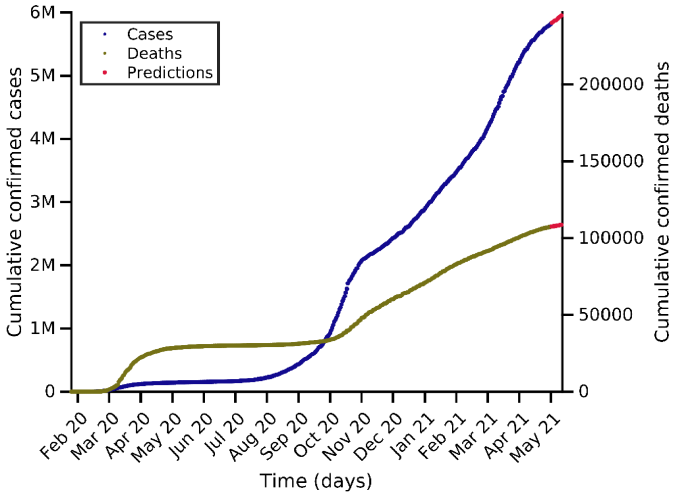








France 19-05-2021. Pop: 65.3M. Cumulative incidence: 8918/10⁵

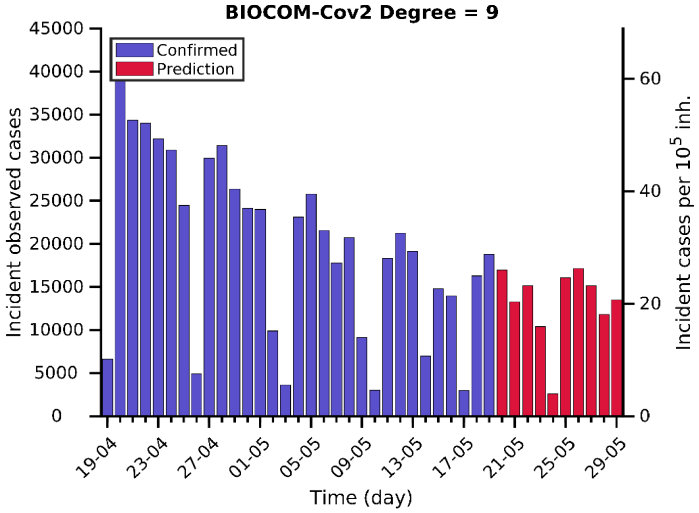


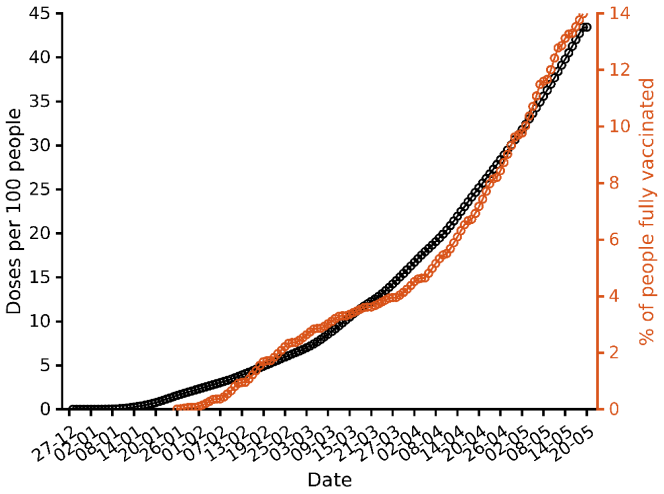
Predictions for next days

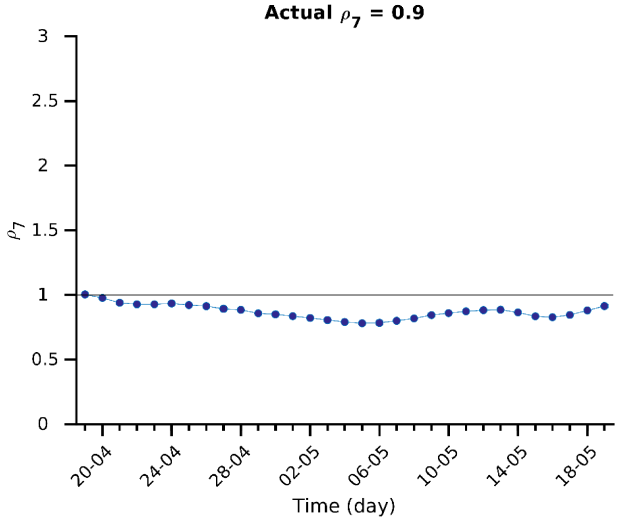
Day	Number of cases
22-05-2021	5866278 (+45360)
26-05-2021	5912470 (+91552)
29-05-2021	5952935 (+132017)

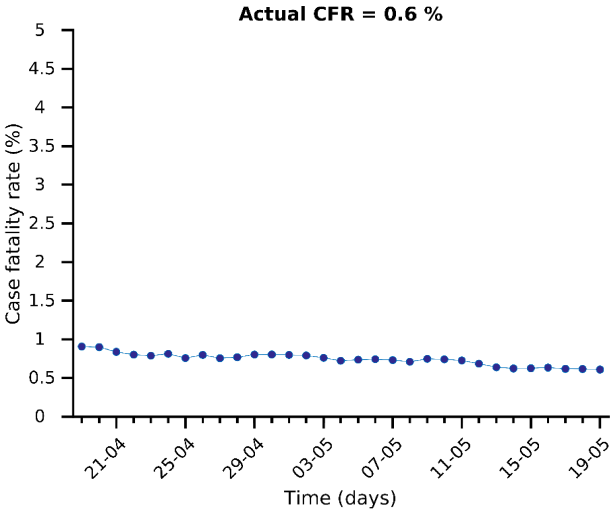
Current indicators

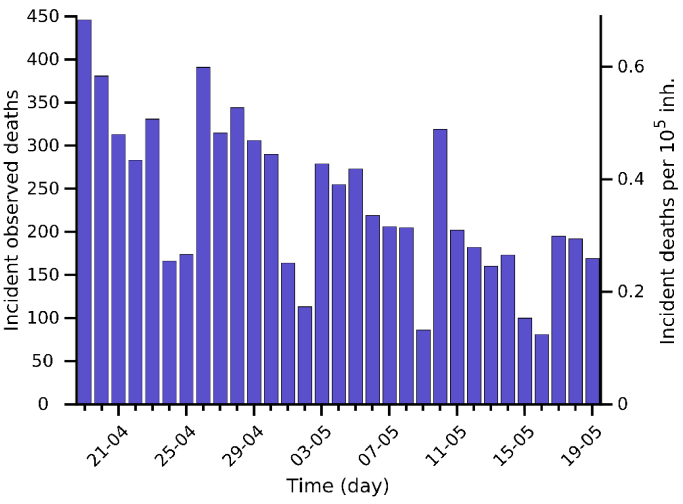
	A14	EPG	CFR	N7	D7
Today	314	287	0.61 %	13270	153
A Week ago	381	336	0.68 %	15978	203
Maximum	1009	1233	4.94 %	54650	1100

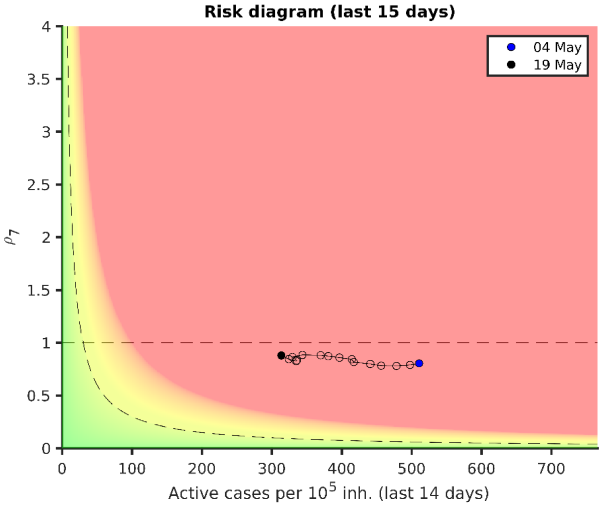




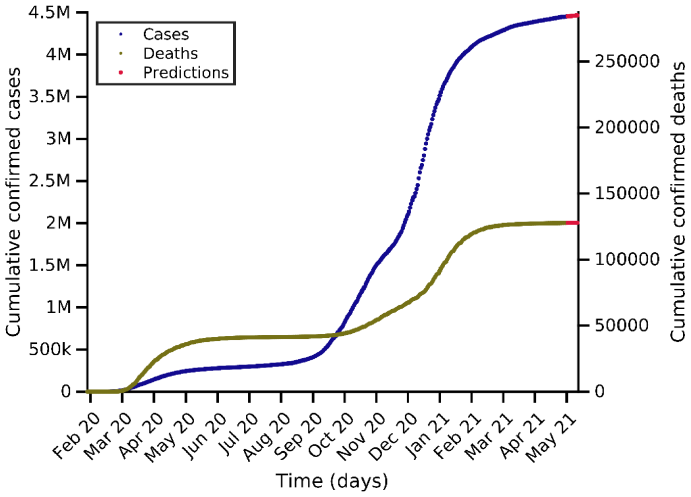








UK 19-05-2021. Pop: 67.9M. Cumulative incidence: 6559/10⁵

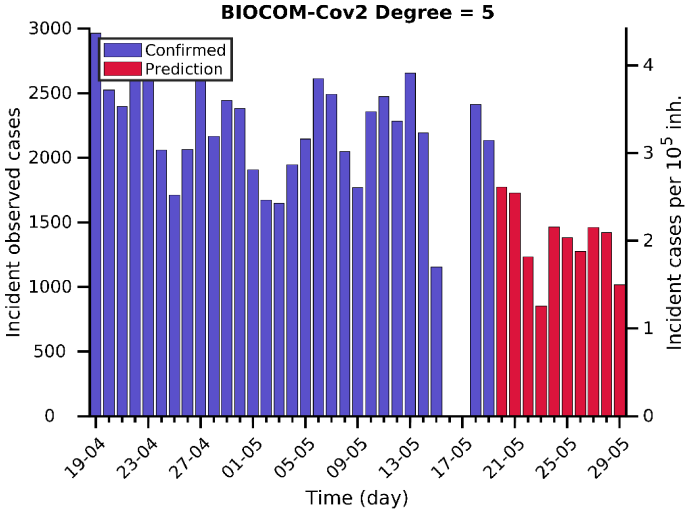


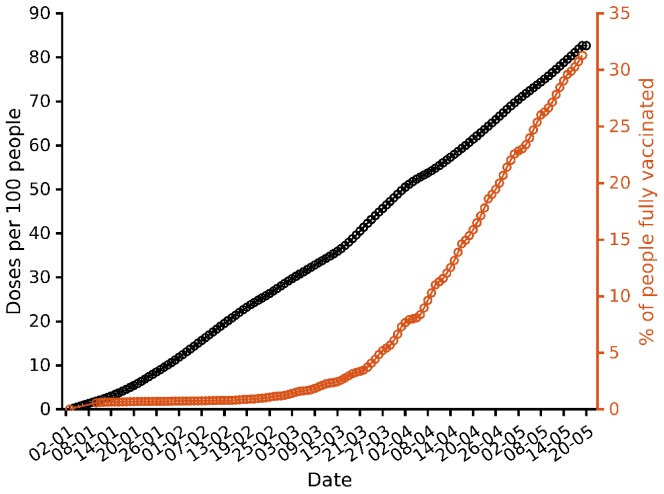
Predictions for next days

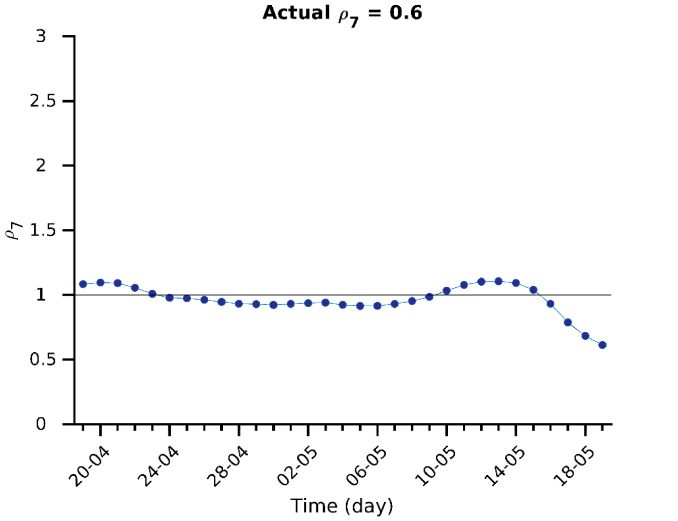
Day	Number of cases
22-05-2021	4457267 (+4736)
26-05-2021	4462241 (+9710)
29-05-2021	4466140 (+13609)

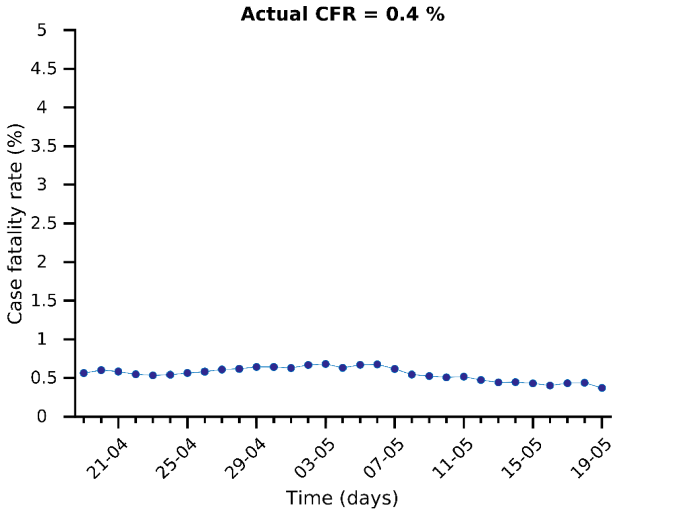
Current indicators

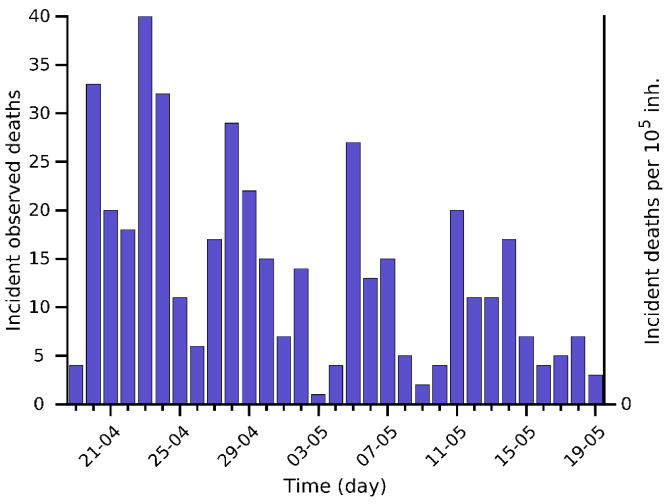
	A14	EPG	CFR	N7	D7
Today	39	24	0.37 %	1507	8
A Week ago	44	49	0.47 %	2291	10
Maximum	1155	1404	4.92 %	61238	1248

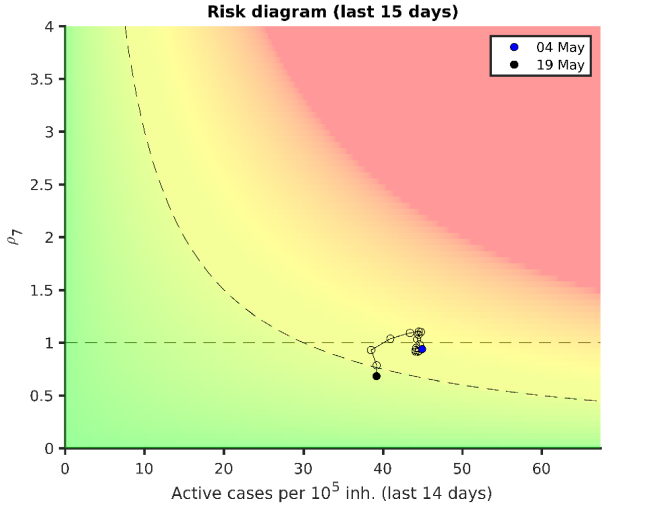




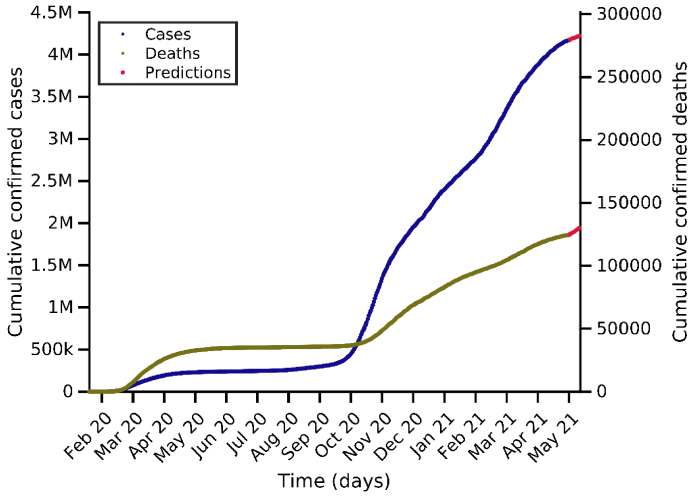








Italy 19-05-2021. Pop: 60.5M. Cumulative incidence: 6901/10⁵

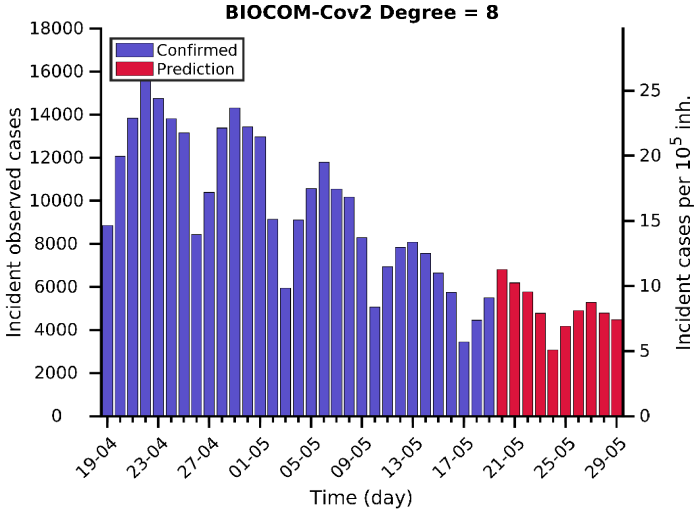


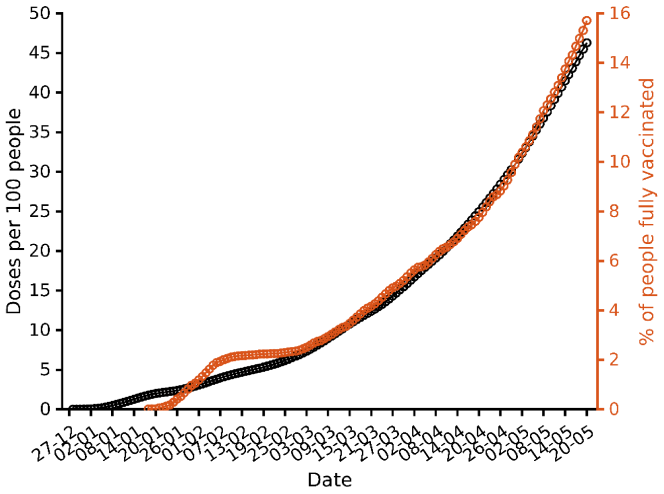
Predictions for next days

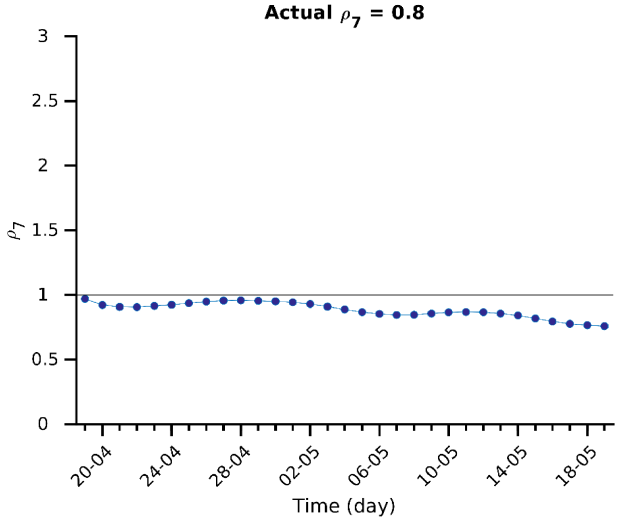
Day	Number of cases
22-05-2021	4191287 (+18762)
26-05-2021	4208211 (+35686)
29-05-2021	4222754 (+50229)

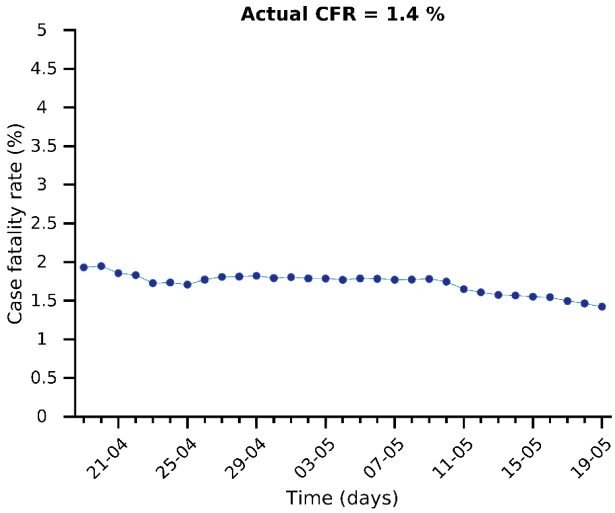
Current indicators

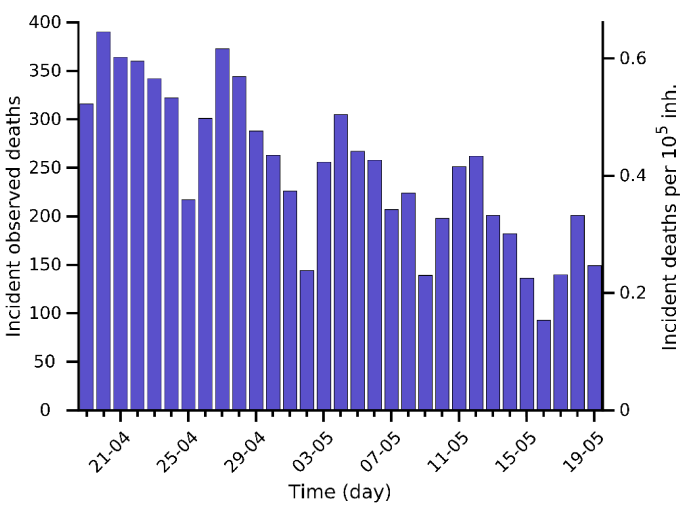
	A14	EPG	CFR	N7	D7
Today	169	128	1.42 %	5921	157
A Week ago	225	195	1.61 %	8668	220
Maximum	800	833	4.99 %	35073	822

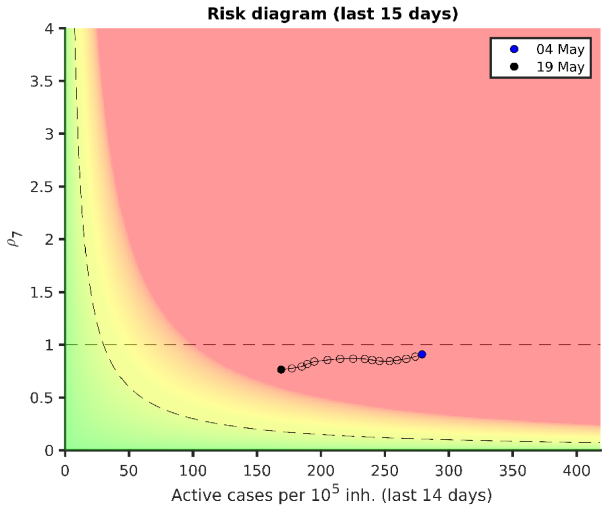




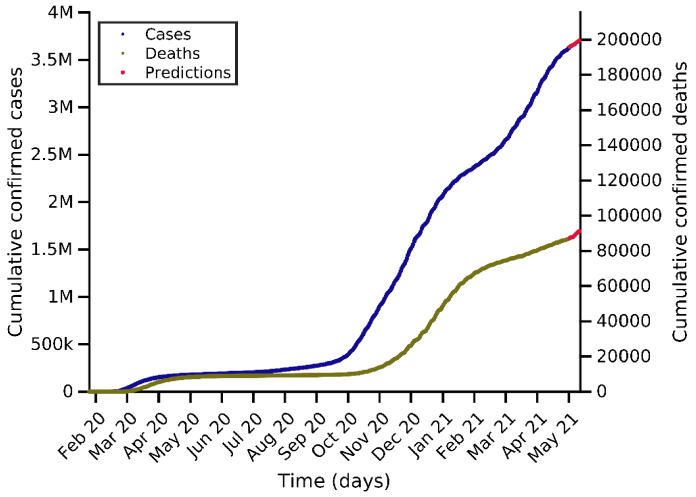








Germany 19-05-2021. Pop: 83.8M. Cumulative incidence: 4328/10⁵

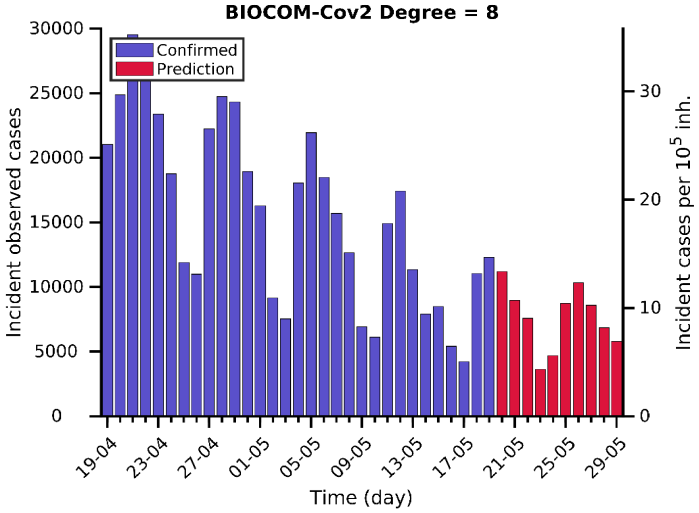


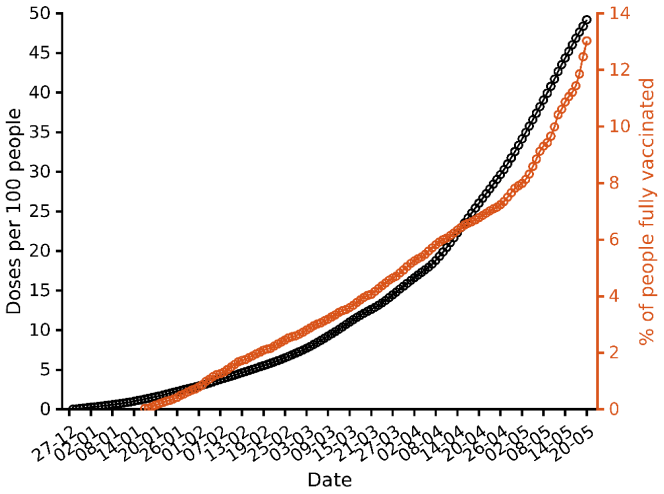
Predictions for next days

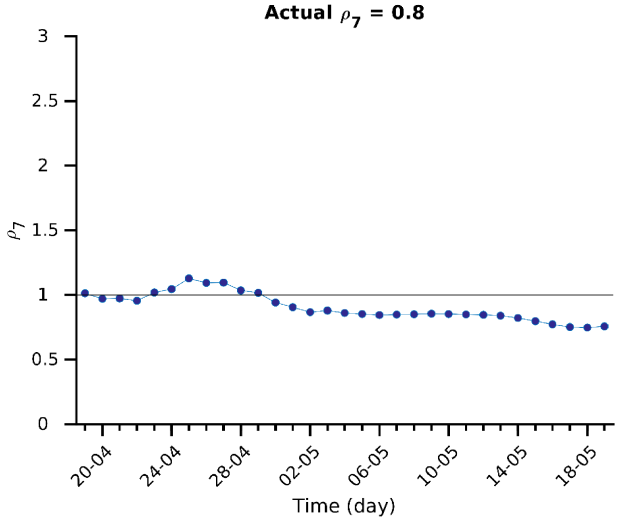
Day	Number of cases
22-05-2021	3654092 (+27699)
26-05-2021	3681457 (+55064)
29-05-2021	3702693 (+76300)

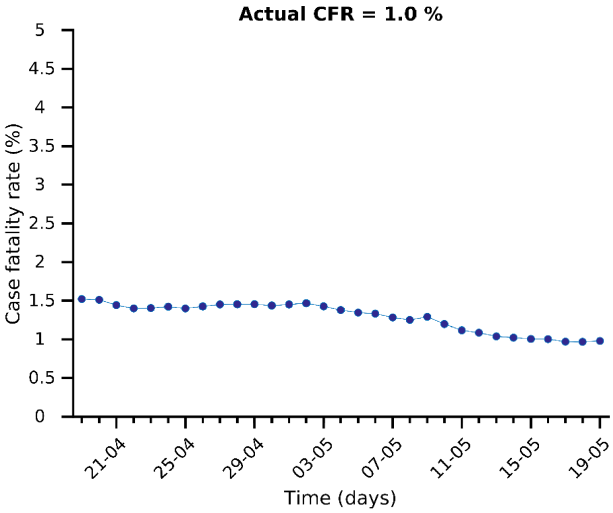
Current indicators

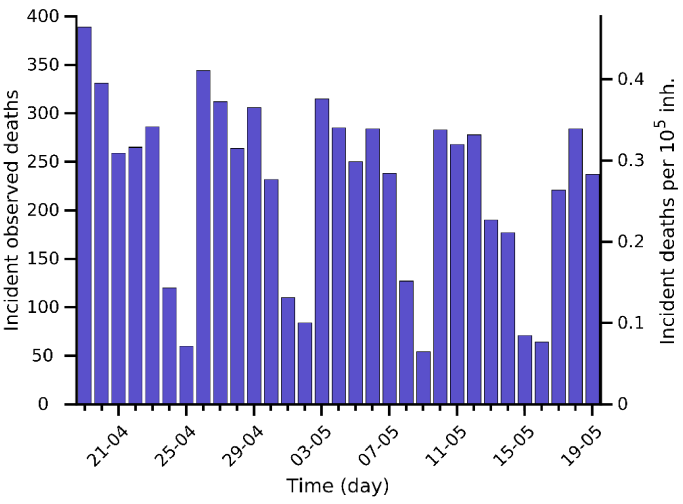
	A14	EPG	CFR	N7	D7
Today	182	138	0.98 %	8670	178
A Week ago	249	210	1.09 %	13172	219
Maximum	412	442	4.57 %	25851	896

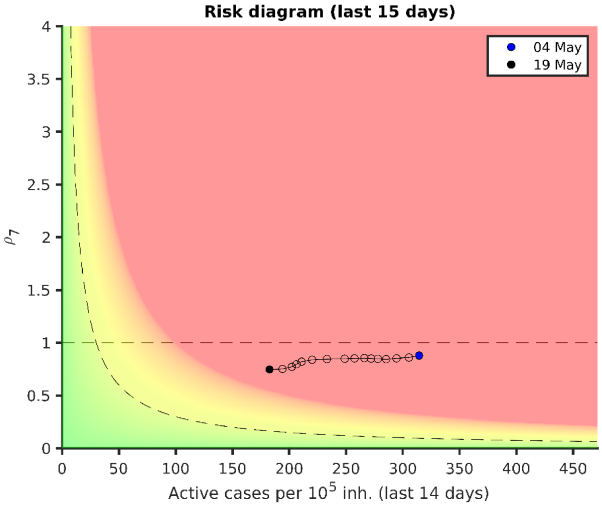




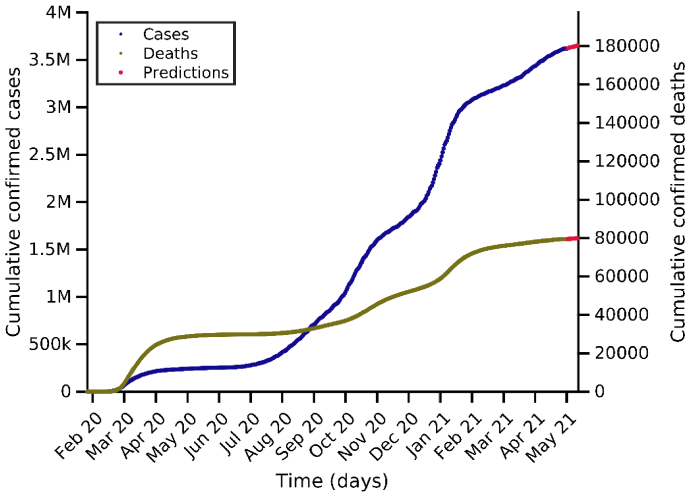








Spain 19-05-2021. Pop: 47.0M. Cumulative incidence: 7698/10⁵

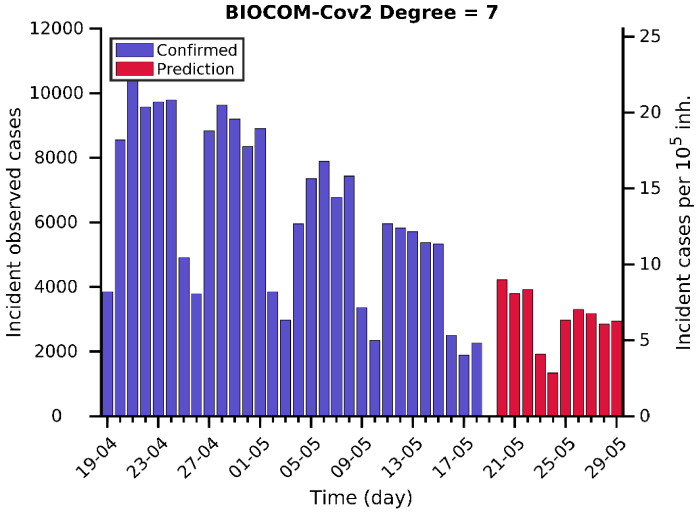


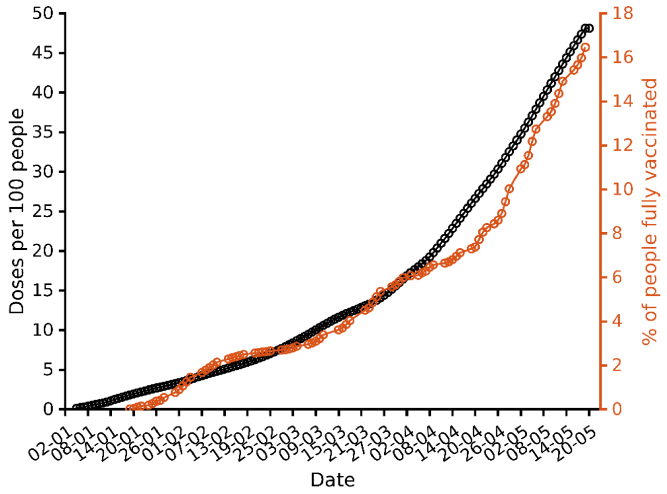
Predictions for next days

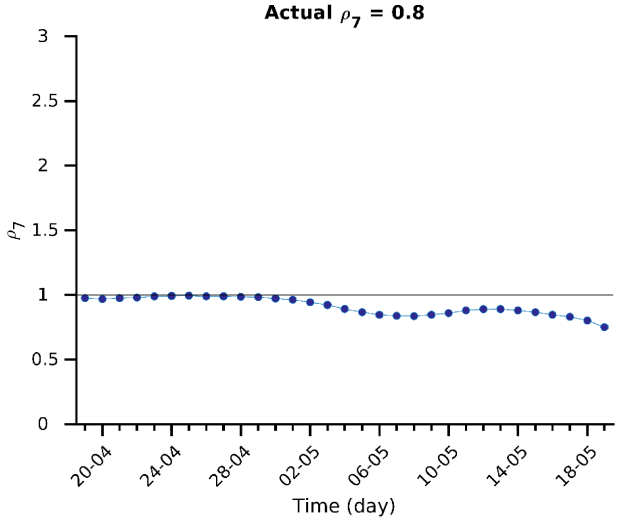
Day	Number of cases
22-05-2021	3631782 (+11934)
26-05-2021	3641318 (+21470)
29-05-2021	3650289 (+30441)

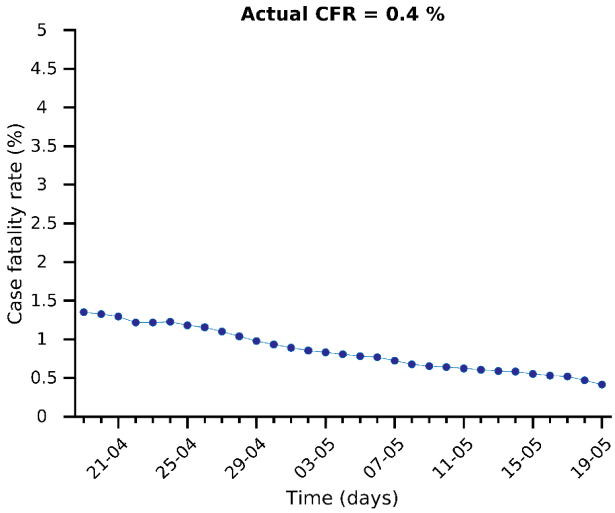
Current indicators

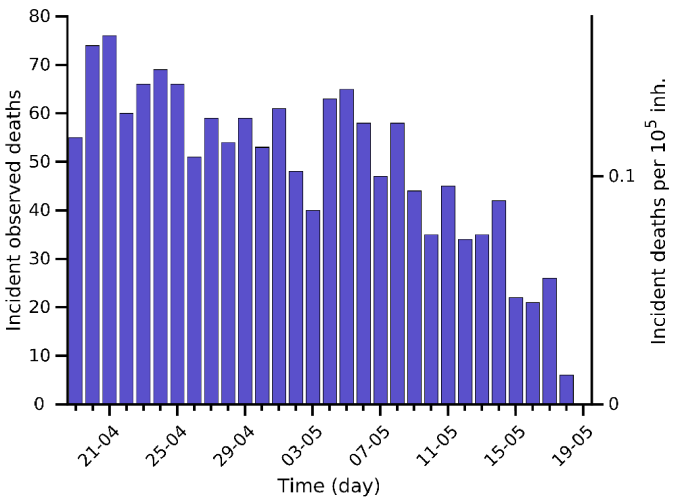
	A14	EPG	CFR	N7	D7
Today	133	100	0.41 %	3296	22
A Week ago	183	163	0.61 %	5655	46
Maximum	1011	1098	4.99 %	35134	877

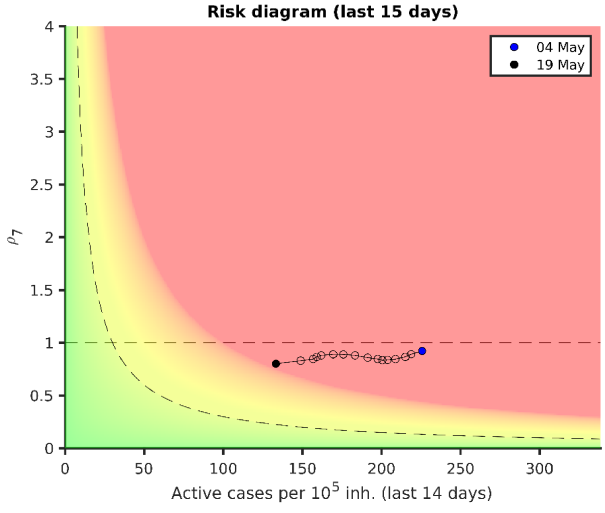




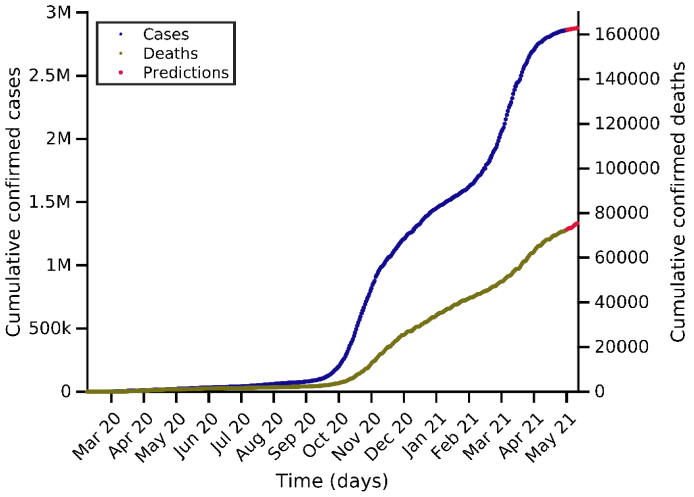








Poland 19-05-2021. Pop: 37.8M. Cumulative incidence: 7560/10⁵

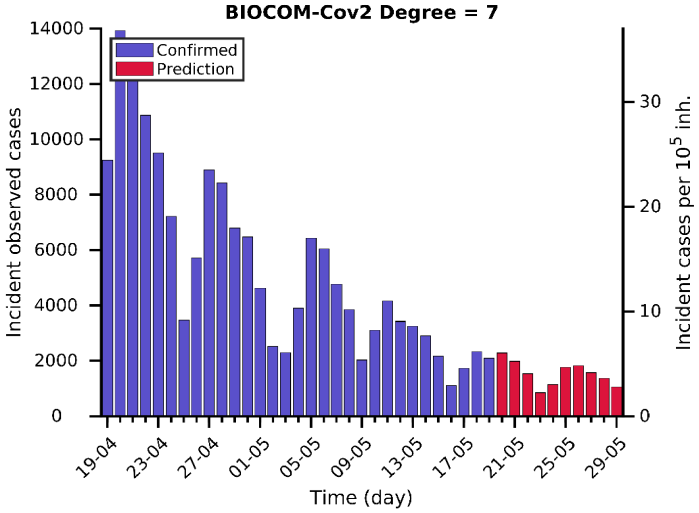


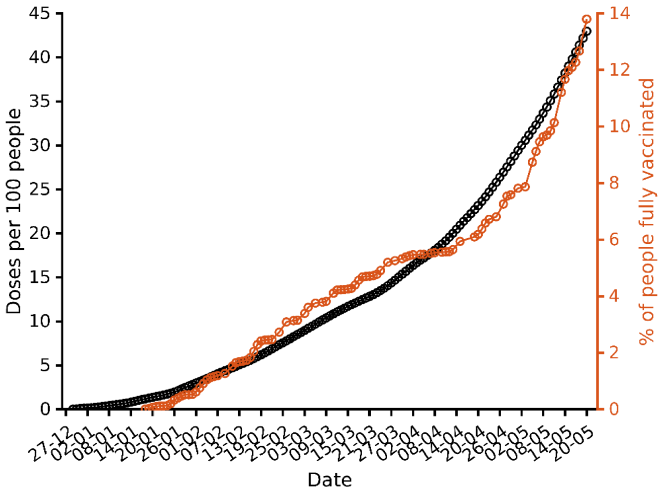
Predictions for next days

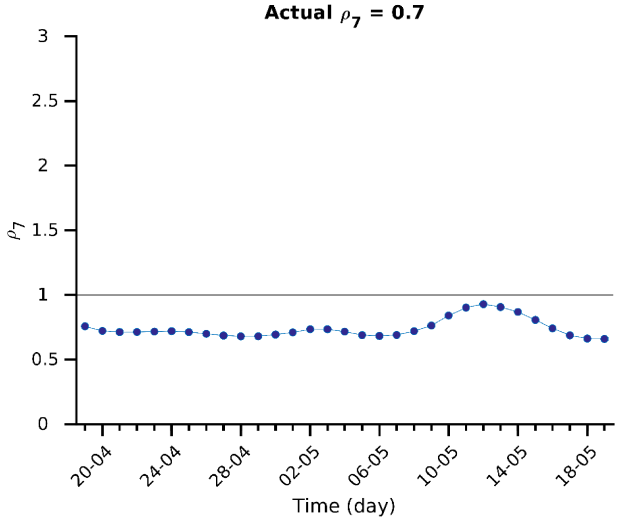
Day	Number of cases
22-05-2021	2867151 (+5800)
26-05-2021	2872728 (+11377)
29-05-2021	2876727 (+15376)

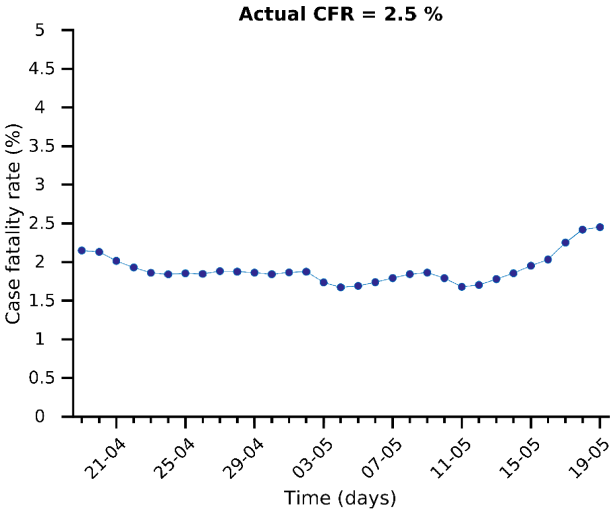
Current indicators

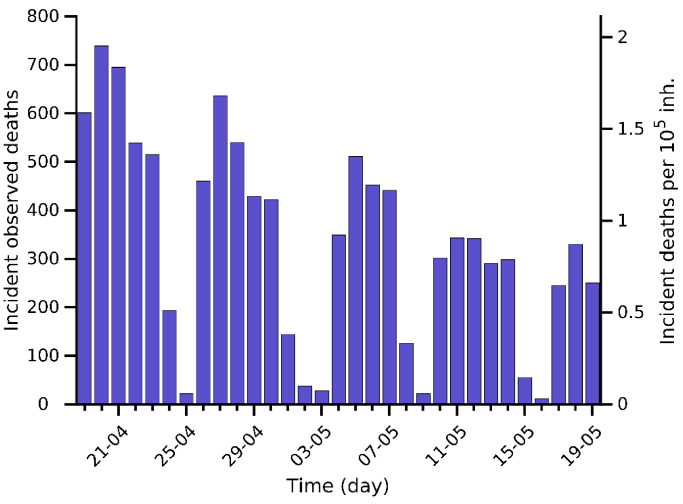
	A14	EPG	CFR	N7	D7
Today	114	75	2.45 %	2227	211
A Week ago	160	148	1.70 %	3912	290
Maximum	1004	1119	5.00 %	28878	604

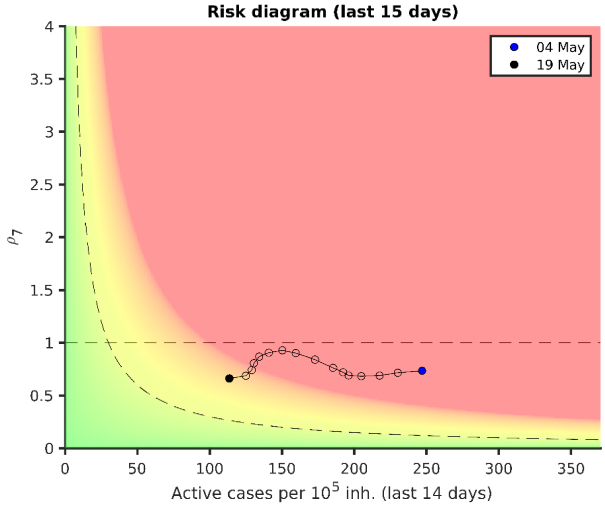




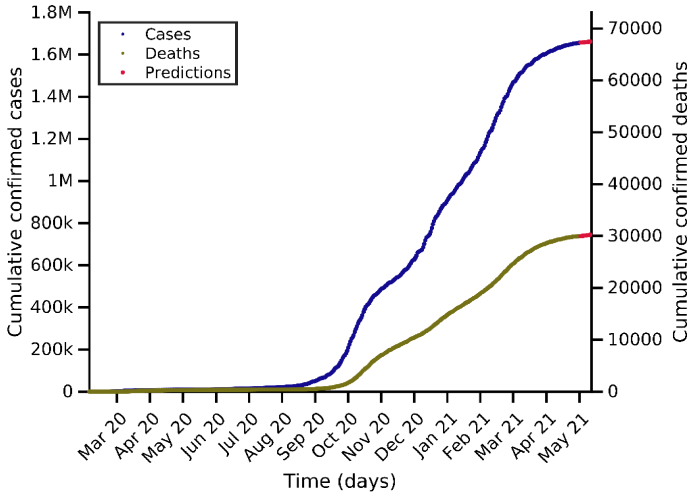








Czech Rep 19-05-2021. Pop: 10.7M. Cumulative incidence: 15466/10^5

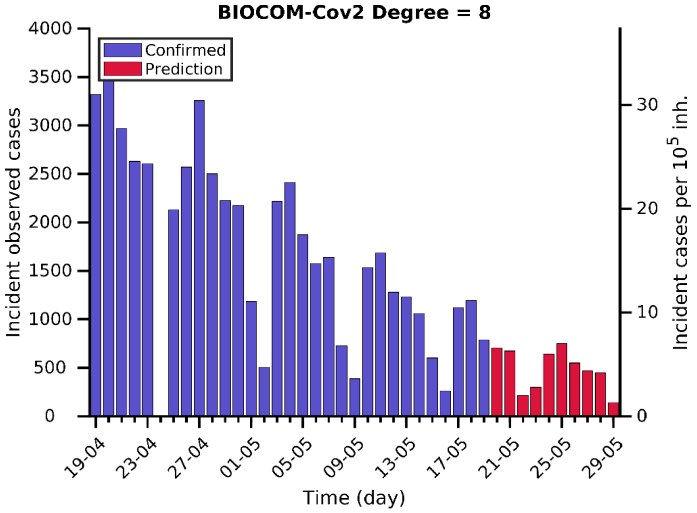


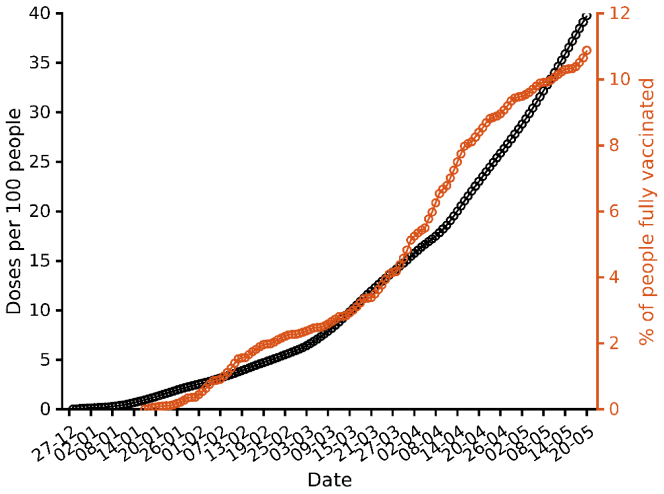
Predictions for next days

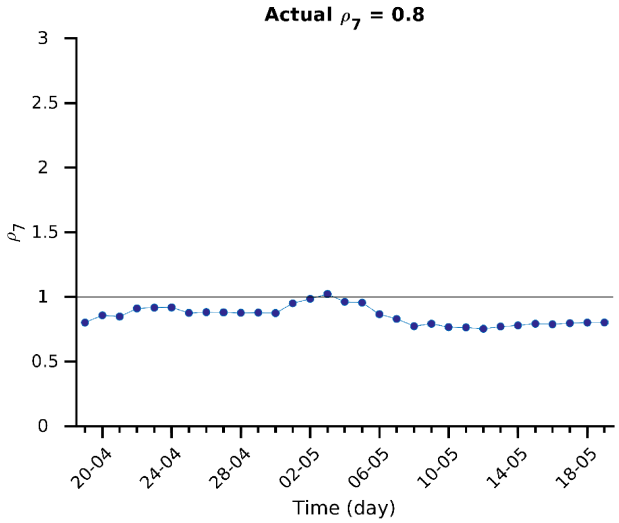
Day	Number of cases
22-05-2021	1657792 (+1590)
26-05-2021	1660031 (+3829)
29-05-2021	1661085 (+4883)

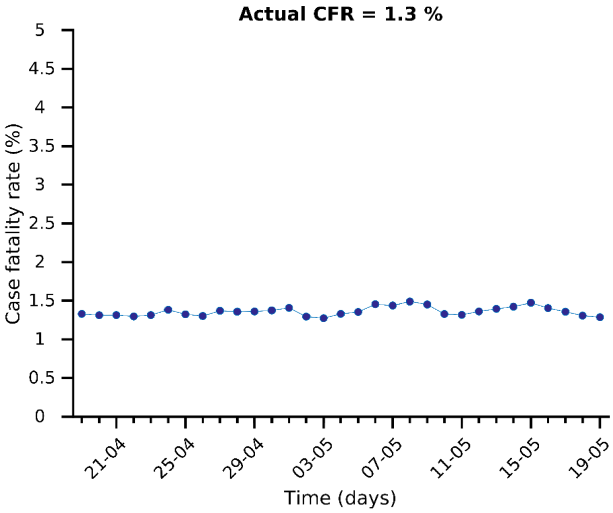
Current indicators

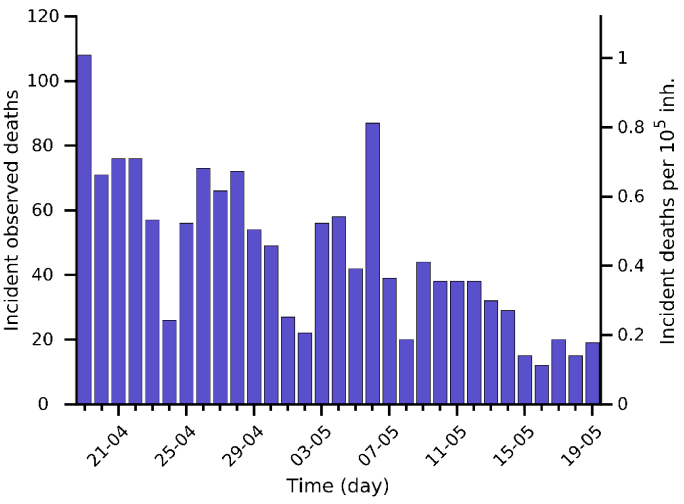
	A14	EPG	CFR	N7	D7
Today	141	113	1.29 %	894	20
A Week ago	200	151	1.36 %	1261	43
Maximum	1586	1852	4.98 %	12955	220

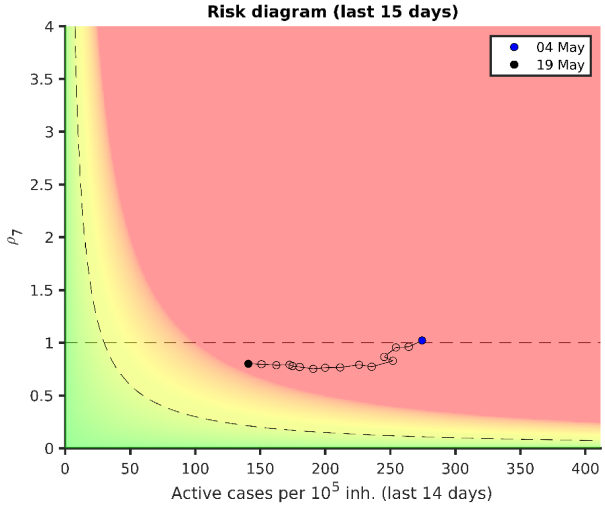




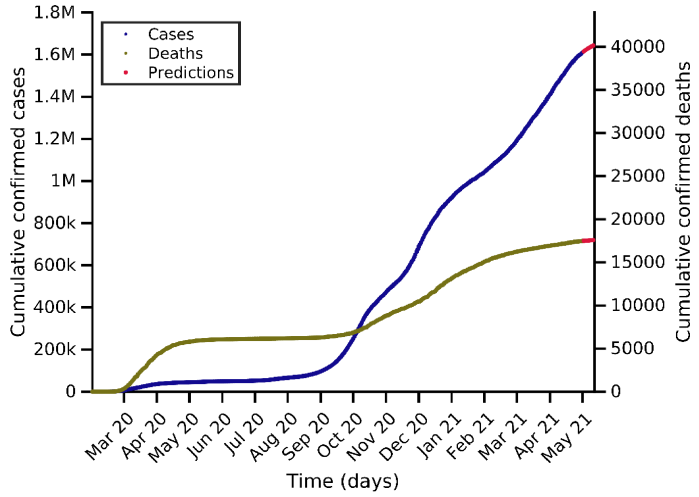








Netherlands 19-05-2021. Pop: 17.1M. Cumulative incidence: 9401/10⁵

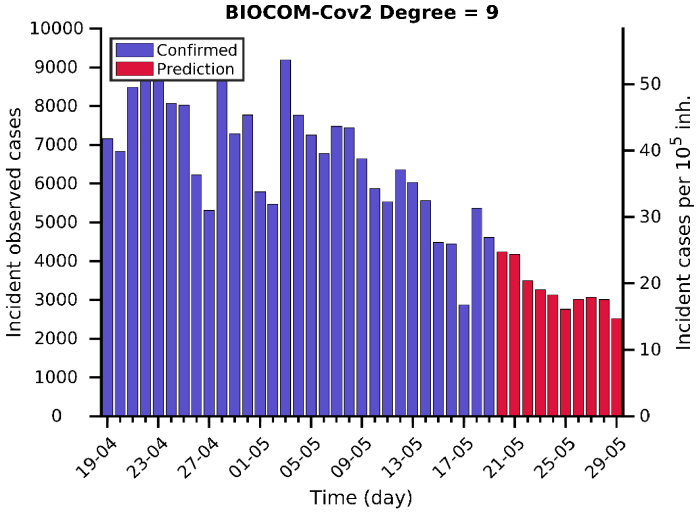


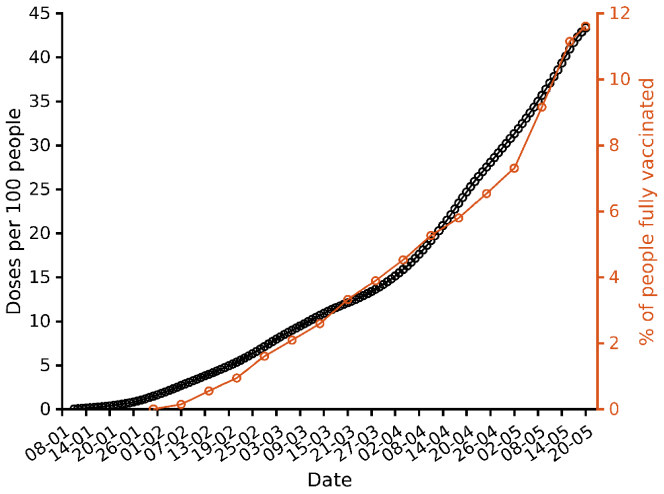
Predictions for next days

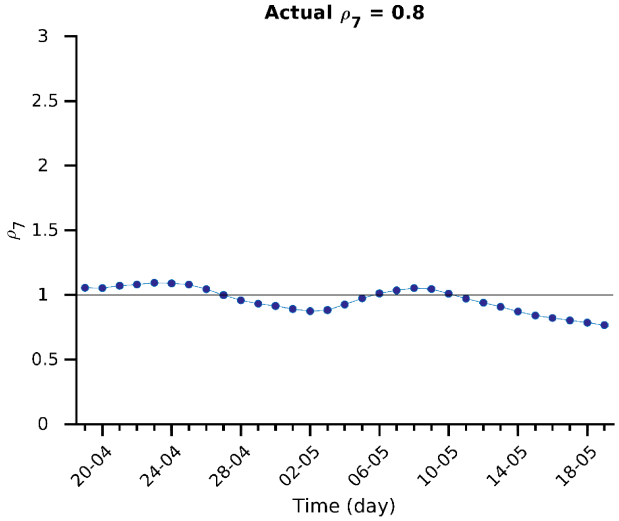
Day	Number of cases
22-05-2021	1622783 (+11915)
26-05-2021	1634944 (+24076)
29-05-2021	1643529 (+32661)

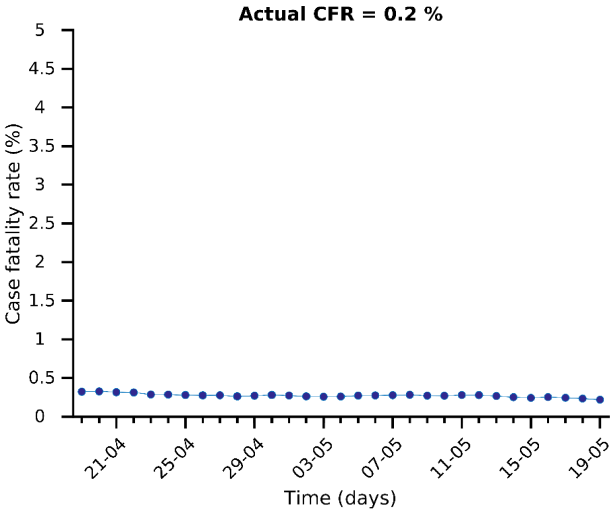
Current indicators

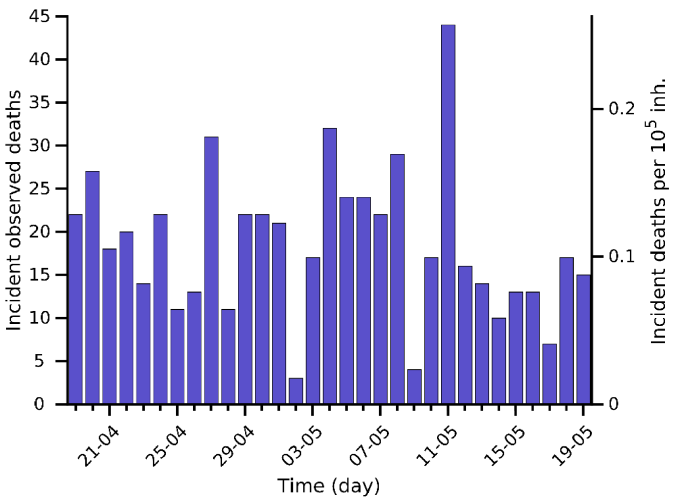
	A14	EPG	CFR	N7	D7
Today	464	355	0.22 %	4765	13
A Week ago	564	530	0.28 %	6584	22
Maximum	877	1029	5.00 %	11729	153

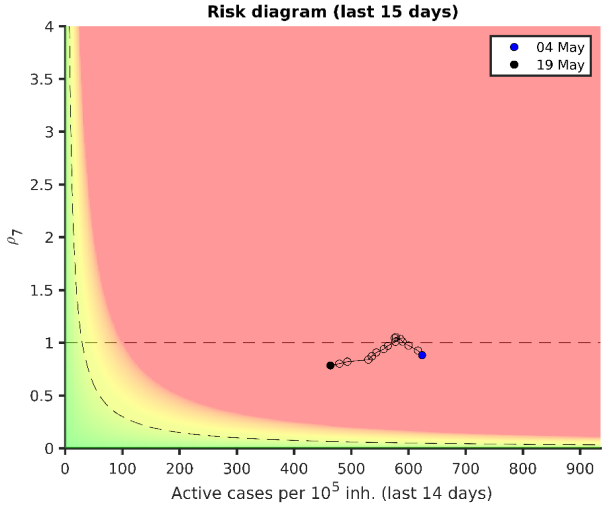




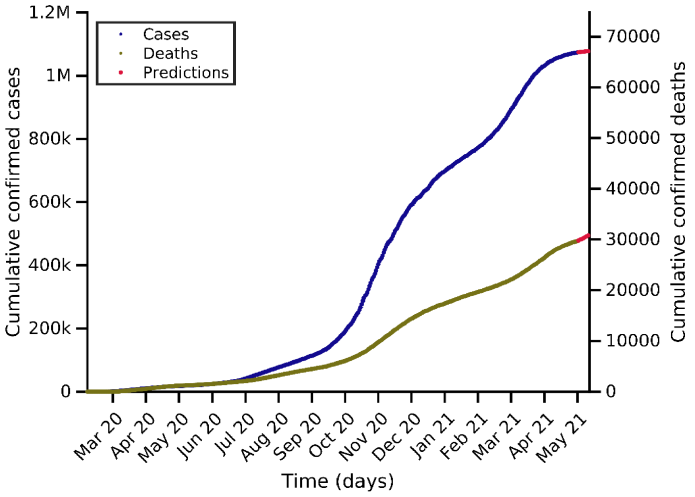








Romania 19-05-2021. Pop: 19.2M. Cumulative incidence: 5581/10⁵

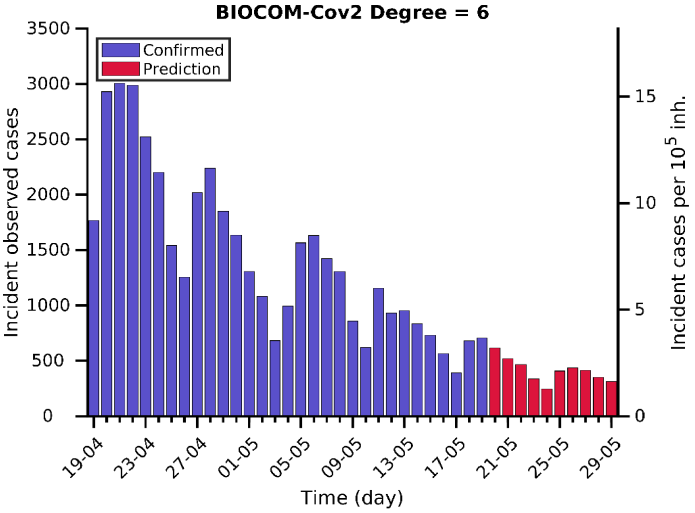


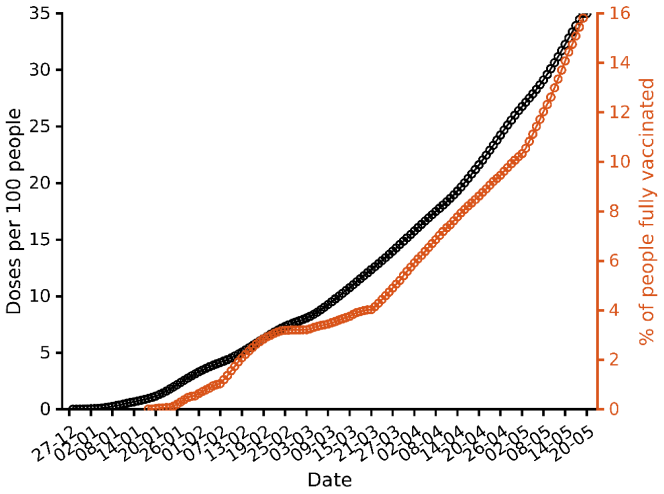
Predictions for next days

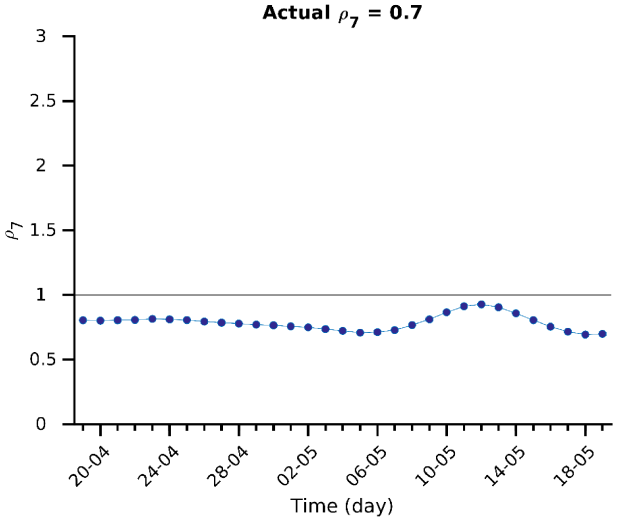
Day	Number of cases
22-05-2021	1075279 (+1600)
26-05-2021	1076707 (+3028)
29-05-2021	1077787 (+4108)

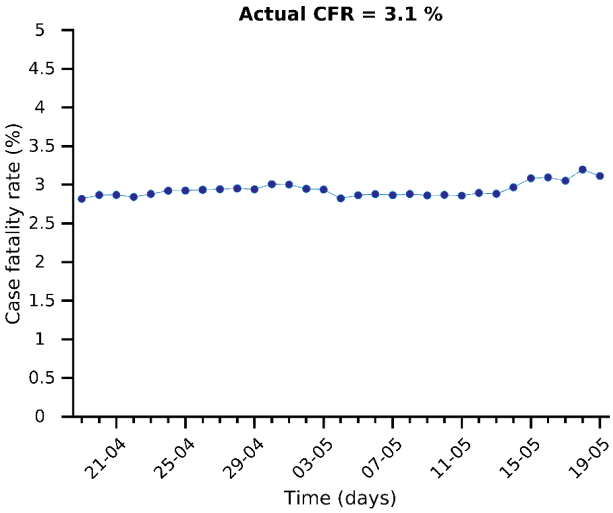
Current indicators

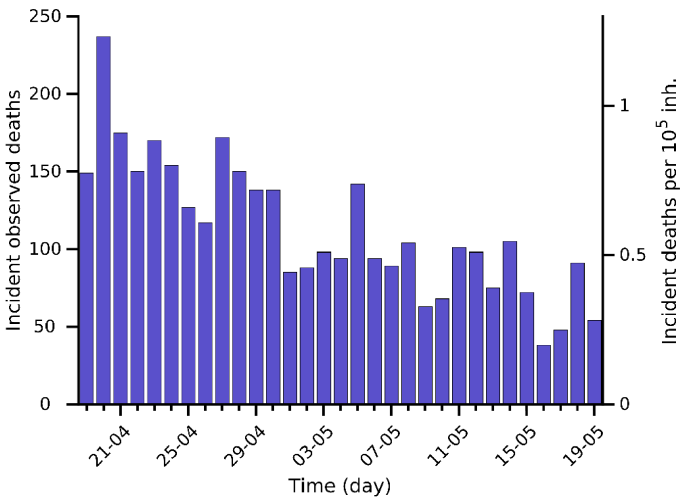
	A14	EPG	CFR	N7	D7
Today	66	46	3.11 %	695	69
A Week ago	89	82	2.89 %	1132	88
Maximum	608	674	4.96 %	8521	171

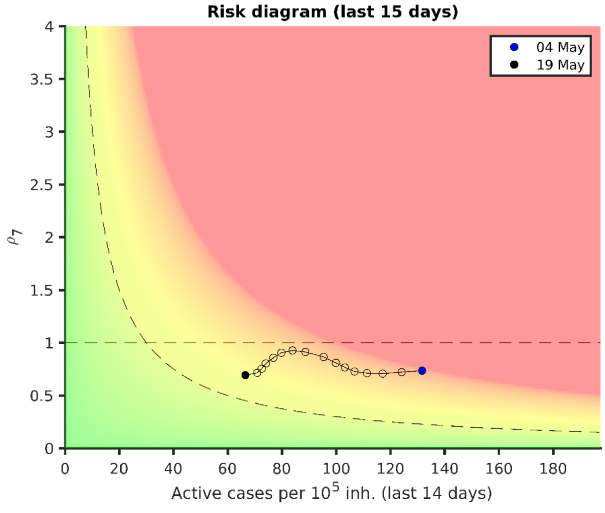




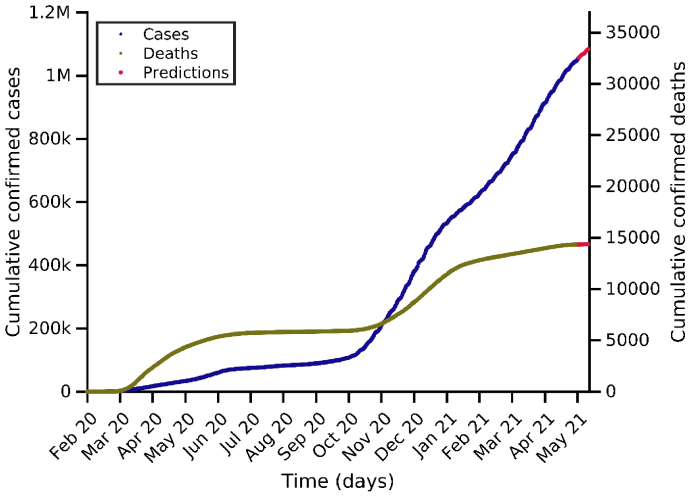








Sweden 19-05-2021. Pop: 10.1M. Cumulative incidence: 10414/10⁵

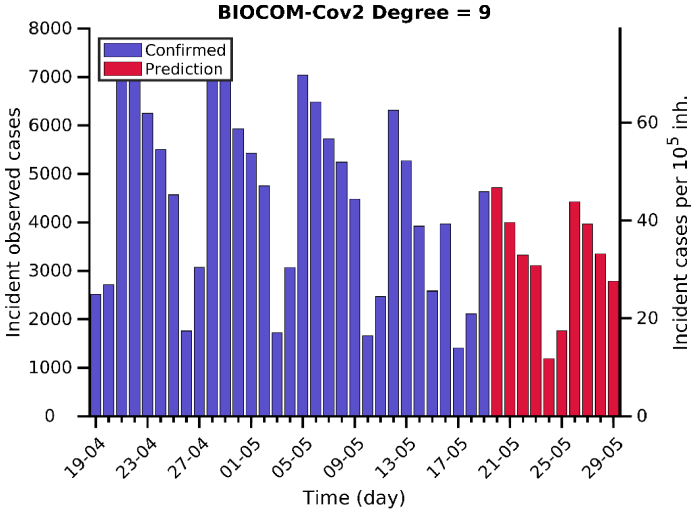


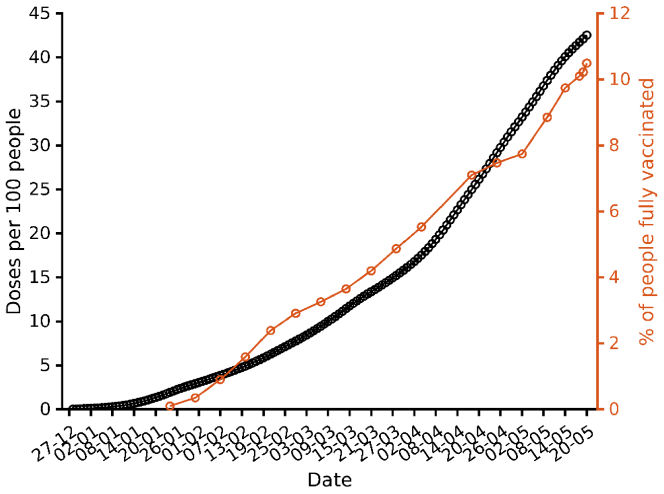
Predictions for next days

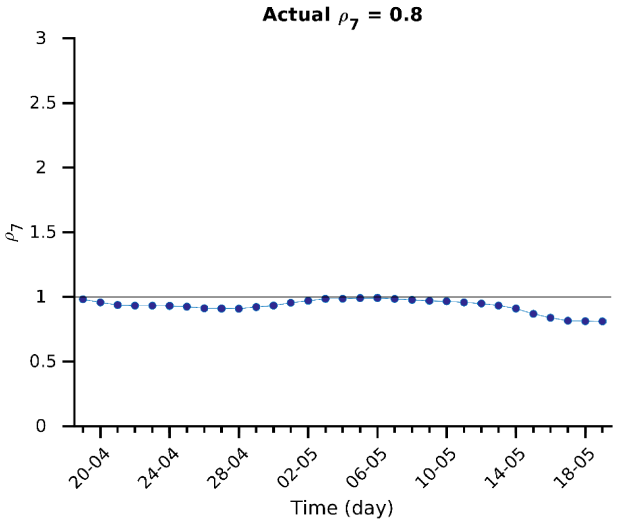
Day	Number of cases
22-05-2021	1063799 (+12037)
26-05-2021	1074288 (+22526)
29-05-2021	1084394 (+32632)

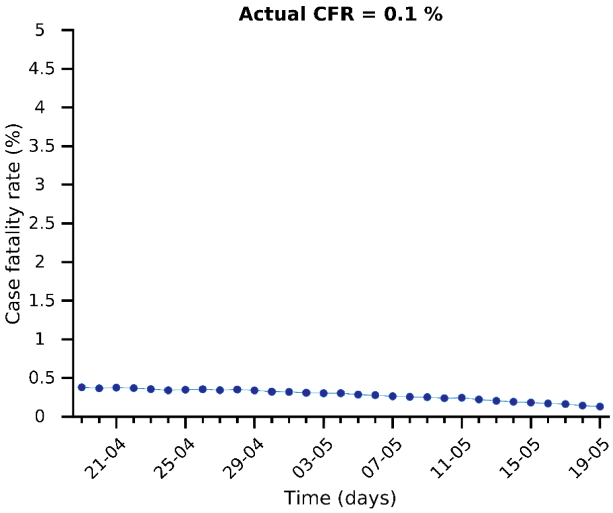
Current indicators

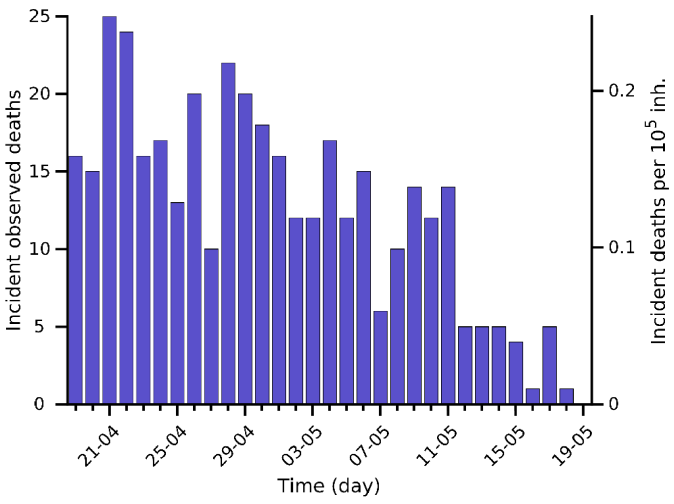
	A14	EPG	CFR	N7	D7
Today	557	452	0.13 %	3414	3
A Week ago	668	634	0.22 %	4624	11
Maximum	924	1008	4.86 %	7136	100

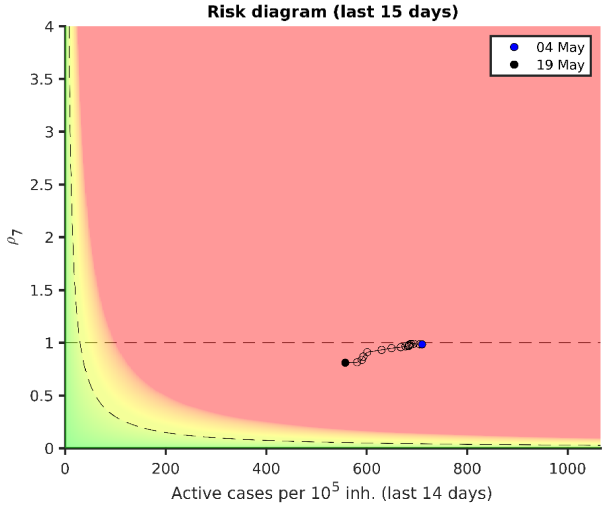




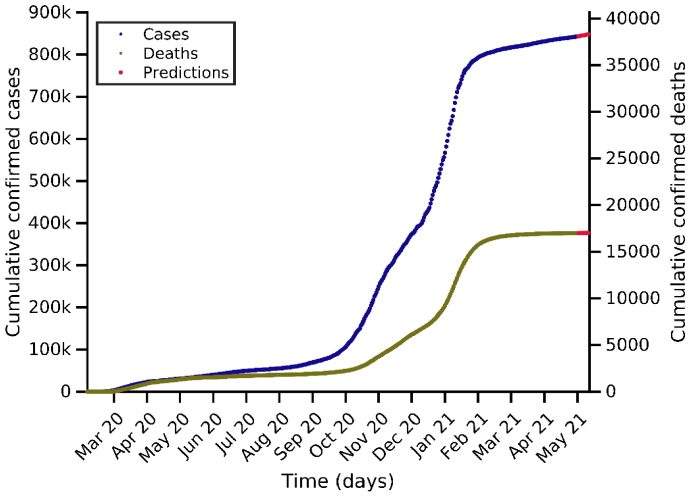








Portugal 19-05-2021. Pop: 10.2M. Cumulative incidence: 8270/10⁵

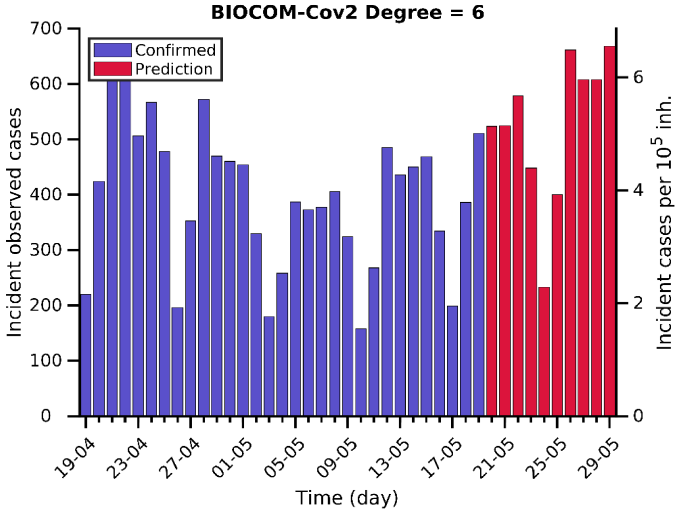


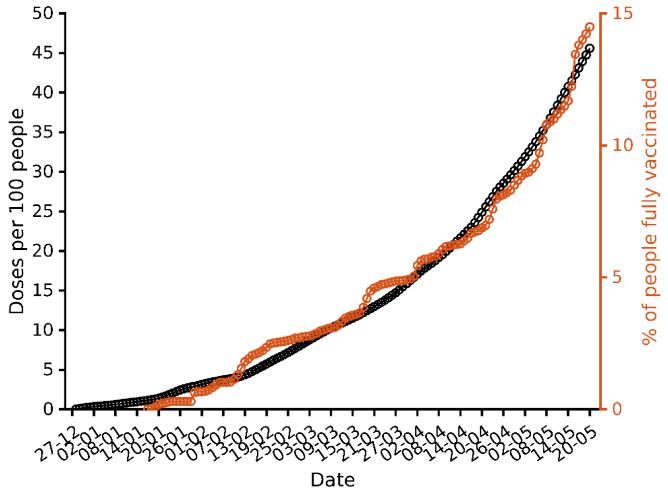
Predictions for next days

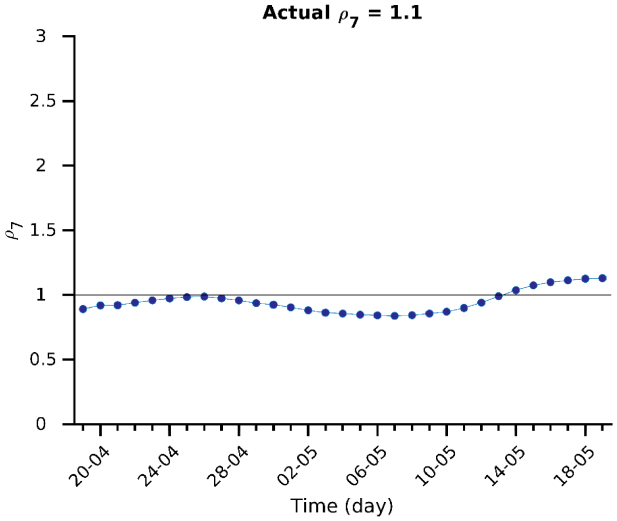
Day	Number of cases
22-05-2021	844904 (+1626)
26-05-2021	846647 (+3369)
29-05-2021	848530 (+5252)

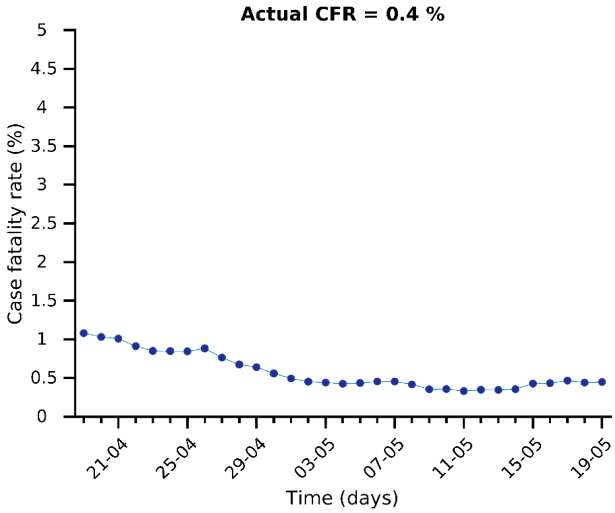
Current indicators

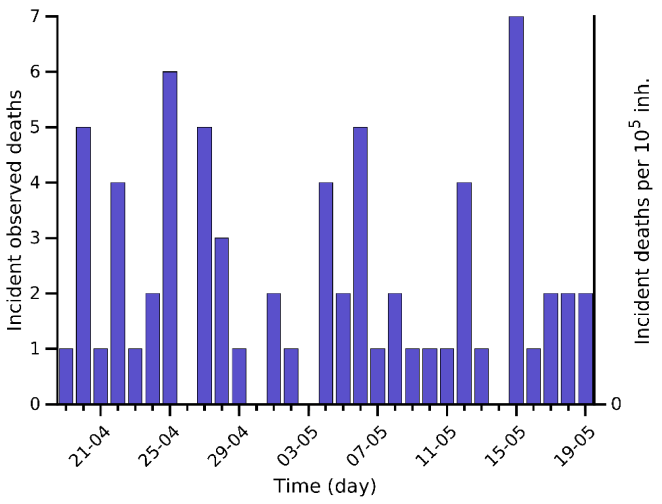
	A14	EPG	CFR	N7	D7
Today	51	57	0.45 %	398	2
A Week ago	48	45	0.35 %	342	2
Maximum	1683	1813	4.98 %	12891	291

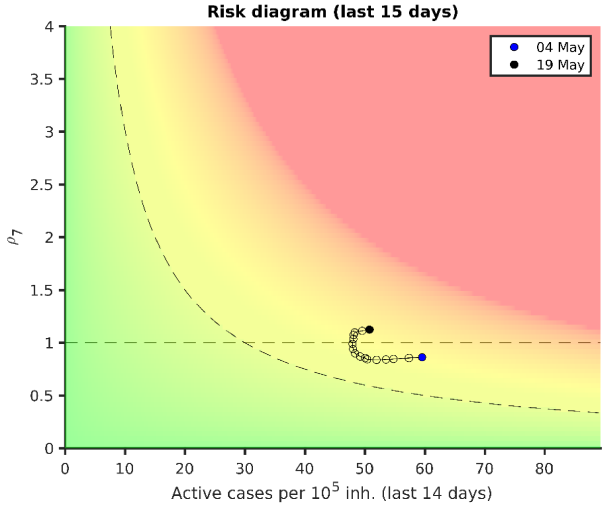




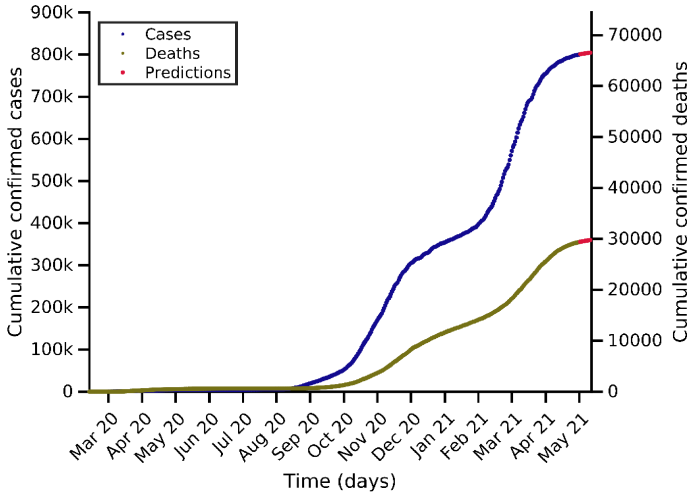








Hungary 19-05-2021. Pop: 9.7M. Cumulative incidence: 8285/10⁵

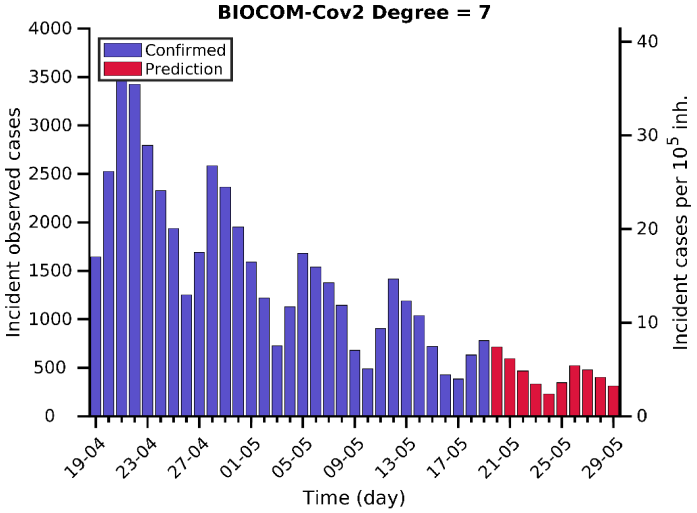


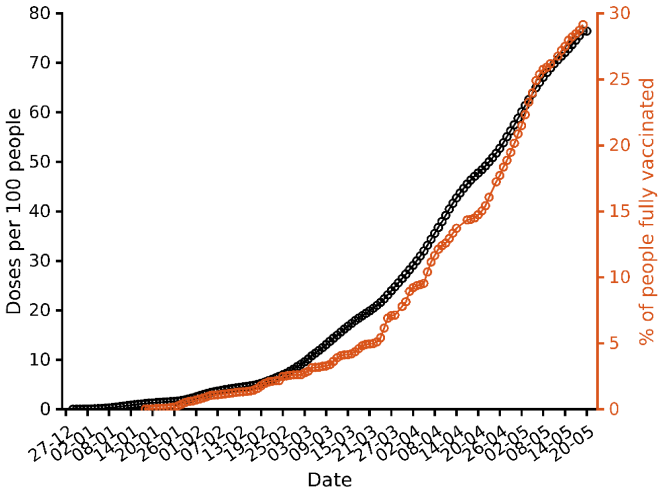
Predictions for next days

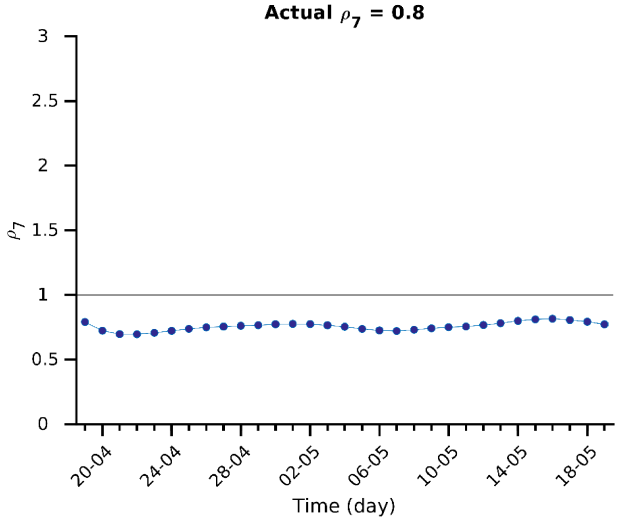
Day	Number of cases
22-05-2021	802141 (+1773)
26-05-2021	803568 (+3200)
29-05-2021	804756 (+4388)

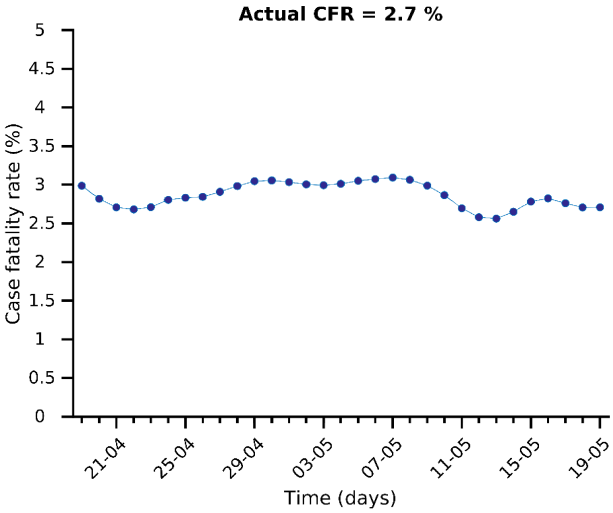
Current indicators

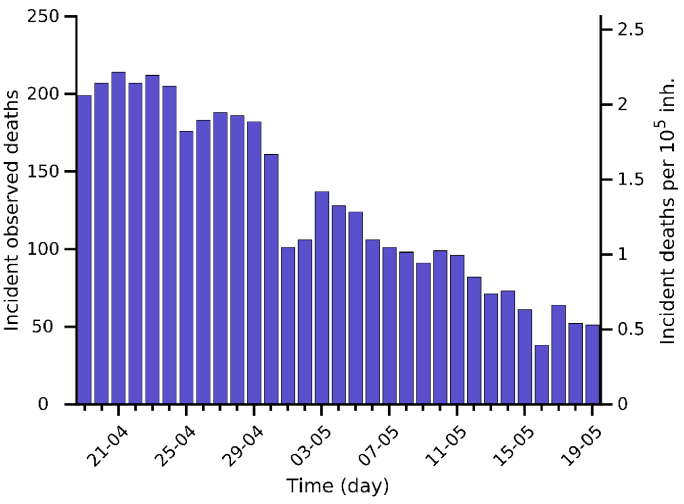
	A14	EPG	CFR	N7	D7
Today	132	102	2.71 %	738	59
A Week ago	189	145	2.58 %	1079	96
Maximum	1270	1470	4.96 %	9253	269

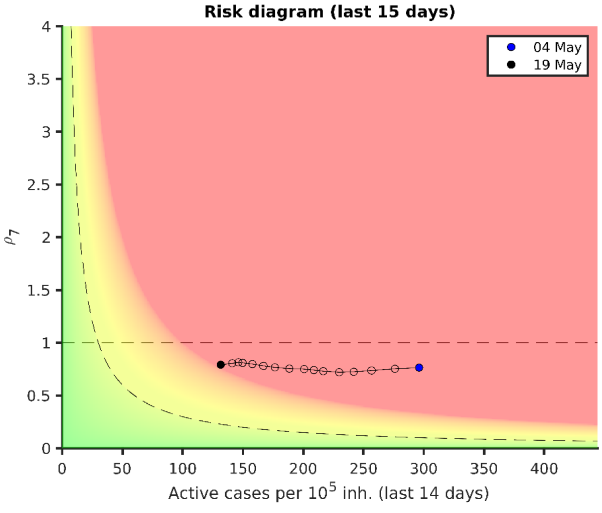




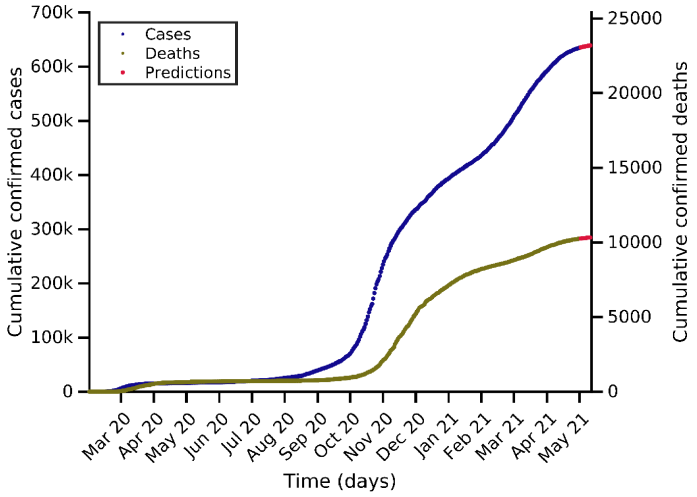








Austria 19-05-2021. Pop: 9.0M. Cumulative incidence: 7050/10⁵

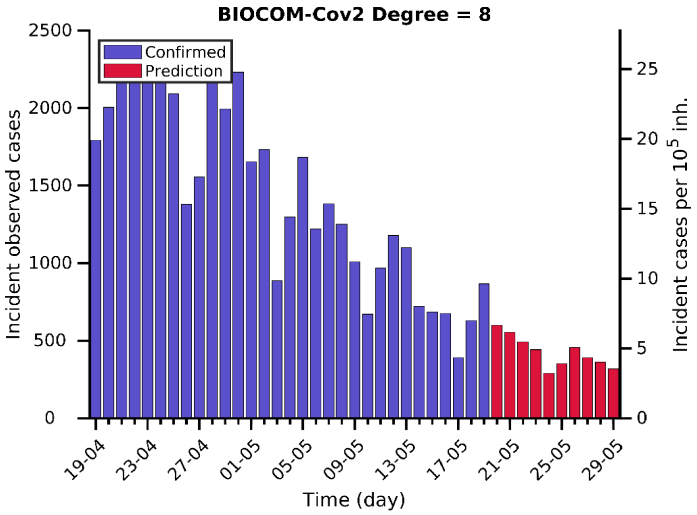


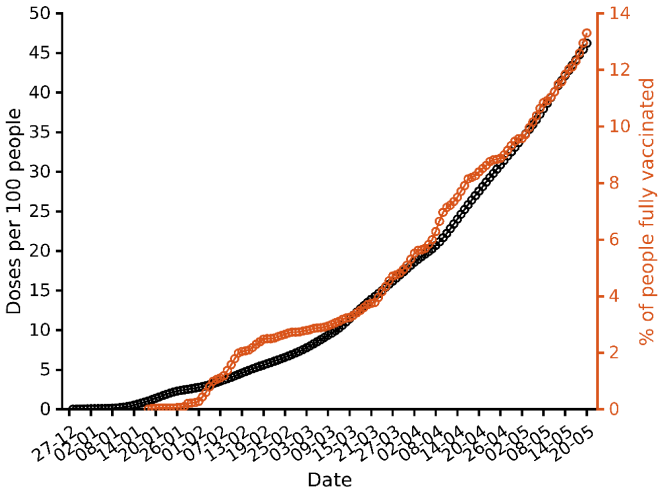
Predictions for next days

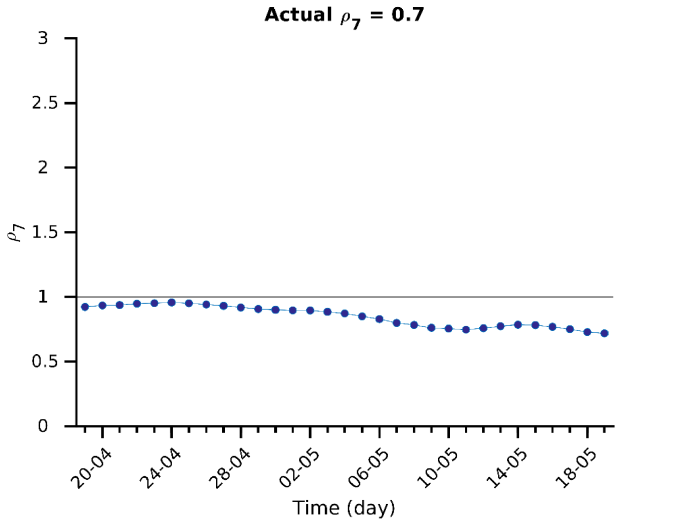
Day	Number of cases
22-05-2021	636605 (+1644)
26-05-2021	638146 (+3185)
29-05-2021	639217 (+4256)

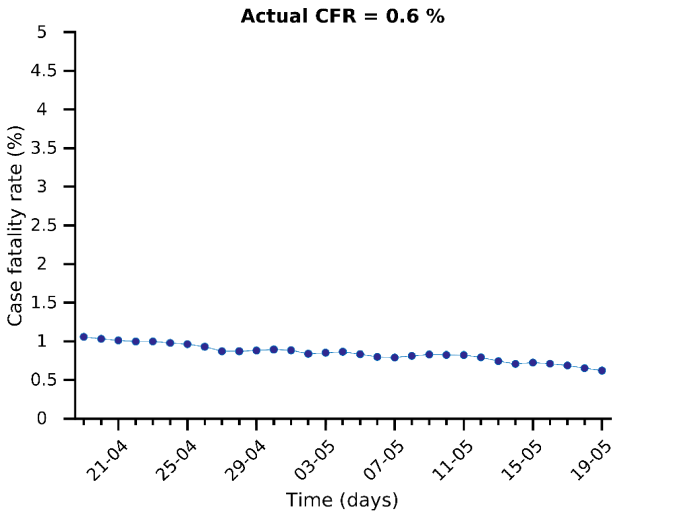
Current indicators

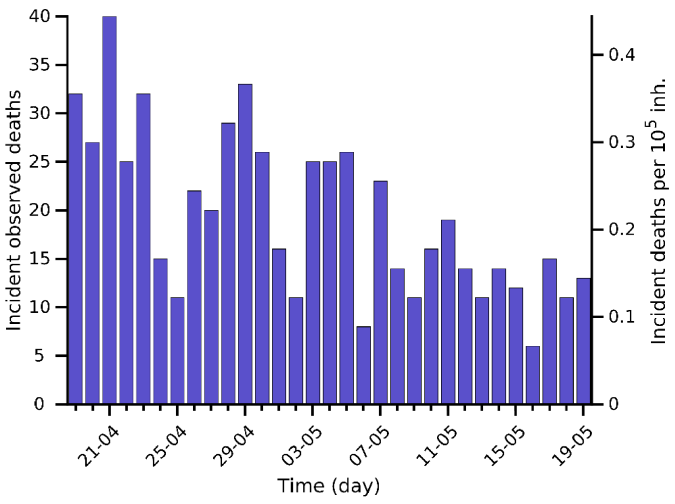
	A14	EPG	CFR	N7	D7
Today	142	102	0.62 %	724	12
A Week ago	213	161	0.79 %	1097	15
Maximum	1067	1260	4.93 %	7489	122

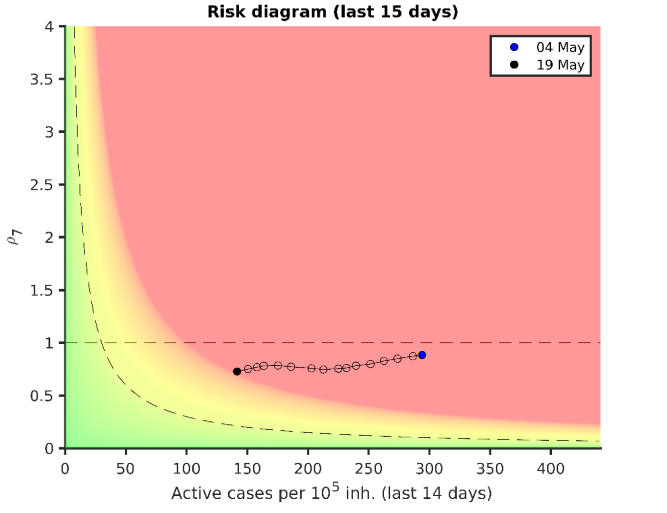




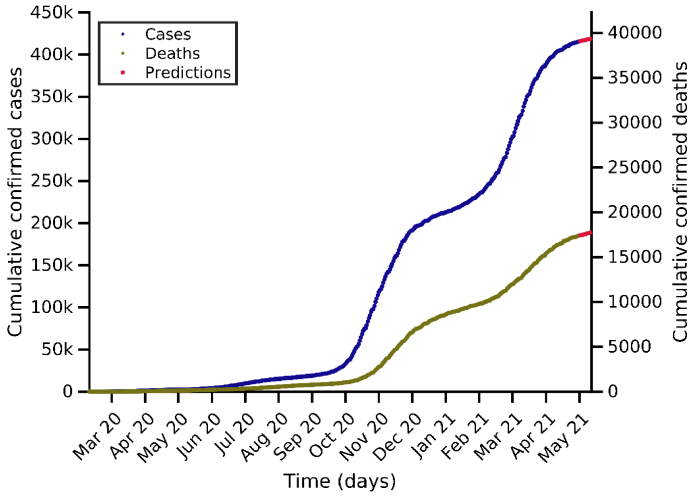








Bulgaria 19-05-2021. Pop: 6.9M. Cumulative incidence: 5982/10⁵

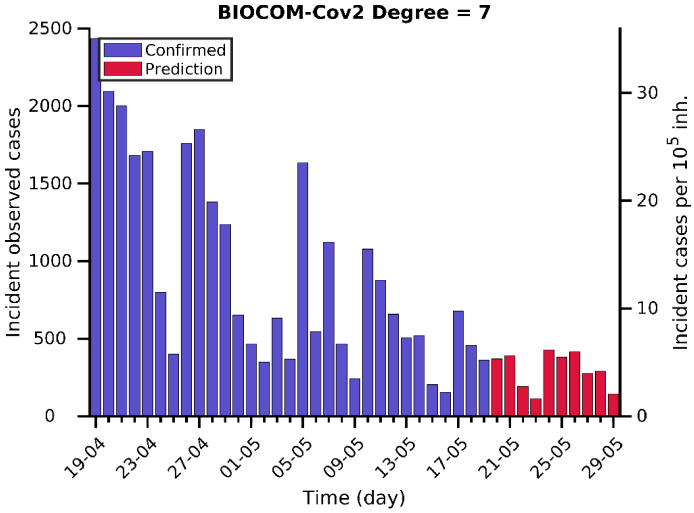


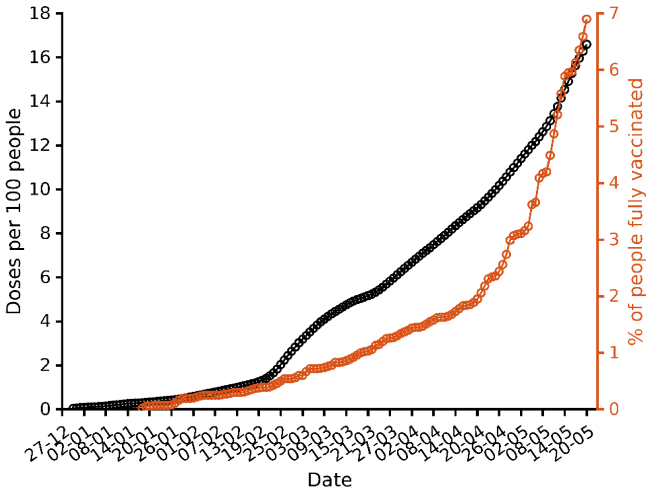
Predictions for next days

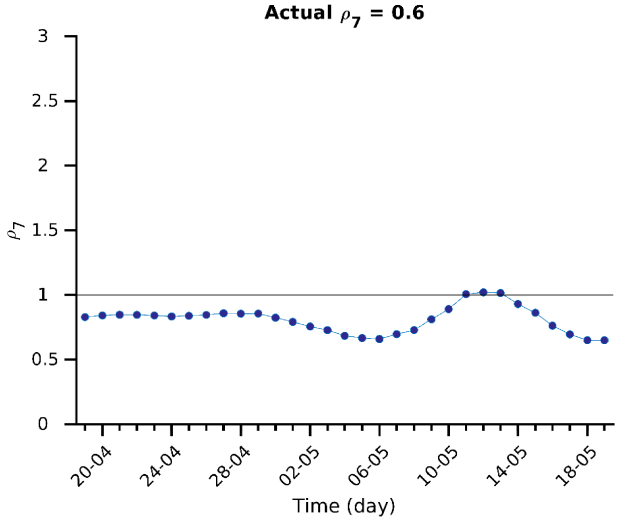
Day	Number of cases
22-05-2021	416639 (+952)
26-05-2021	417977 (+2290)
29-05-2021	418687 (+3000)

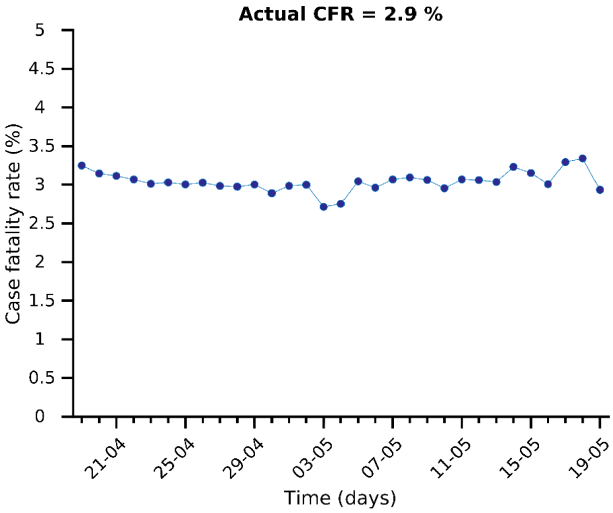
Current indicators

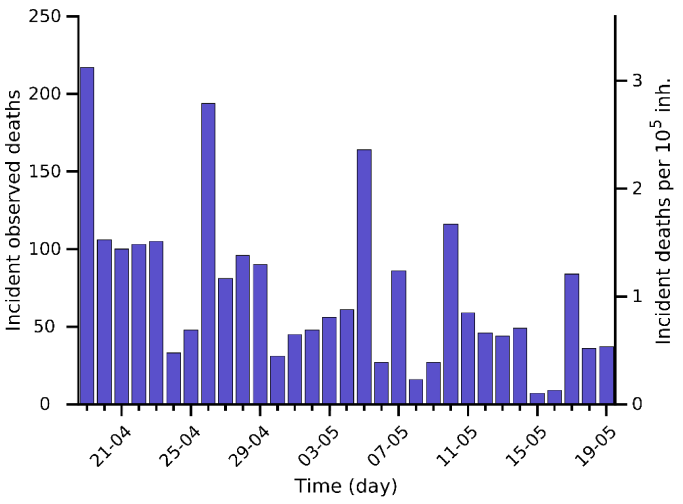
	A14	EPG	CFR	N7	D7
Today	113	73	2.93 %	410	38
A Week ago	149	152	3.06 %	712	54
Maximum	732	778	5.00 %	3669	140

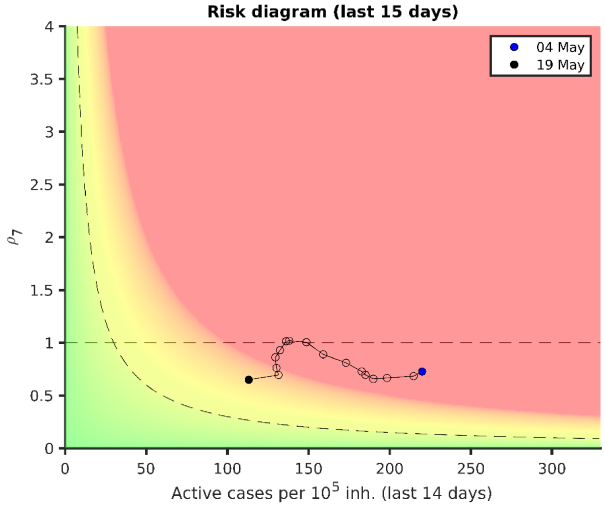




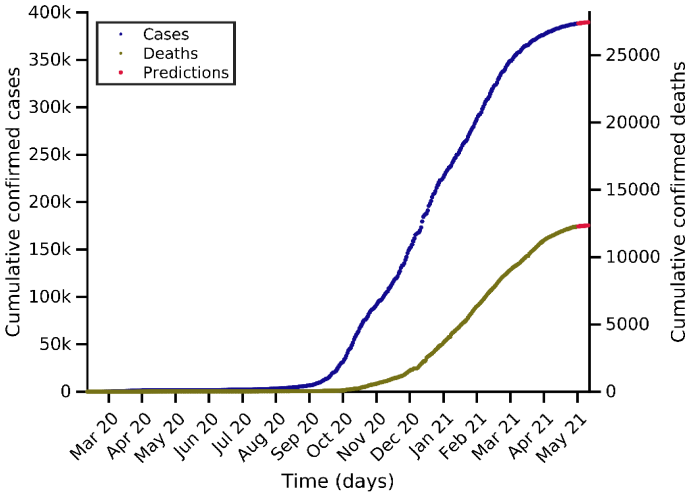








Slovakia 19-05-2021. Pop: 5.5M. Cumulative incidence: 7114/10⁵

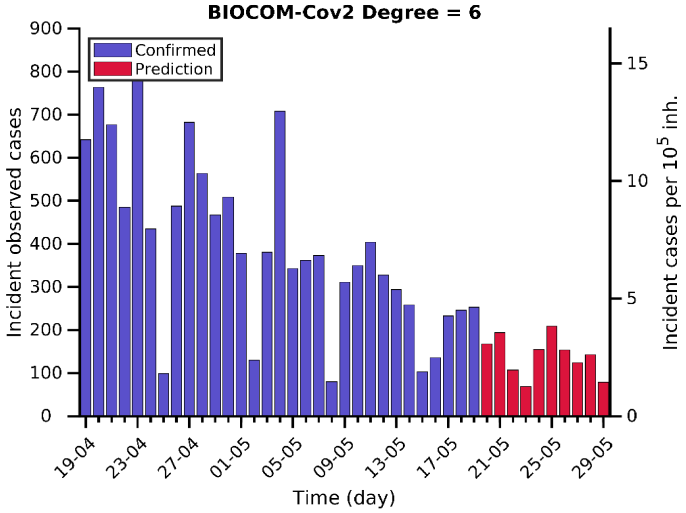


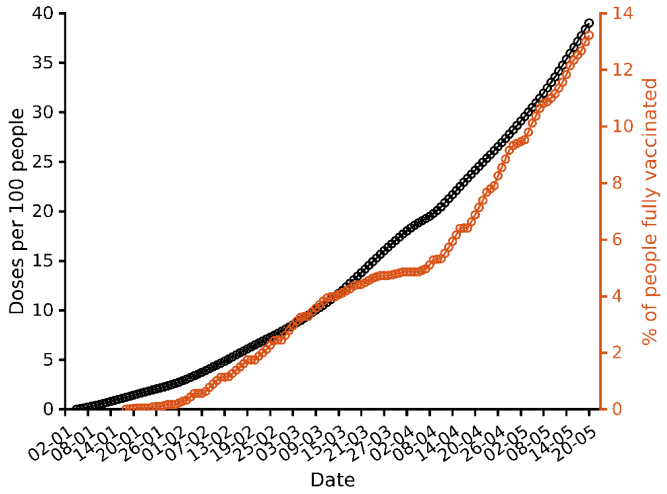
Predictions for next days

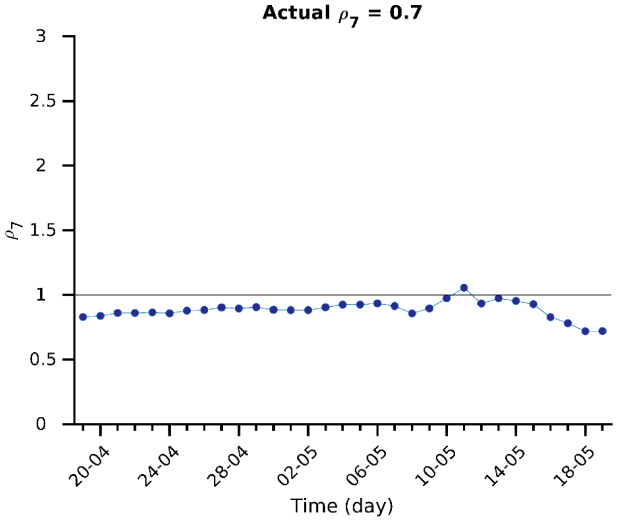
Day	Number of cases
22-05-2021	388860 (+469)
26-05-2021	389446 (+1055)
29-05-2021	389792 (+1401)

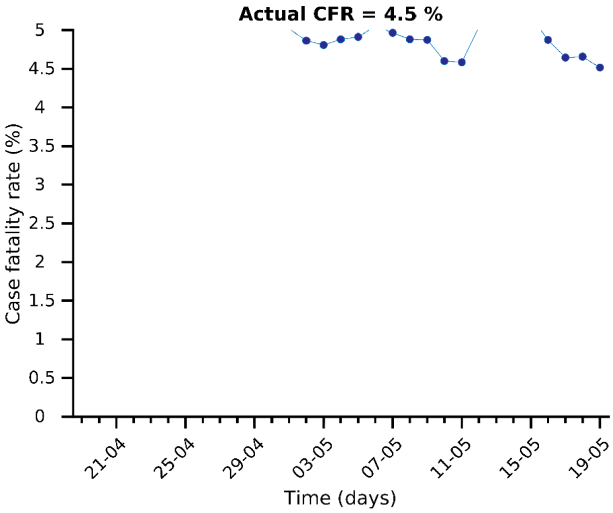
Current indicators

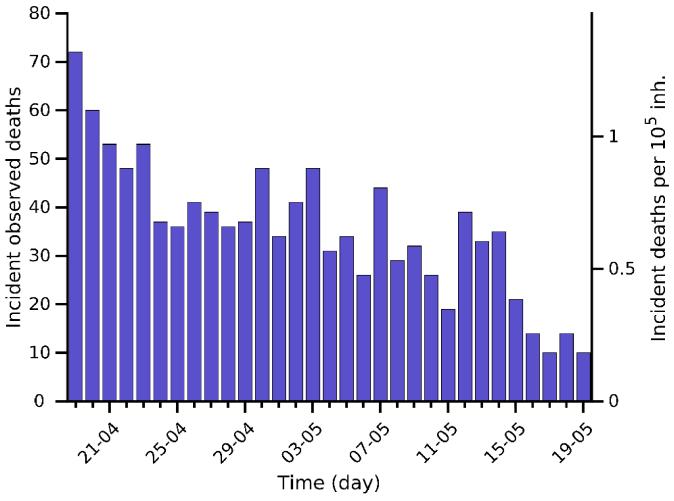
	A14	EPG	CFR	N7	D7
Today	68	49	4.52 %	218	20
A Week ago	94	88	5.04 %	315	31
Maximum	766	873	4.98 %	3260	113

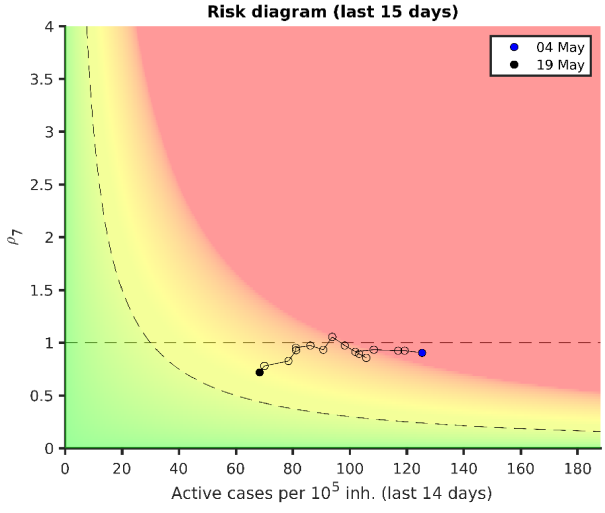




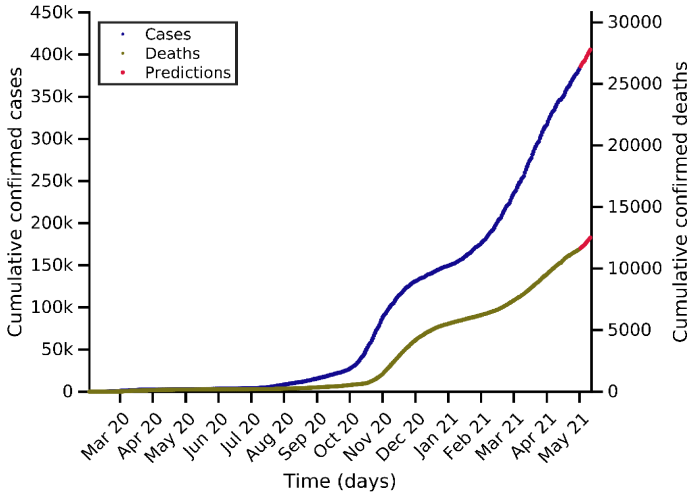








Greece 19-05-2021. Pop: 10.4M. Cumulative incidence: 3680/10^5

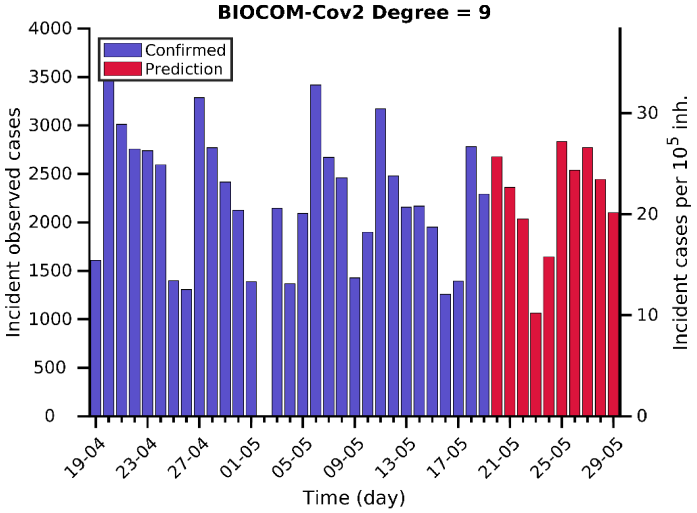


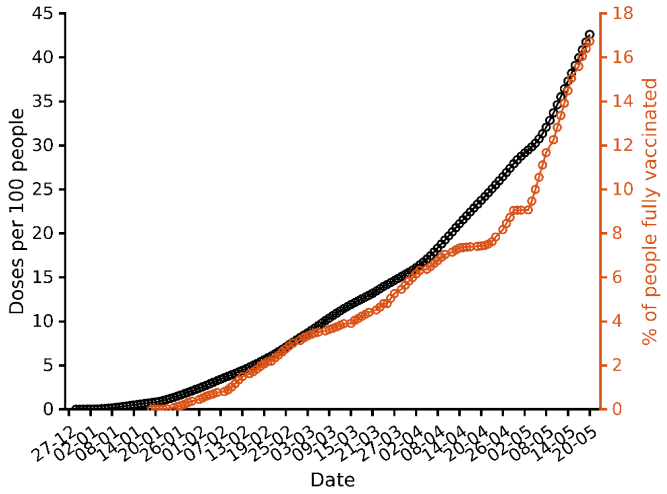
Predictions for next days

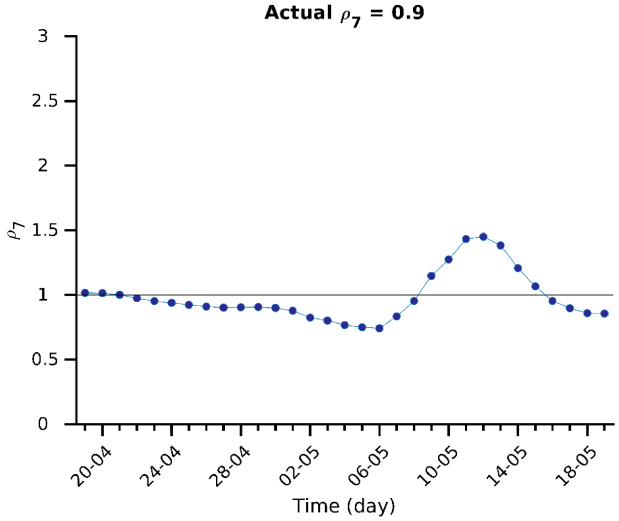
Day	Number of cases
22-05-2021	390633 (+7075)
26-05-2021	398714 (+15156)
29-05-2021	406030 (+22472)

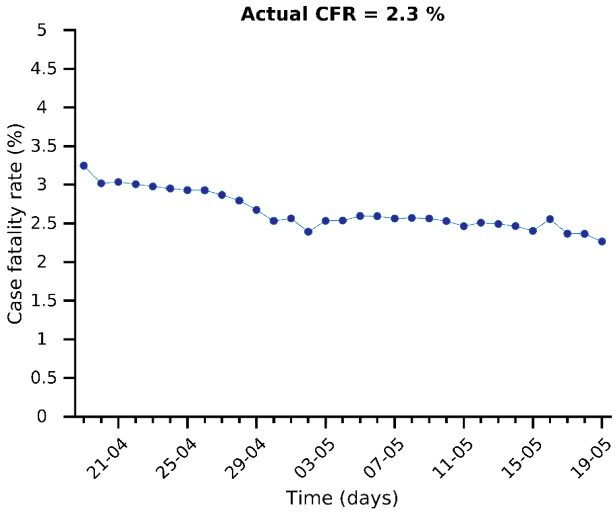
Current indicators

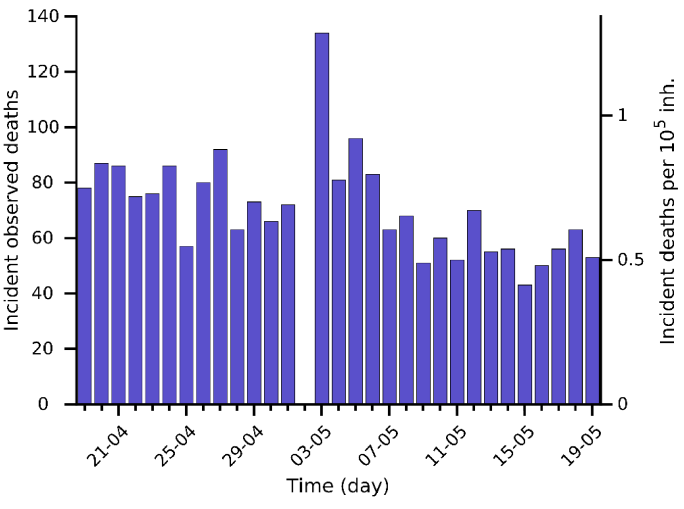
	A14	EPG	CFR	N7	D7
Today	303	259	2.27 %	2001	54
A Week ago	279	404	2.51 %	2504	64
Maximum	398	446	4.95 %	3075	101

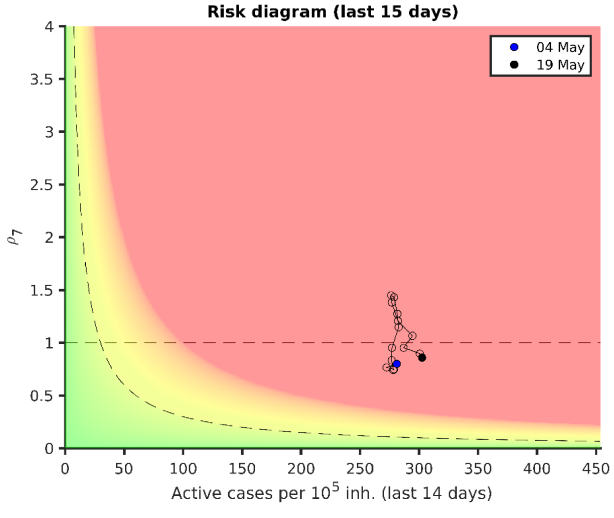




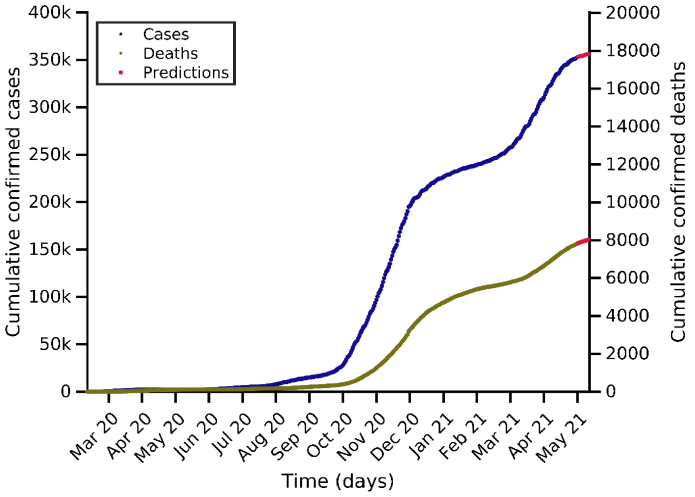








Croatia 19-05-2021. Pop: 4.1M. Cumulative incidence: 8591/10^5

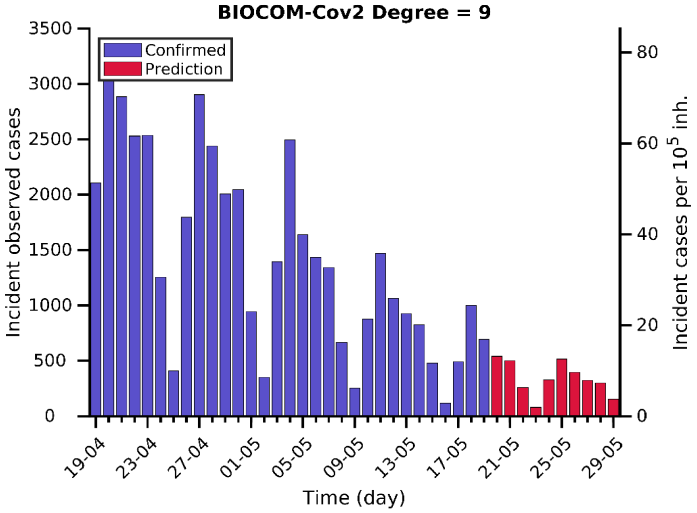


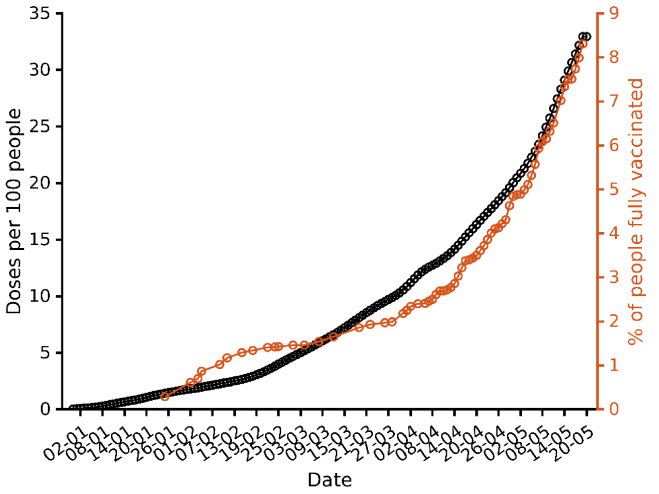
Predictions for next days

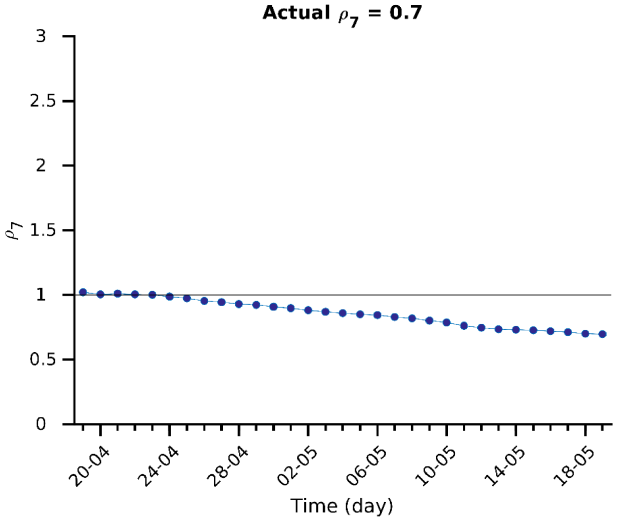
Day	Number of cases
22-05-2021	353990 (+1298)
26-05-2021	355308 (+2616)
29-05-2021	356085 (+3393)

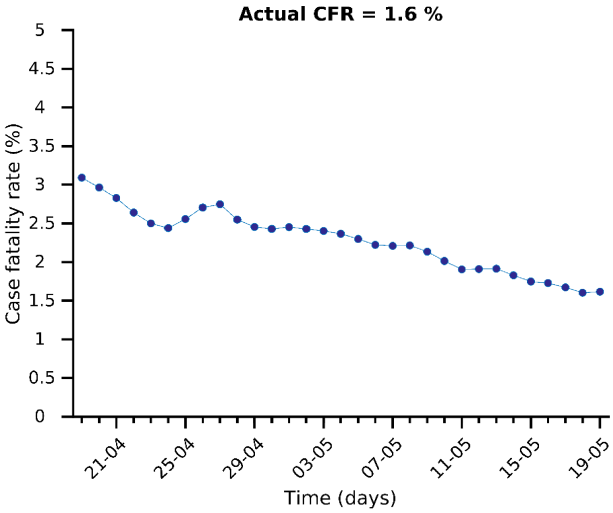
Current indicators

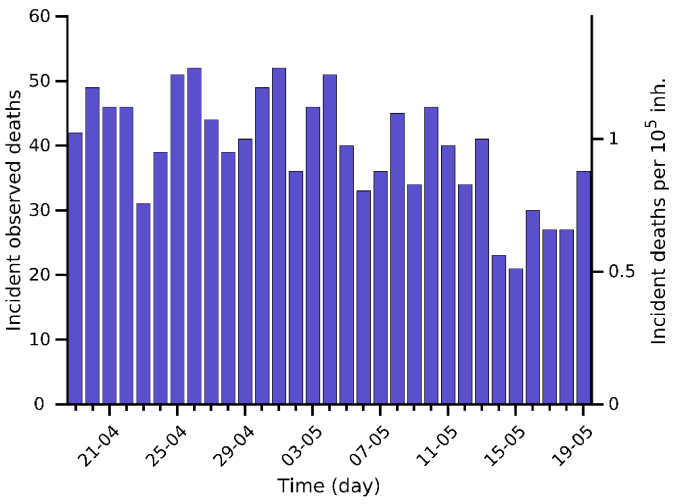
	A14	EPG	CFR	N7	D7
Today	284	197	1.62 %	648	29
A Week ago	438	327	1.91 %	1015	38
Maximum	1200	1264	4.90 %	3648	89

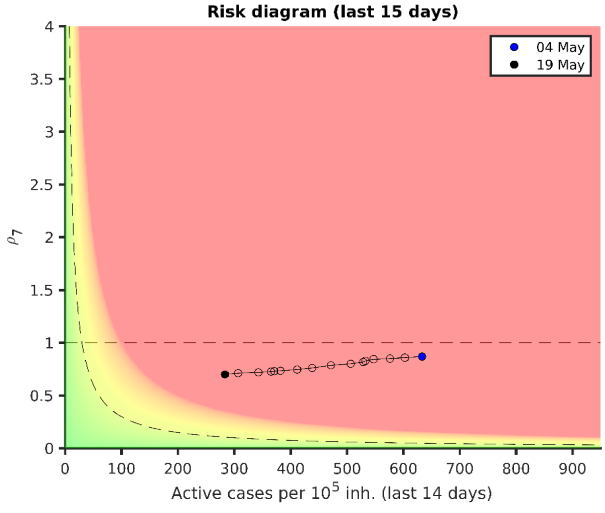




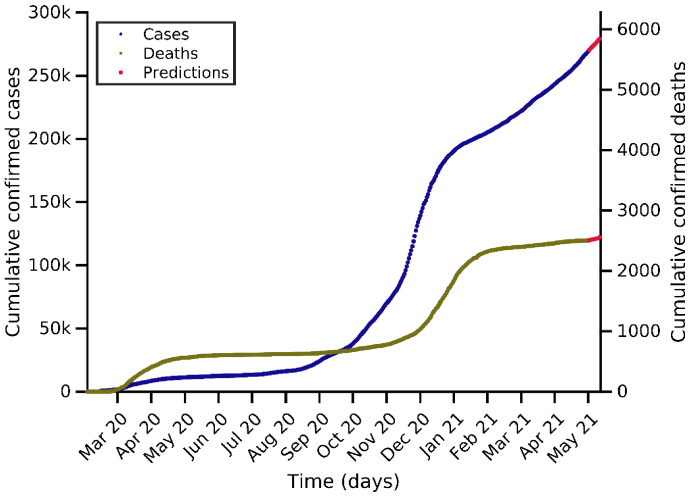








Denmark 19-05-2021. Pop: 5.8M. Cumulative incidence: 4650/10⁵

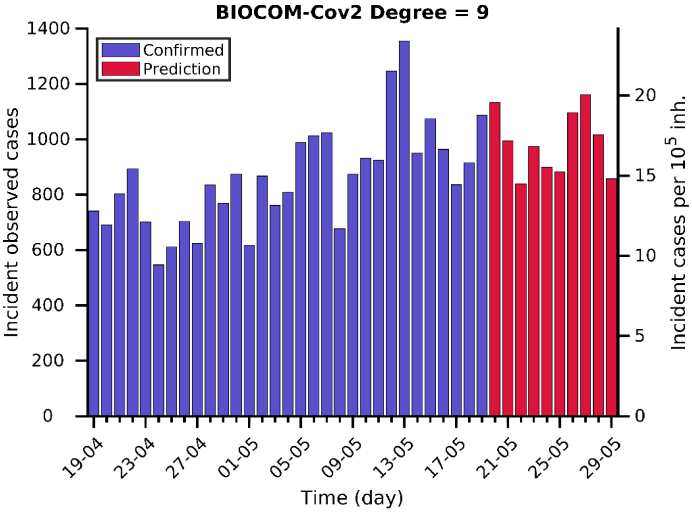


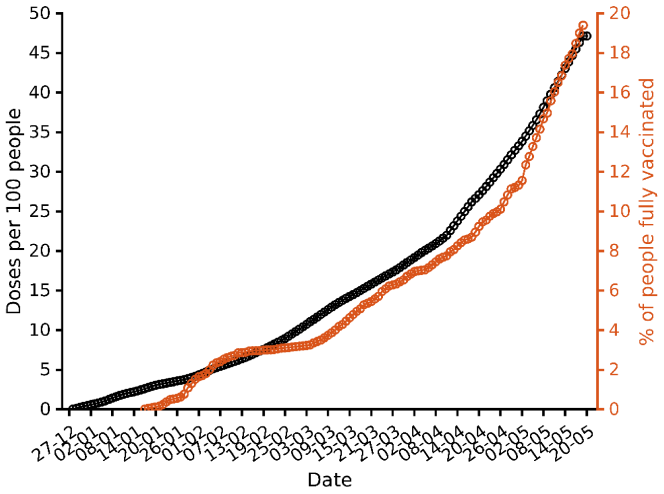
Predictions for next days

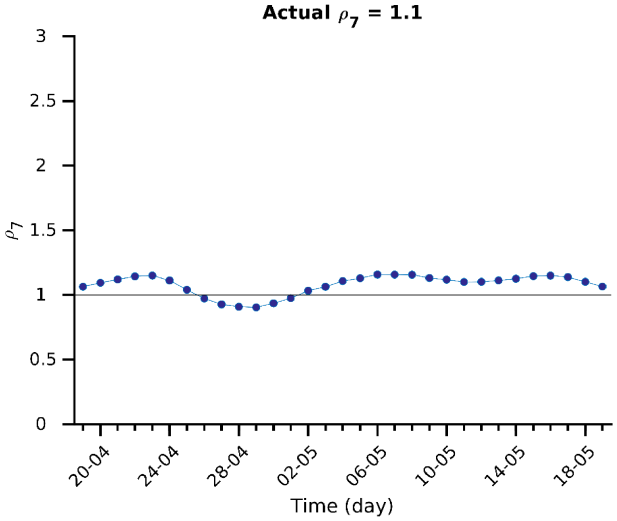
Day	Number of cases
22-05-2021	272308 (+2965)
26-05-2021	276160 (+6817)
29-05-2021	279196 (+9853)

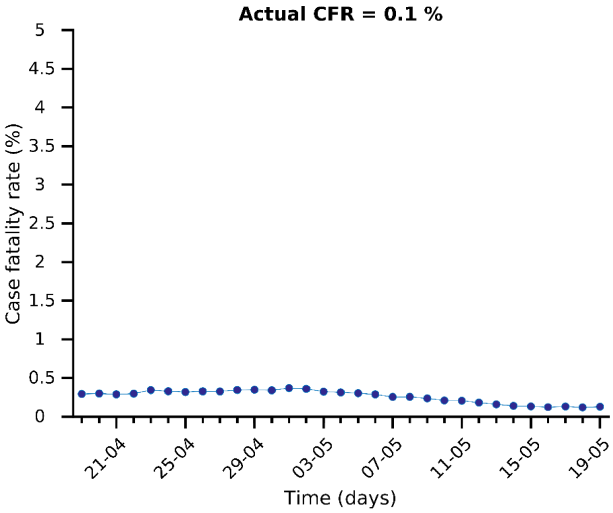
Current indicators

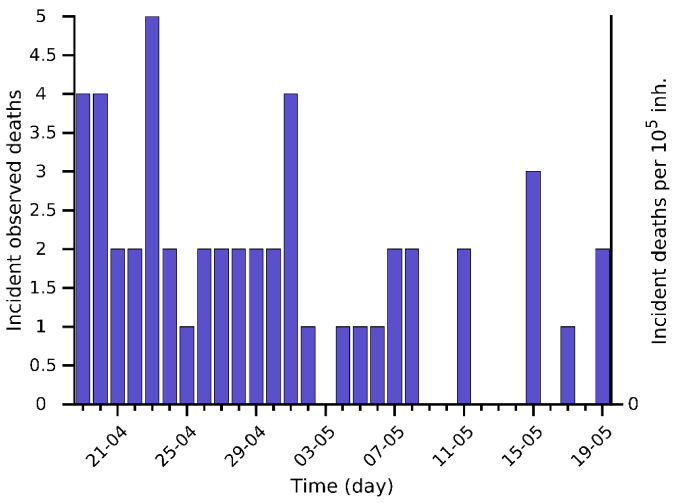
	A14	EPG	CFR	N7	D7
Today	240	255	0.13 %	1026	1
A Week ago	214	235	0.18 %	956	1
Maximum	801	983	4.97 %	3647	32

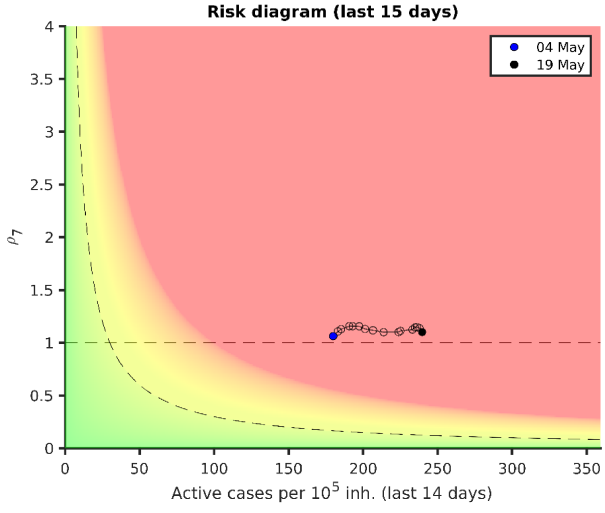




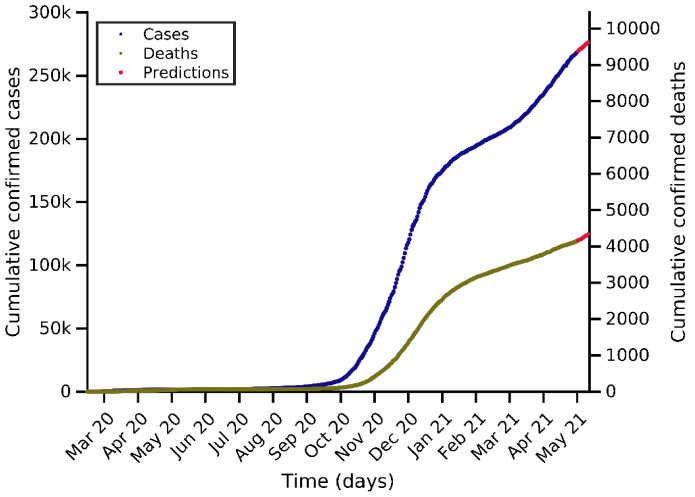








Lithuania 19-05-2021. Pop: 2.7M. Cumulative incidence: 9870/10⁵

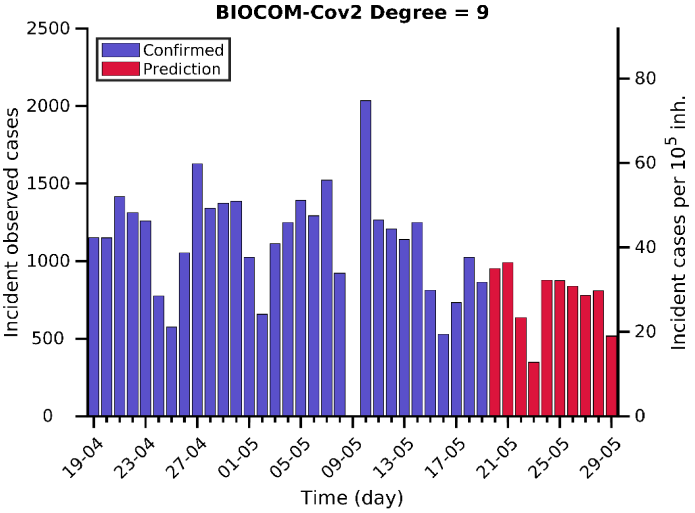


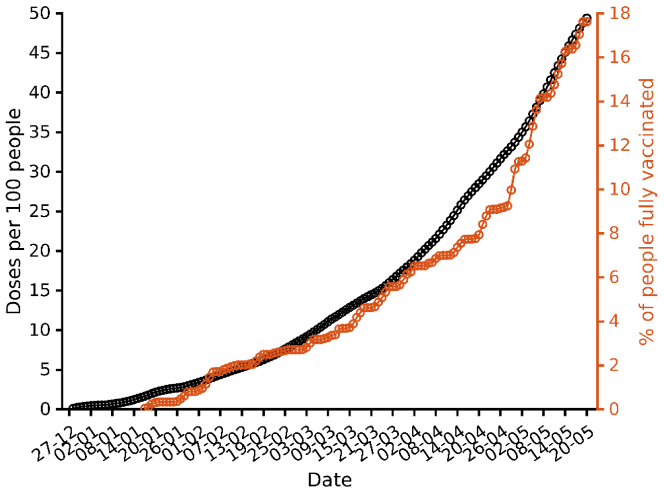
Predictions for next days

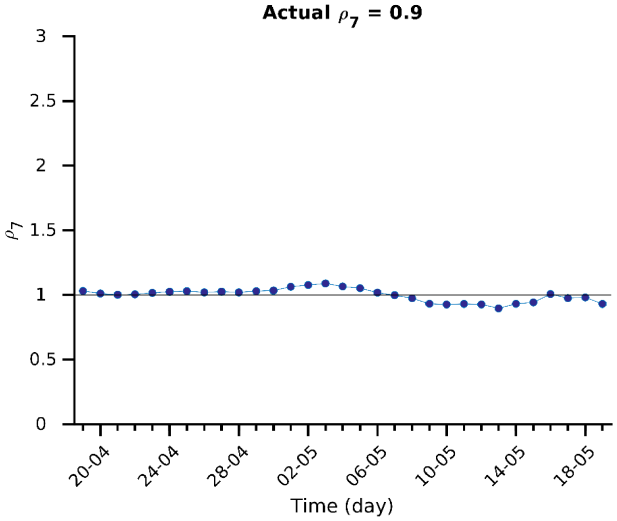
Day	Number of cases
22-05-2021	271266 (+2582)
26-05-2021	274203 (+5519)
29-05-2021	276306 (+7622)

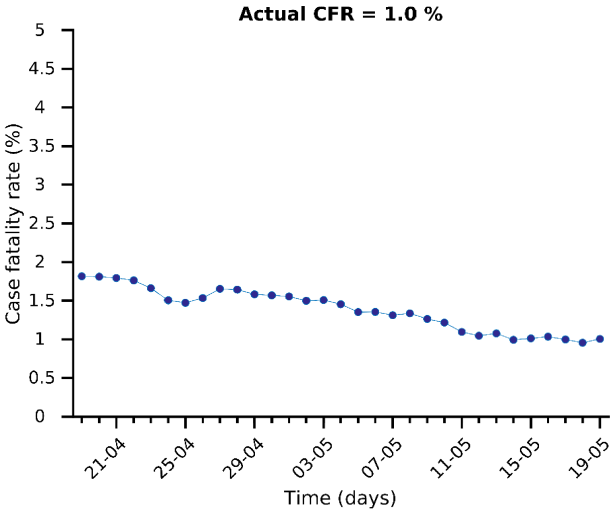
Current indicators

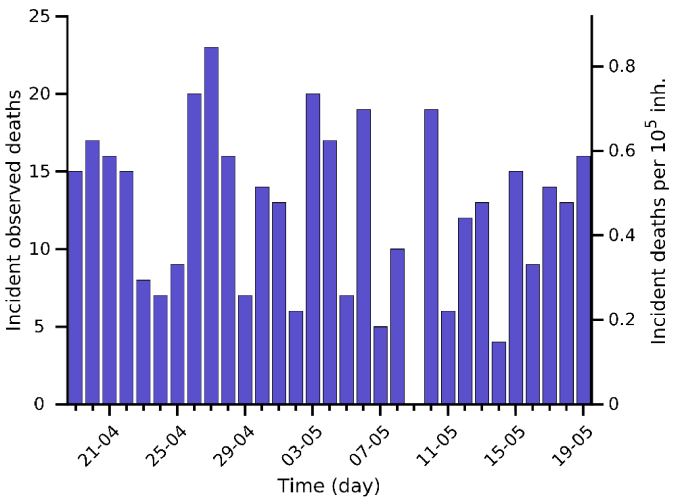
	A14	EPG	CFR	N7	D7
Today	536	499	1.00 %	907	12
A Week ago	604	559	1.05 %	1178	10
Maximum	1545	1698	4.88 %	3159	47

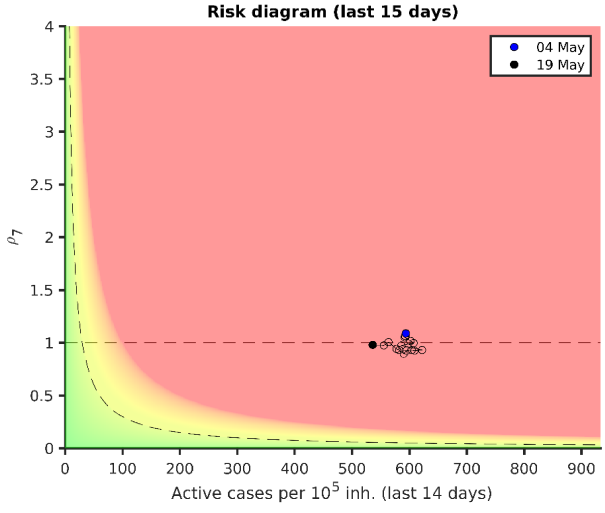




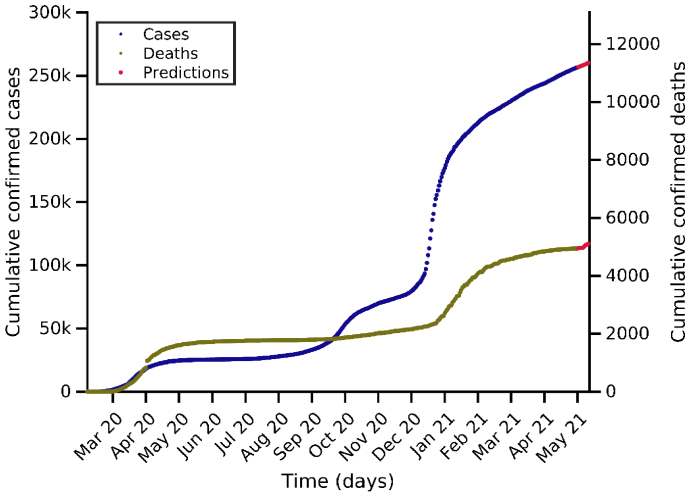








Ireland 19-05-2021. Pop: 4.9M. Cumulative incidence: 5194/10^5

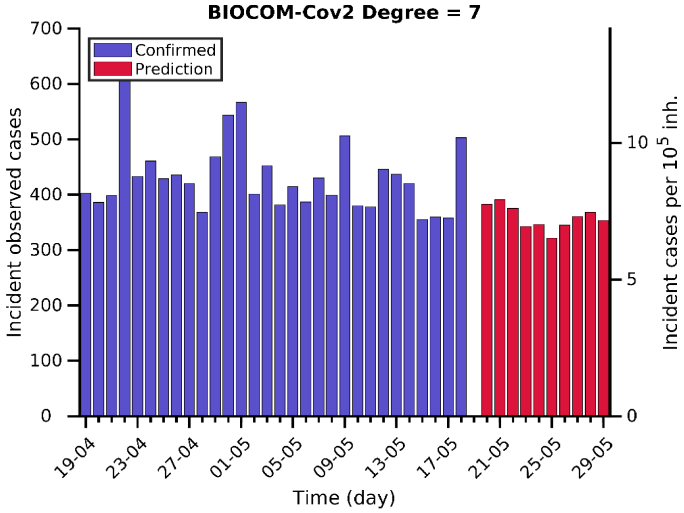


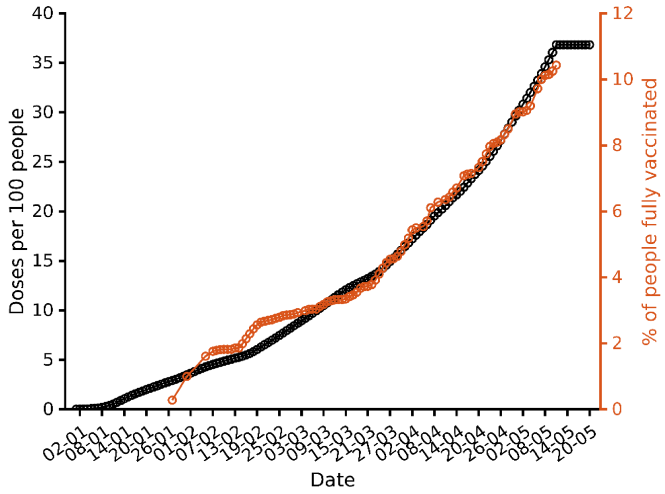
Predictions for next days

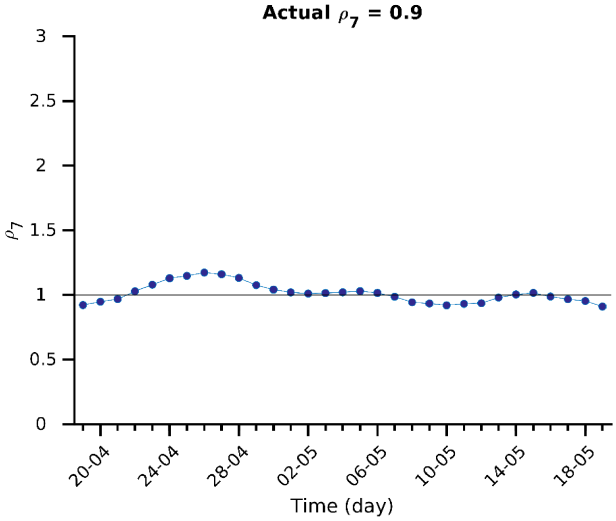
Day	Number of cases
22-05-2021	257595 (+1149)
26-05-2021	258950 (+2504)
29-05-2021	260032 (+3586)

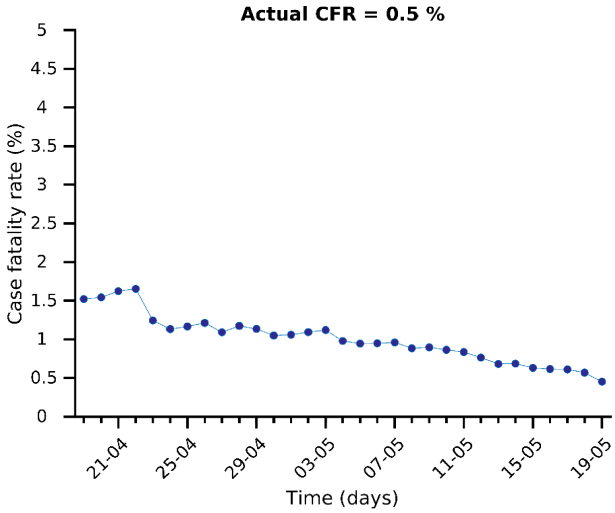
Current indicators

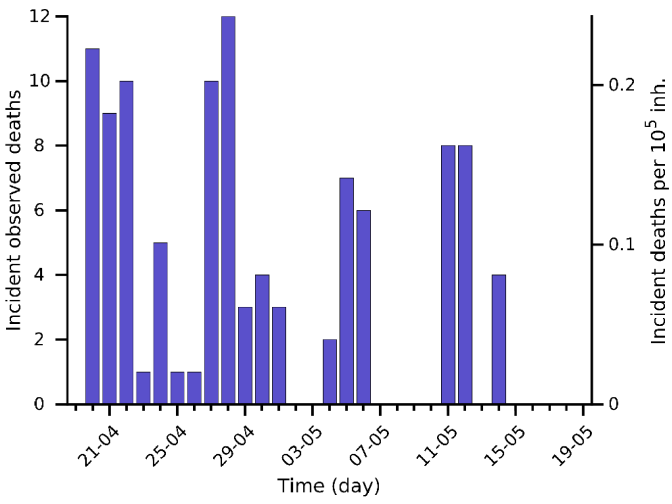
	A14	EPG	CFR	N7	D7
Today	109	99	0.45 %	348	1
A Week ago	125	117	0.76 %	418	3
Maximum	1479	3228	4.93 %	6532	70

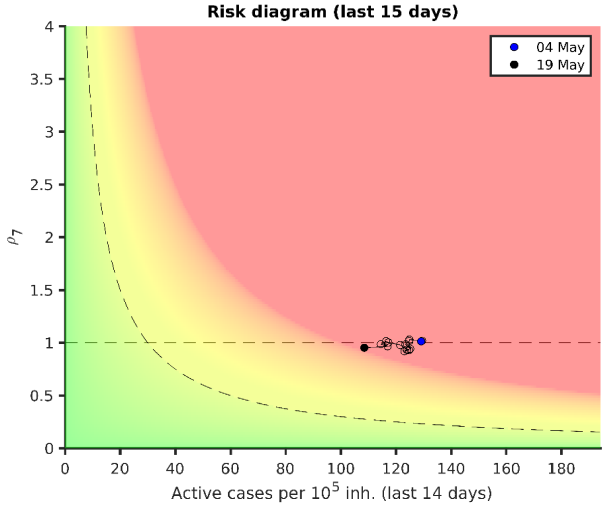




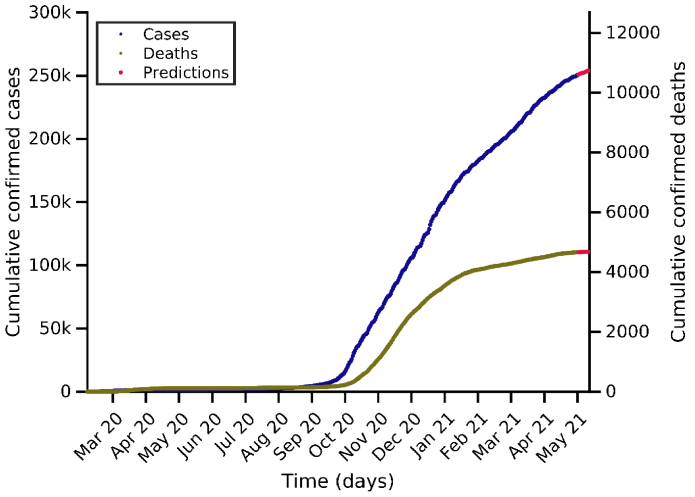








Slovenia 19-05-2021. Pop: 2.1M. Cumulative incidence: 12047/10^5

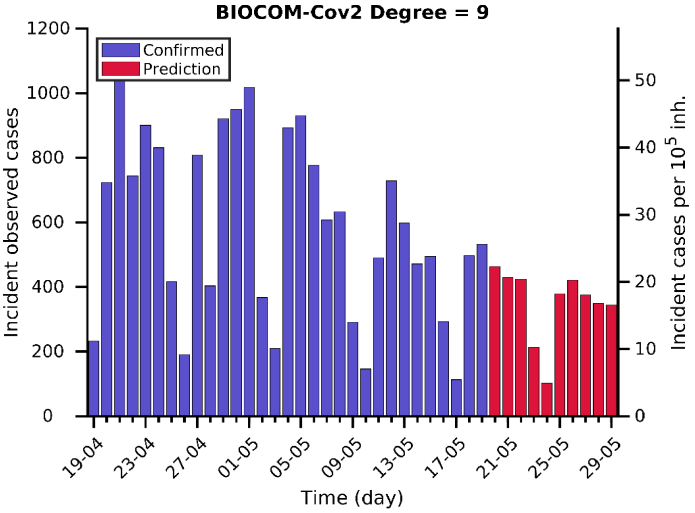


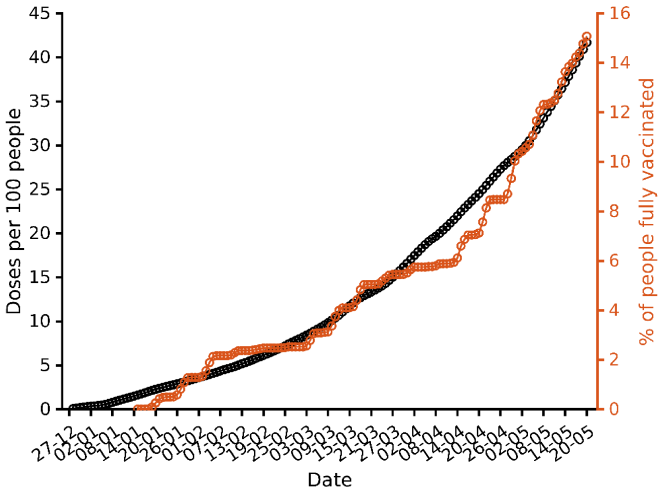
Predictions for next days

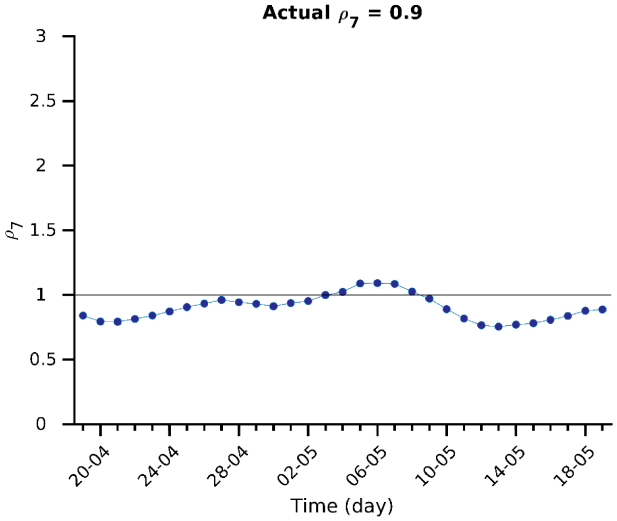
Day	Number of cases
22-05-2021	251770 (+1317)
26-05-2021	252885 (+2432)
29-05-2021	253954 (+3501)

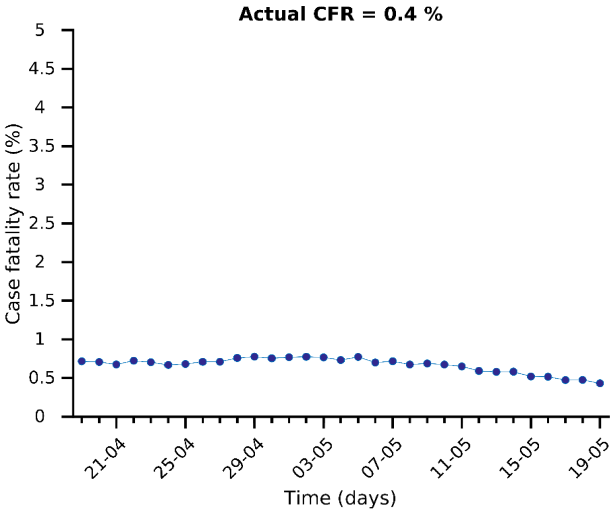
Current indicators

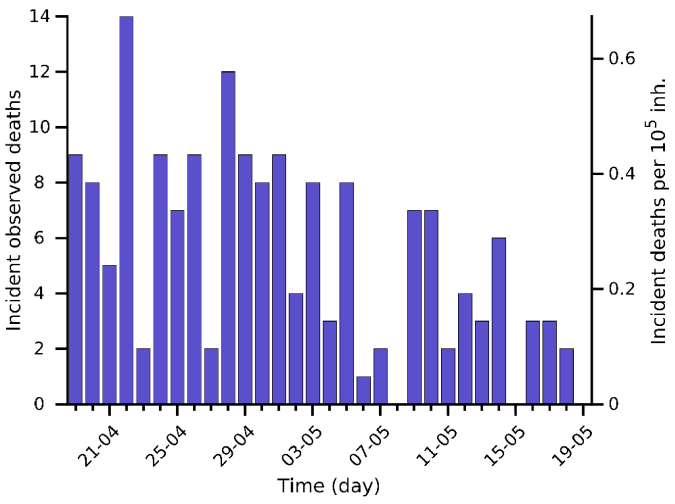
	A14	EPG	CFR	N7	D7
Today	321	285	0.43 %	429	2
A Week ago	431	330	0.59 %	525	3
Maximum	1179	1569	4.93 %	2029	58

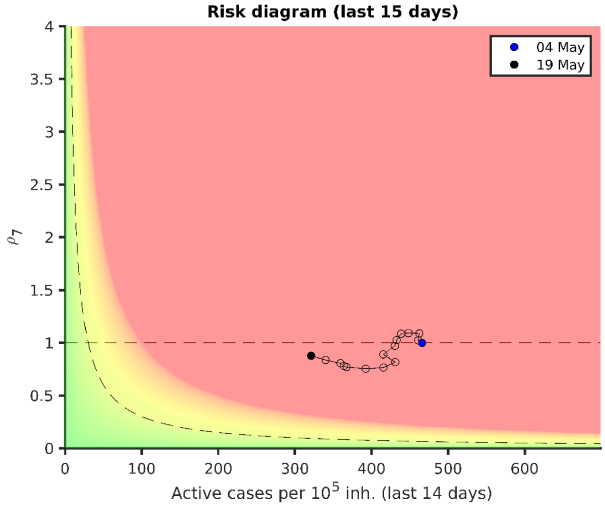




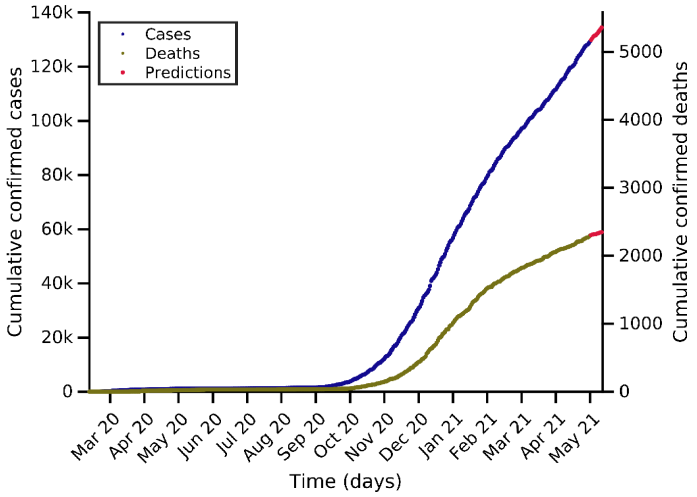








Latvia 19-05-2021. Pop: 1.9M. Cumulative incidence: 6855/10⁵

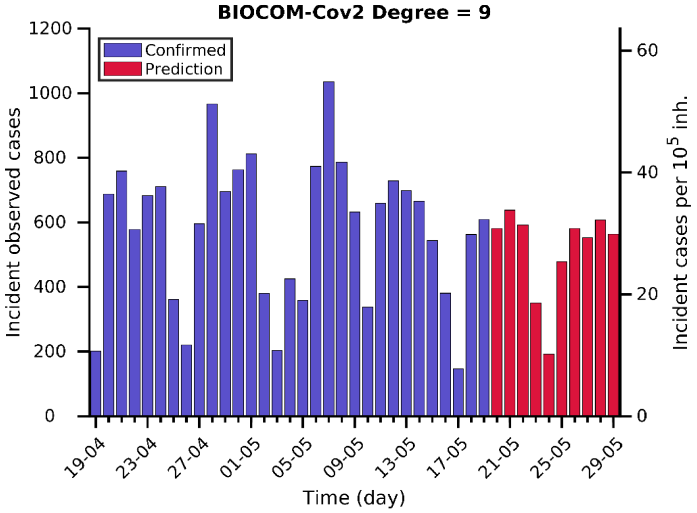


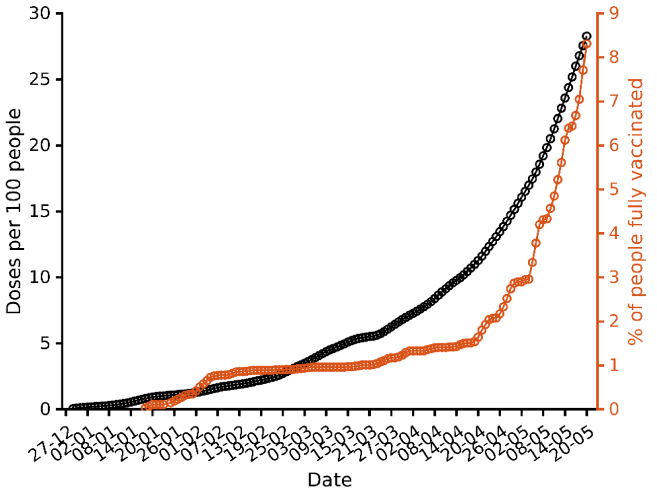
Predictions for next days

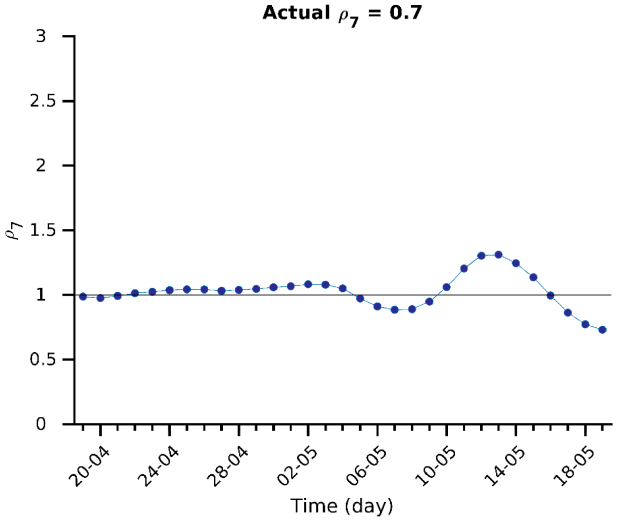
Day	Number of cases
22-05-2021	131107 (+1810)
26-05-2021	132709 (+3412)
29-05-2021	134433 (+5136)

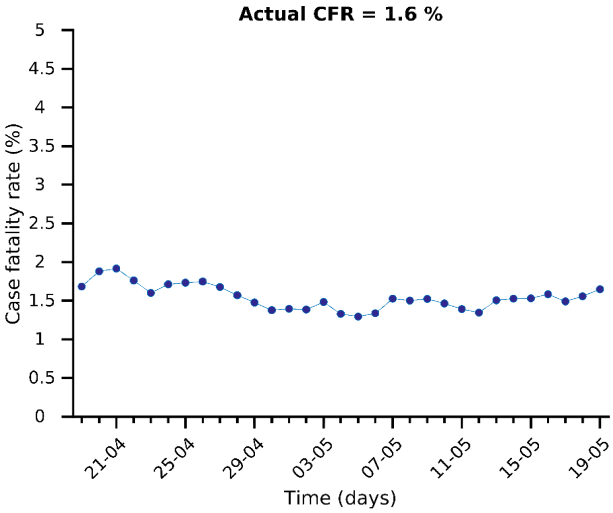
Current indicators

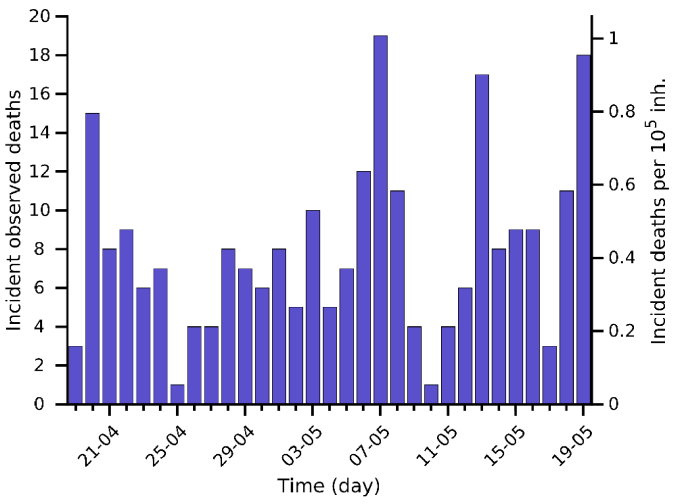
	A14	EPG	CFR	N7	D7
Today	454	331	1.65 %	515	11
A Week ago	455	593	1.34 %	708	8
Maximum	702	809	4.88 %	1010	25

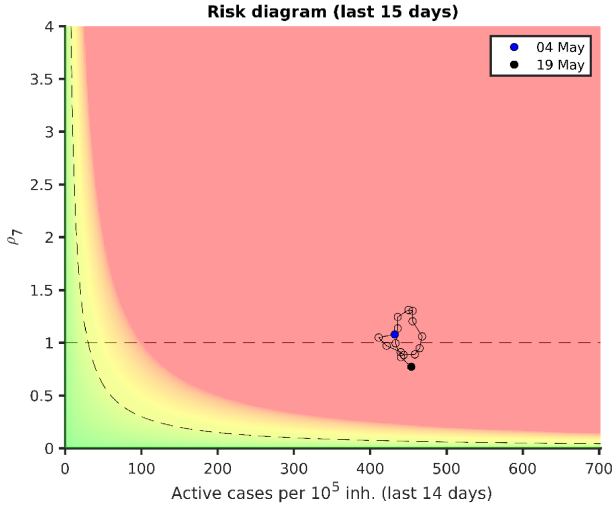




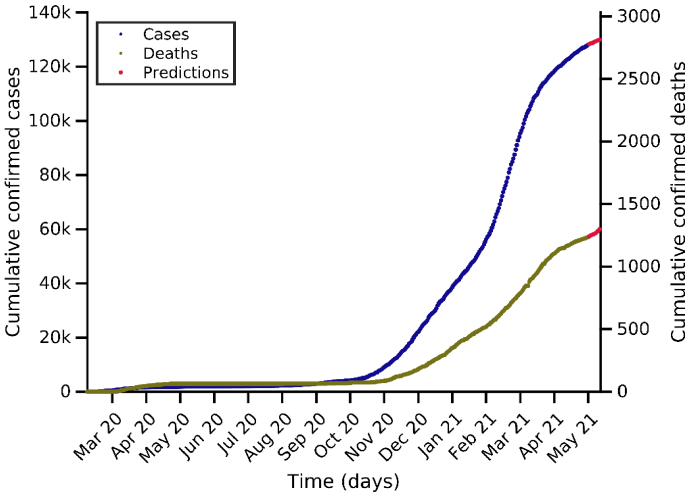








Estonia 19-05-2021. Pop: 1.3M. Cumulative incidence: 9656/10⁵

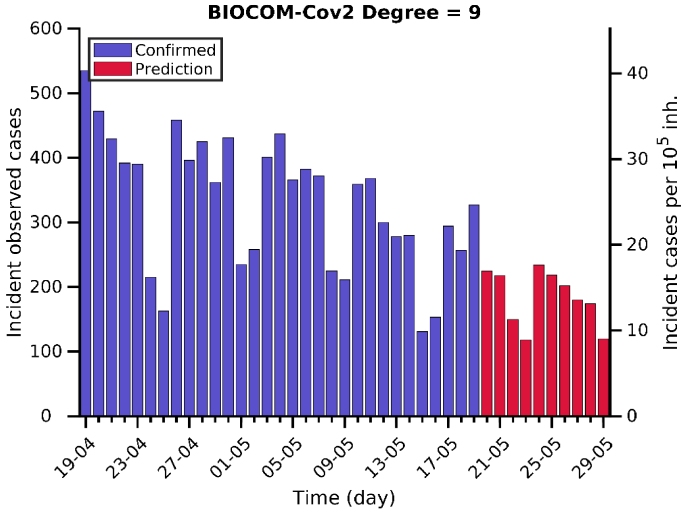


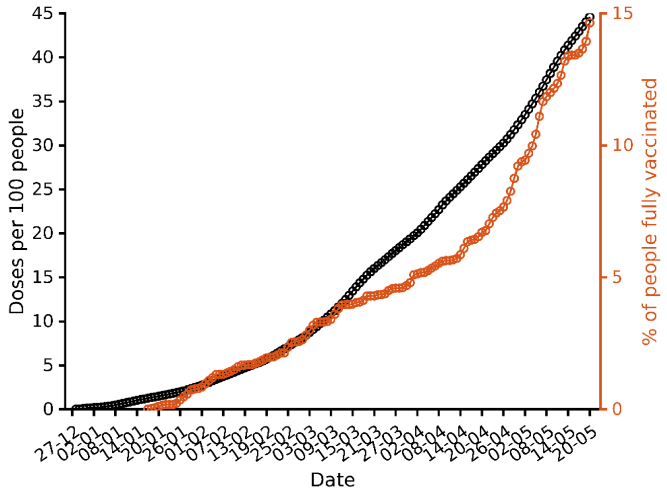
Predictions for next days

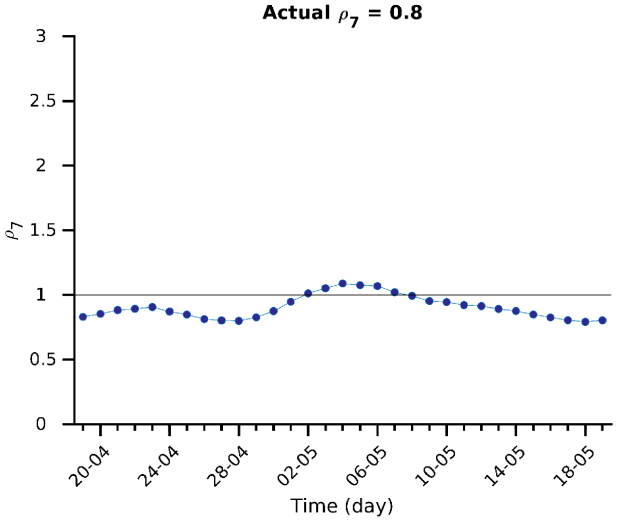
Day	Number of cases
22-05-2021	128676 (+592)
26-05-2021	129449 (+1365)
29-05-2021	129922 (+1838)

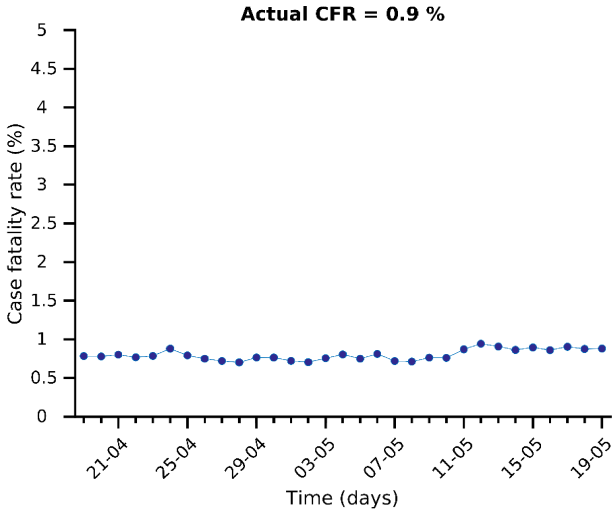
Current indicators

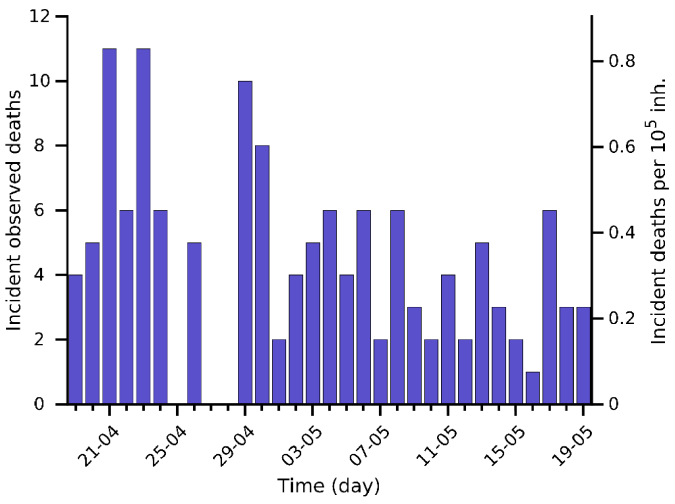
	A14	EPG	CFR	N7	D7
Today	297	238	0.88 %	246	3
A Week ago	355	324	0.94 %	317	4
Maximum	1556	1623	4.92 %	1513	13

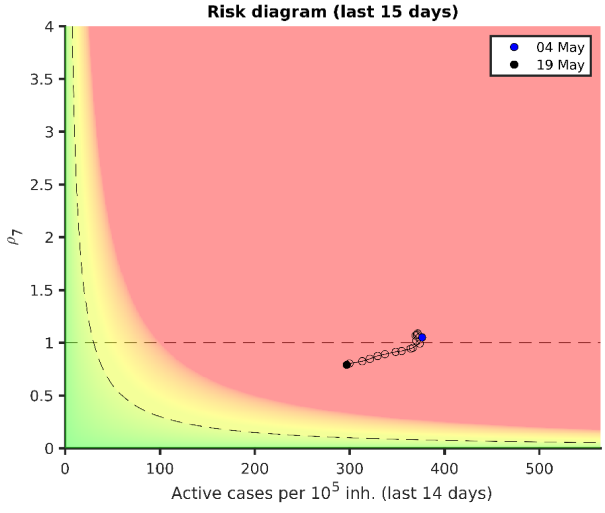




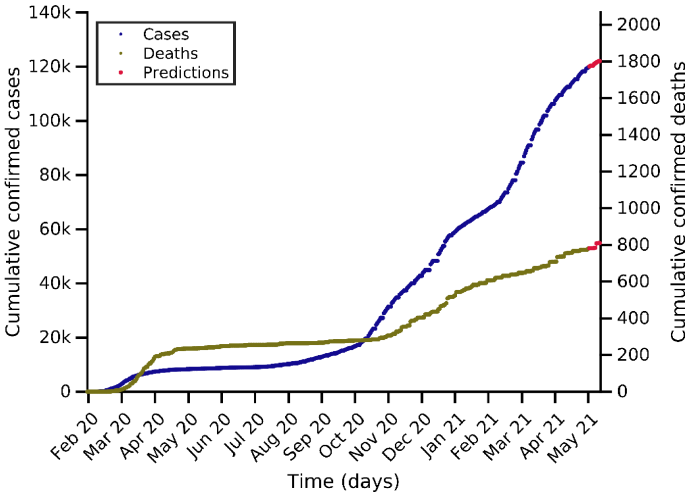








Norway 19-05-2021. Pop: 5.4M. Cumulative incidence: 2209/10⁵



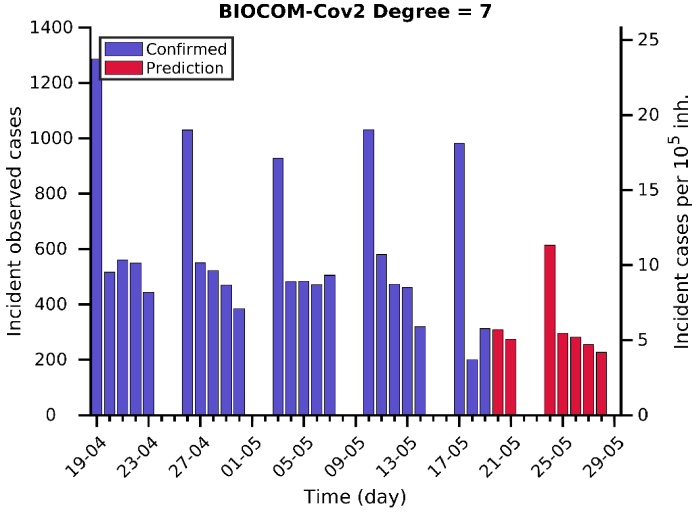
Predictions for next days

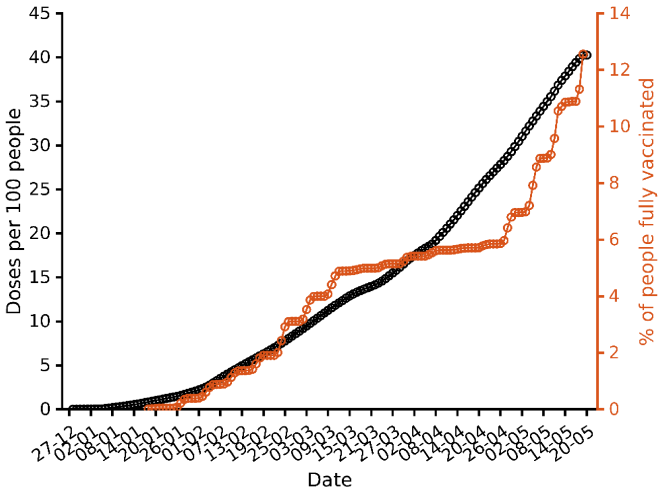
Day	Number of cases
22-05-2021	120353 (+582)
26-05-2021	121546 (+1775)
29-05-2021	122028 (+2257)

Current indicators

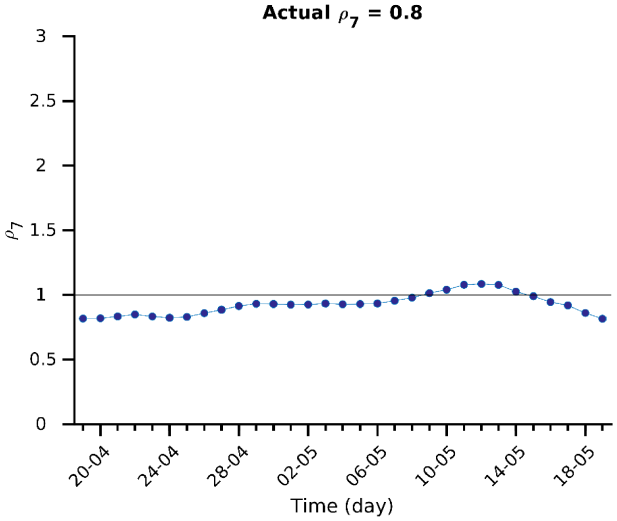
	A14	EPG	CFR	N7	D7
Today	98	80	0.21 %	325	1
A Week ago	107	116	0.25 %	437	1
Maximum	239	500	4.97 %	1028	8

BIOCOM-Cov2 Degree = 7

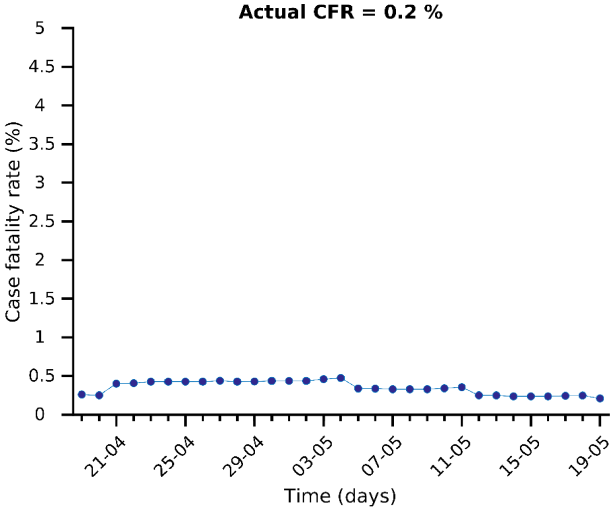


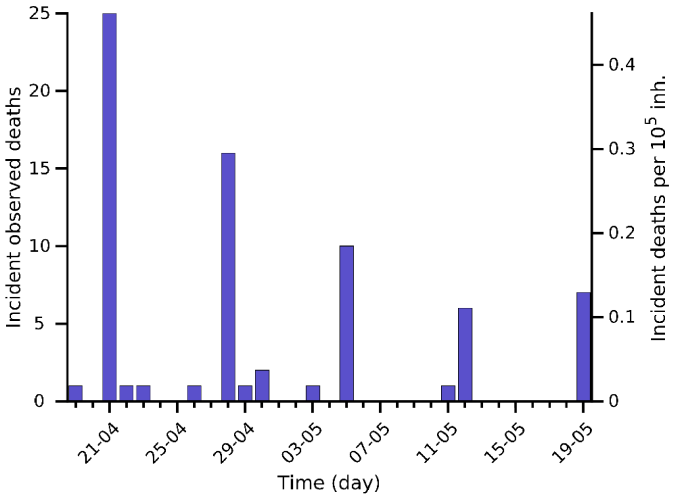


Actual ρ_7 = 0.8

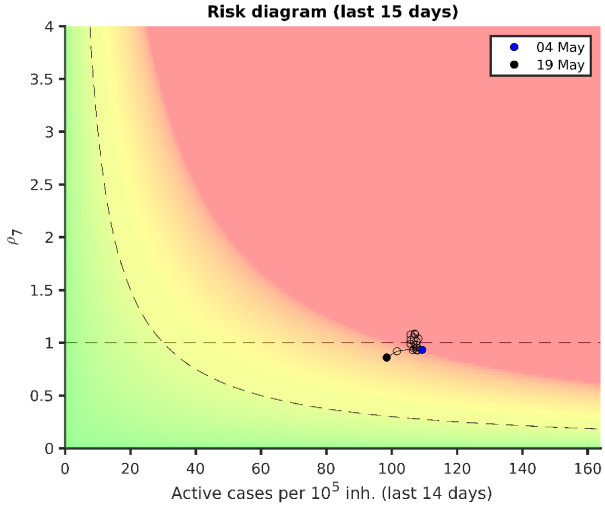


Actual CFR = 0.2 %

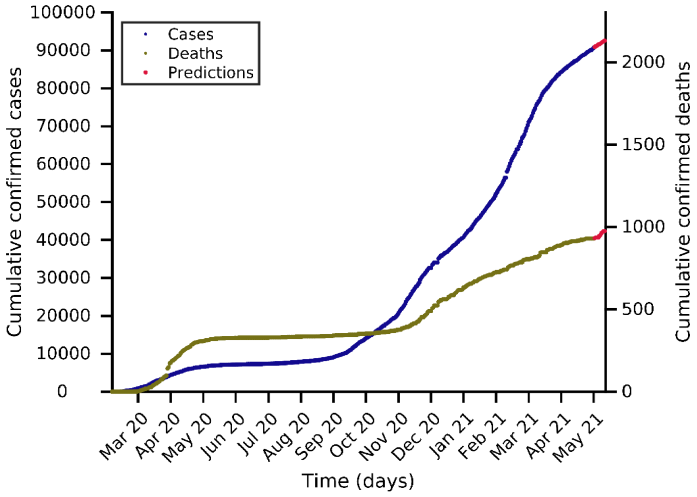




Risk diagram (last 15 days)



Finland 19-05-2021. Pop: 5.5M. Cumulative incidence: 1637/10⁵

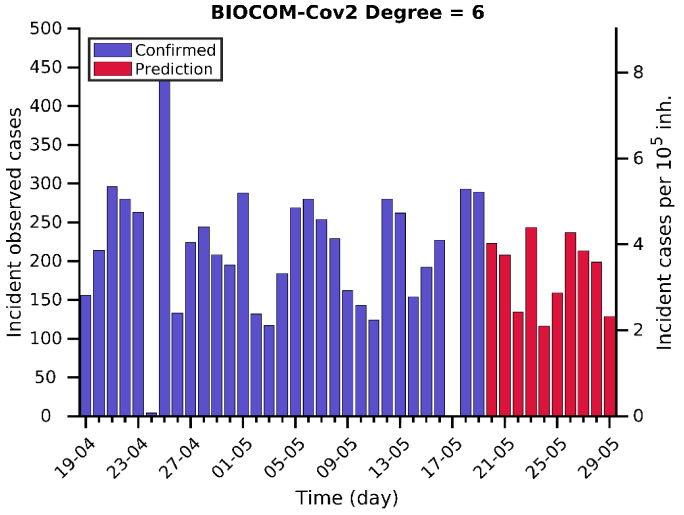


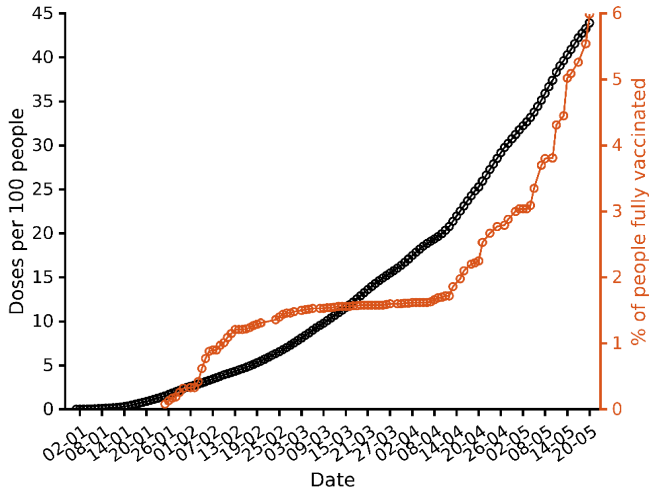
Predictions for next days

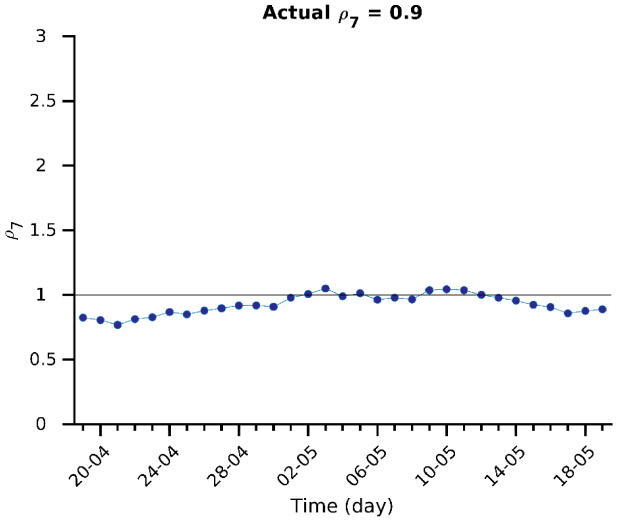
Day	Number of cases
22-05-2021	91252 (+565)
26-05-2021	92007 (+1320)
29-05-2021	92548 (+1861)

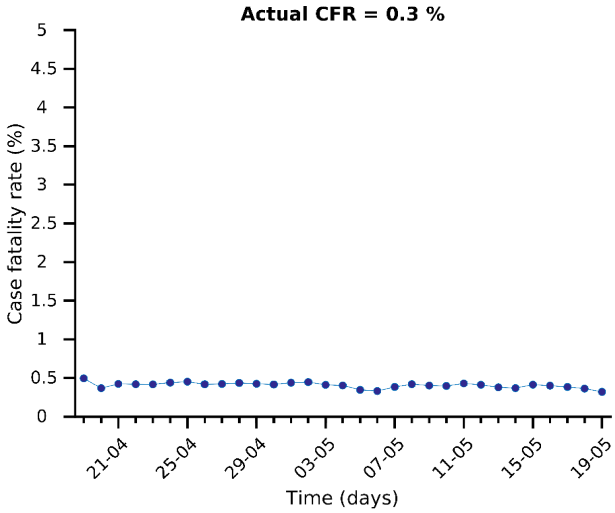
Current indicators

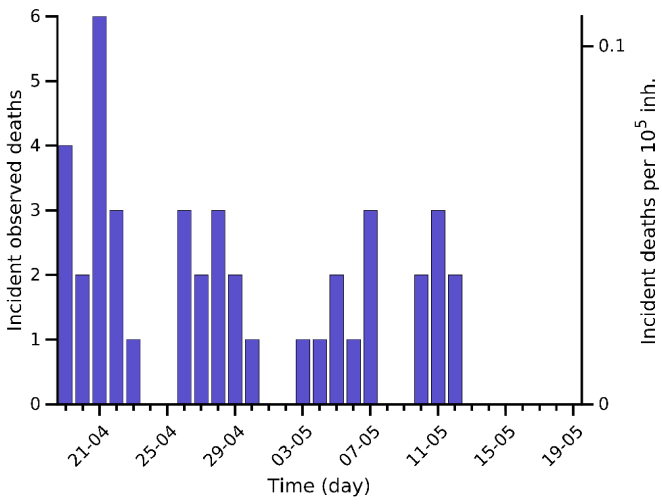
	A14	EPG	CFR	N7	D7
Today	52	46	0.32 %	202	0
A Week ago	52	52	0.41 %	210	2
Maximum	174	224	4.90 %	808	14

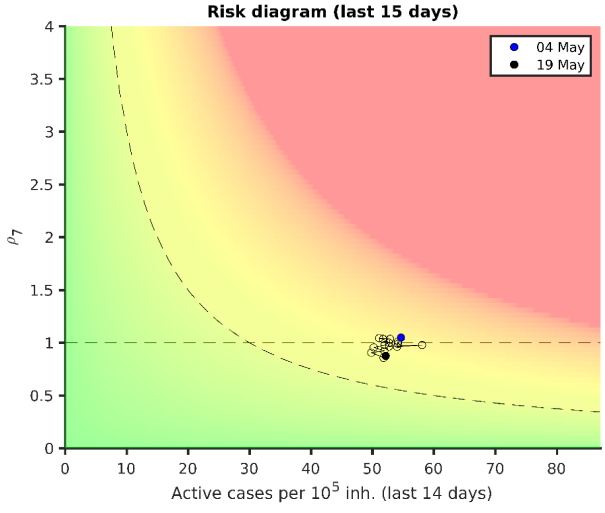




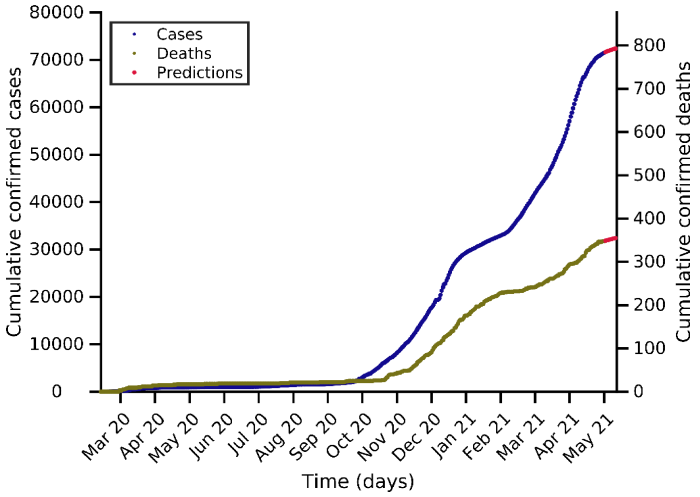








Cyprus 19-05-2021. Pop: 1.2M. Cumulative incidence: 5925/10^5

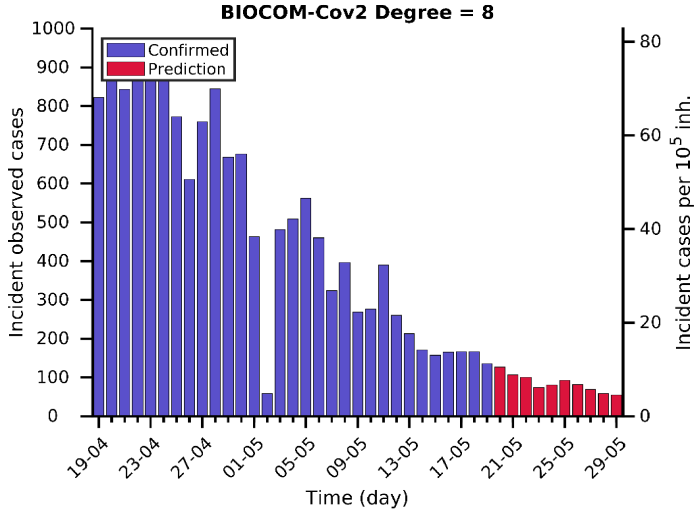


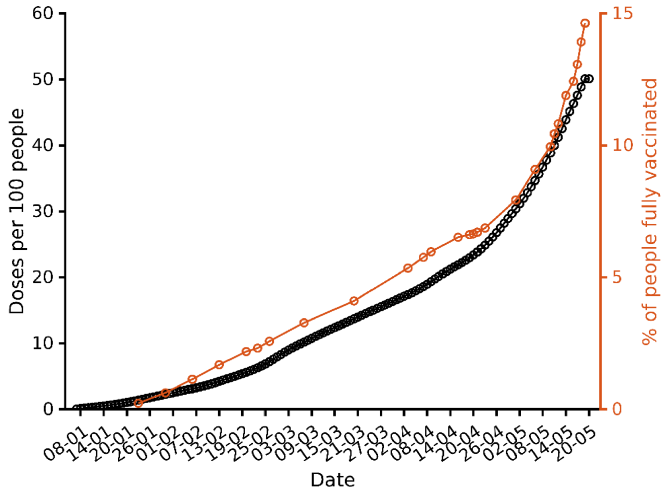
Predictions for next days

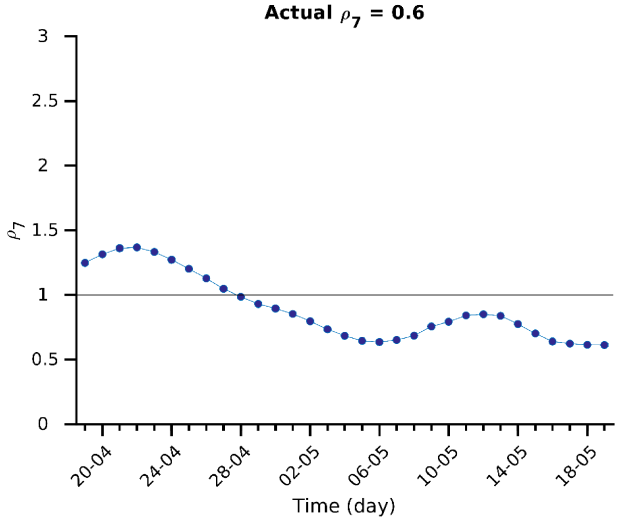
Day	Number of cases
22-05-2021	71867 (+334)
26-05-2021	72194 (+661)
29-05-2021	72376 (+843)

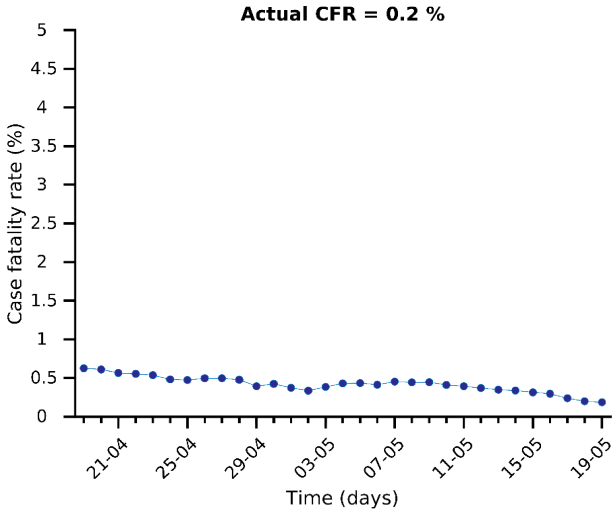
Current indicators

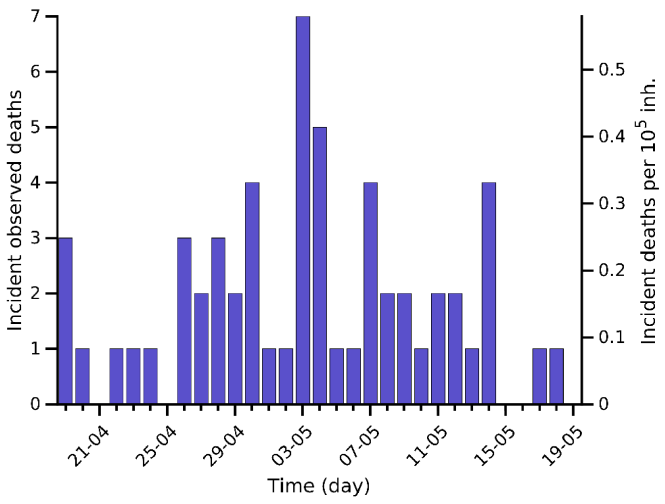
	A14	EPG	CFR	N7	D7
Today	294	180	0.19 %	168	1
A Week ago	480	408	0.37 %	339	2
Maximum	937	1114	4.48 %	881	4

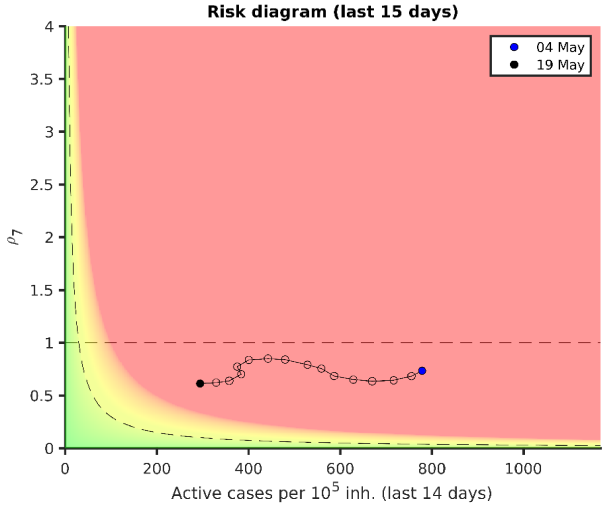




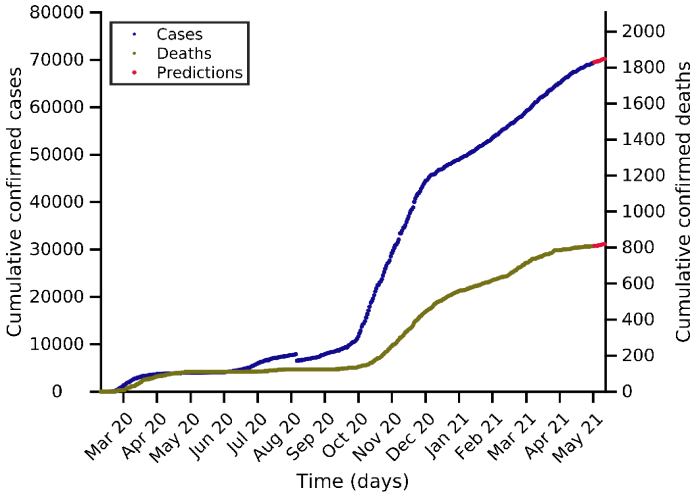








Luxembourg 19-05-2021. Pop: 0.6M. Cumulative incidence: 11086/10⁵

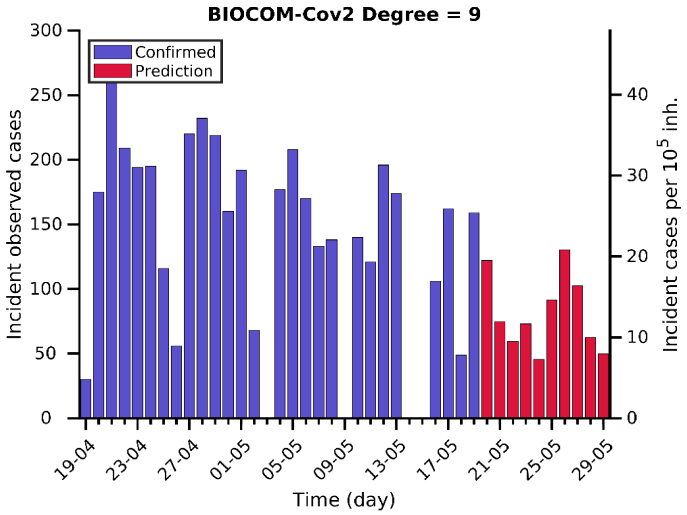


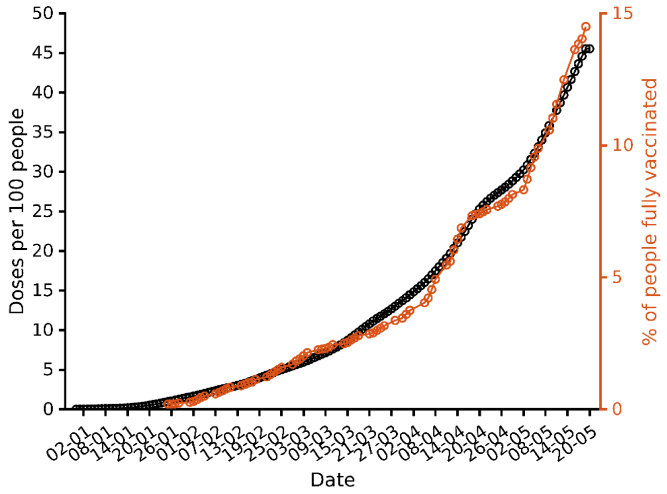
Predictions for next days

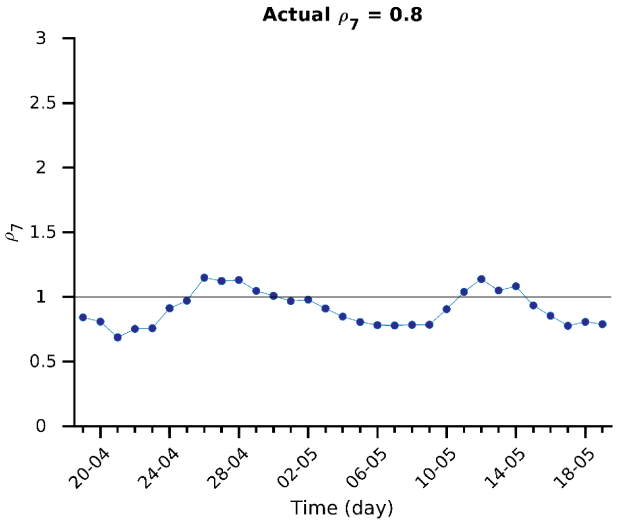
Day	Number of cases
22-05-2021	69654 (+256)
26-05-2021	69994 (+596)
29-05-2021	70209 (+811)

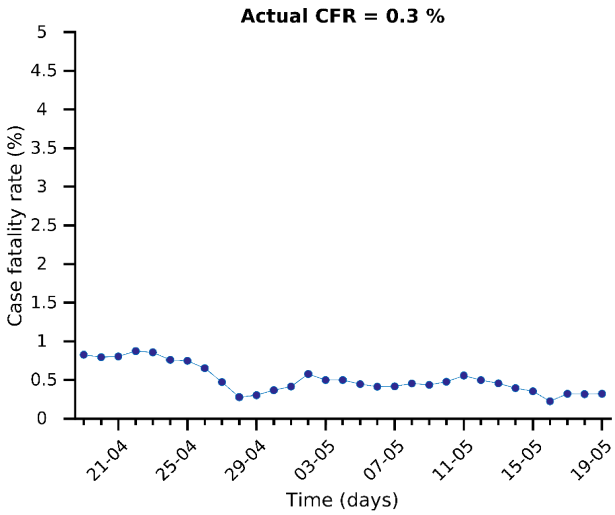
Current indicators

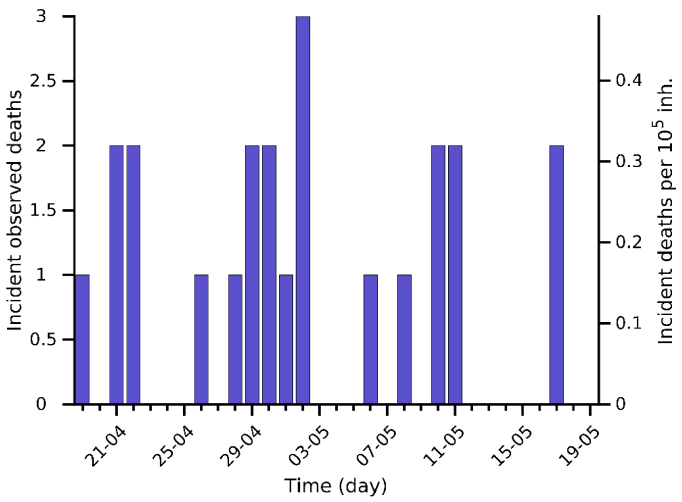
	A14	EPG	CFR	N7	D7
Today	247	195	0.32 %	93	0
A Week ago	307	349	0.50 %	128	1
Maximum	1431	3122	4.03 %	684	8

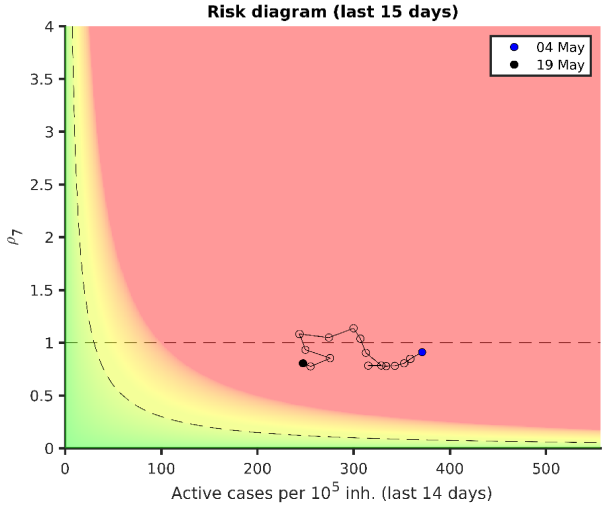




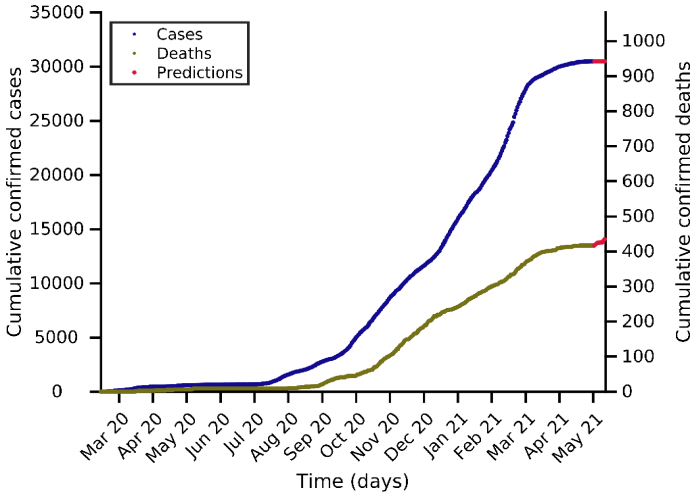








Malta 19-05-2021. Pop: 0.4M. Cumulative incidence: 6905/10⁵

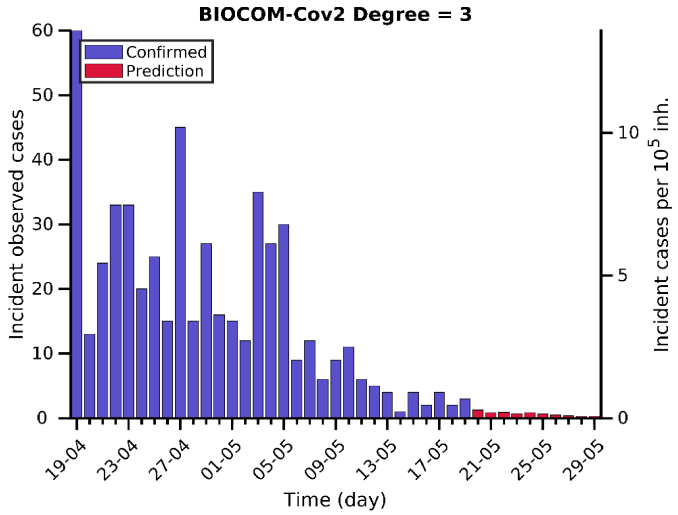


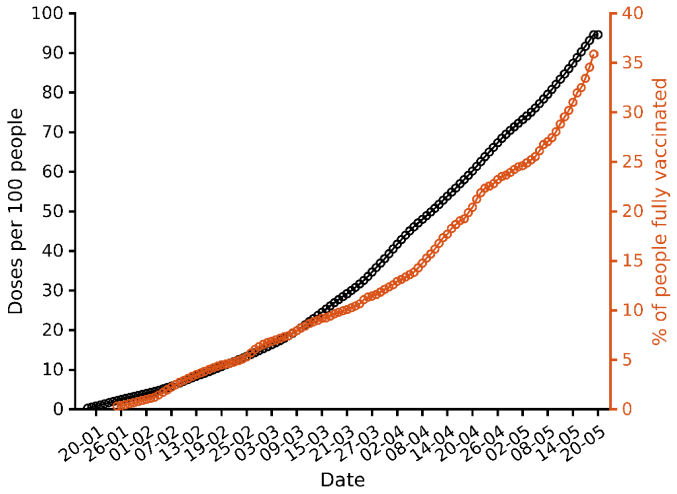
Predictions for next days

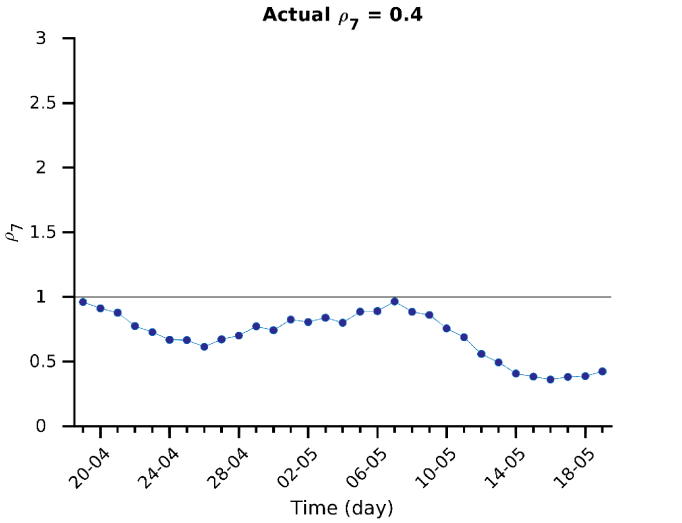
Day	Number of cases
22-05-2021	30492 (+3)
26-05-2021	30495 (+6)
29-05-2021	30496 (+7)

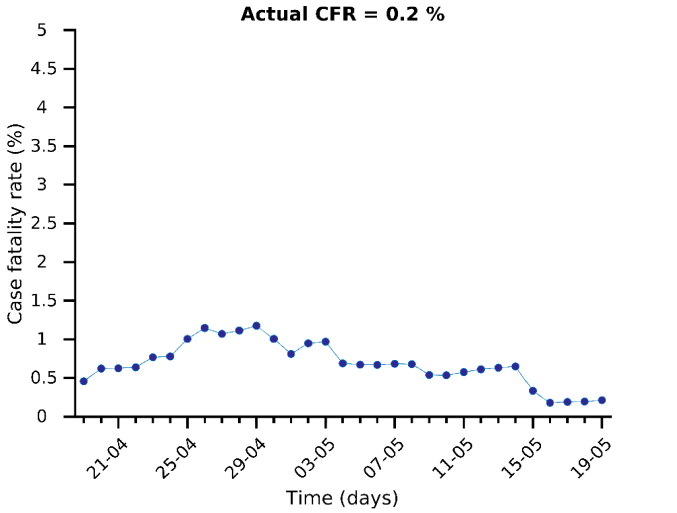
Current indicators

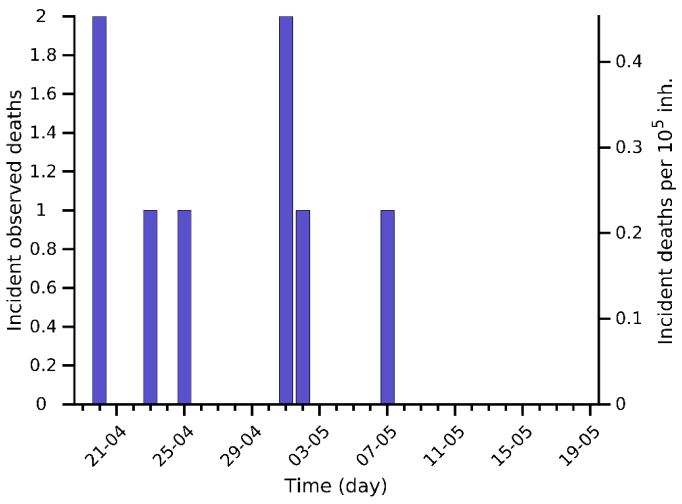
	A14	EPG	CFR	N7	D7
Today	18	7	0.21 %	3	0
A Week ago	50	28	0.61 %	8	0
Maximum	927	997	4.68 %	316	4

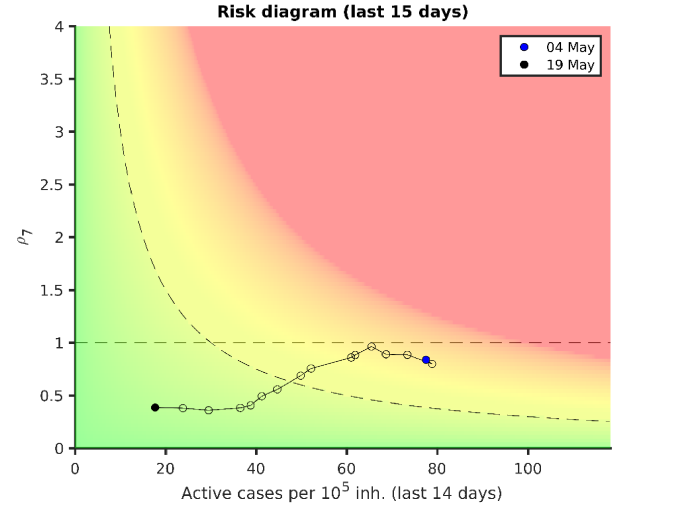




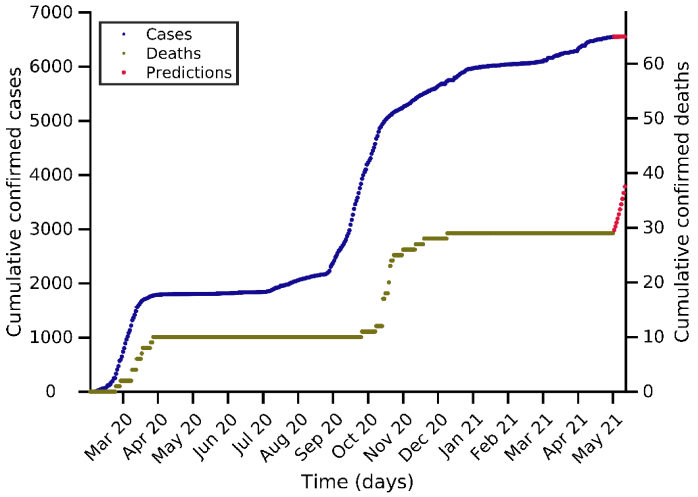








Iceland 19-05-2021. Pop: 0.3M. Cumulative incidence: 1920/10^5

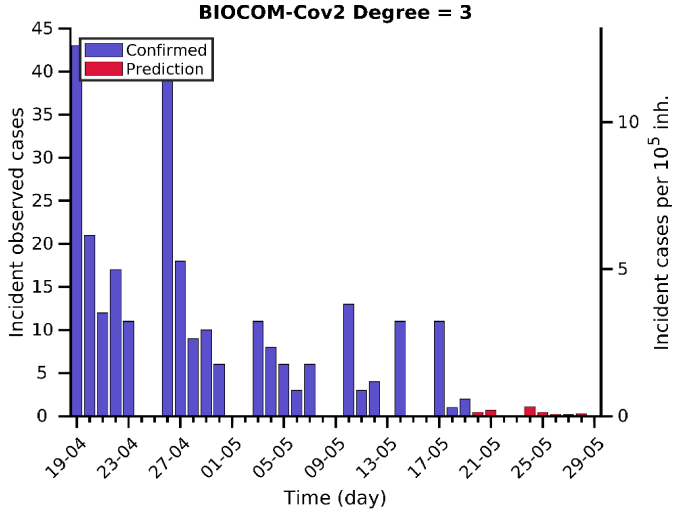


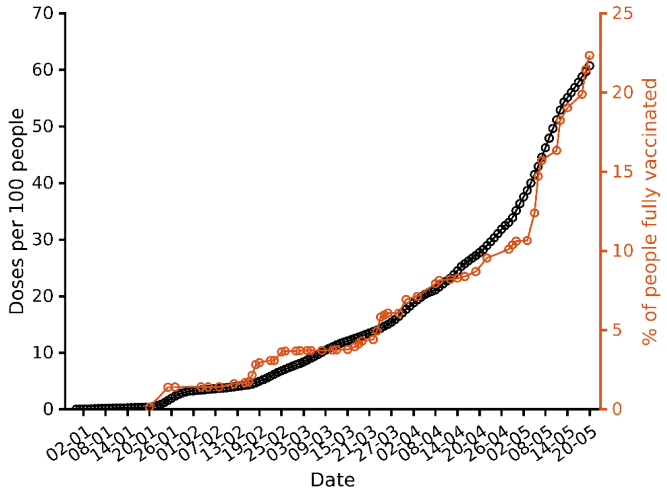
Predictions for next days

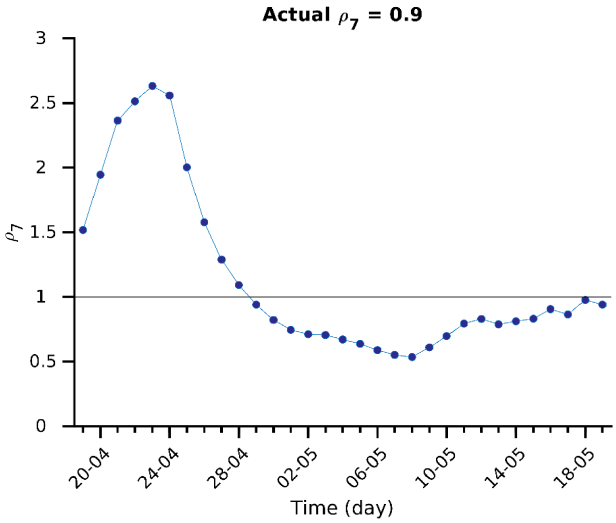
Day	Number of cases
22-05-2021	6552 (+1)
26-05-2021	6554 (+3)
29-05-2021	6554 (+3)

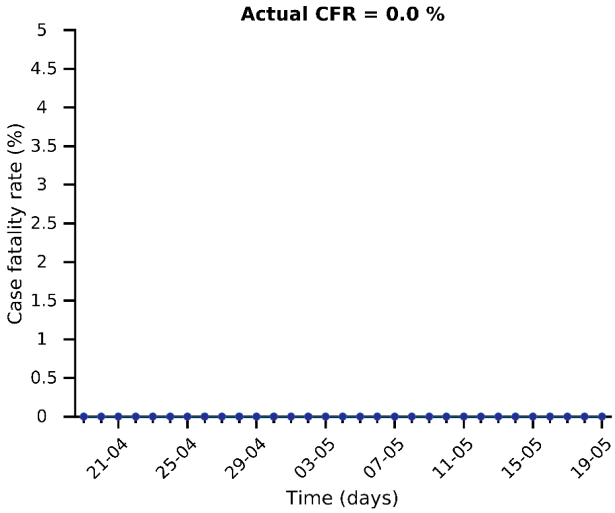
Current indicators

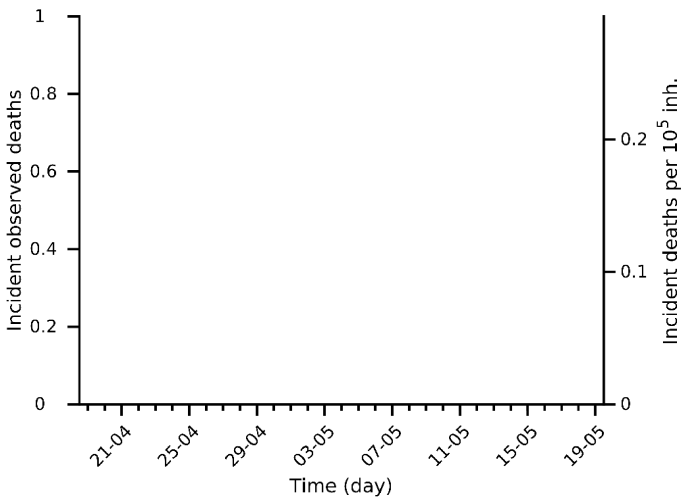
	A14	EPG	CFR	N7	D7
Today	16	15	0.00 %	4	0
A Week ago	21	17	0.00 %	4	0
Maximum	332	462	4.65 %	86	2

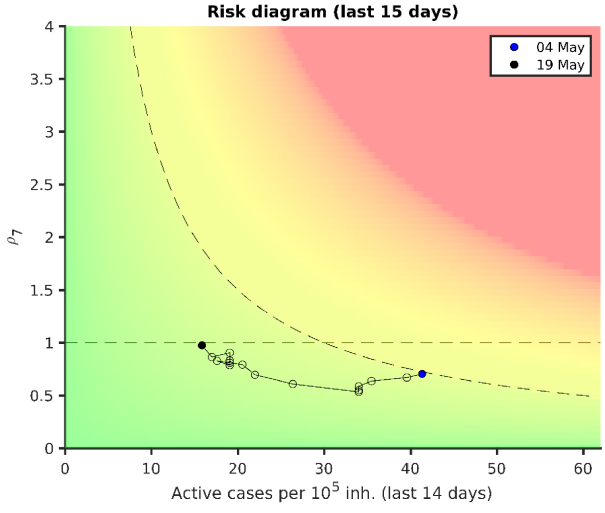






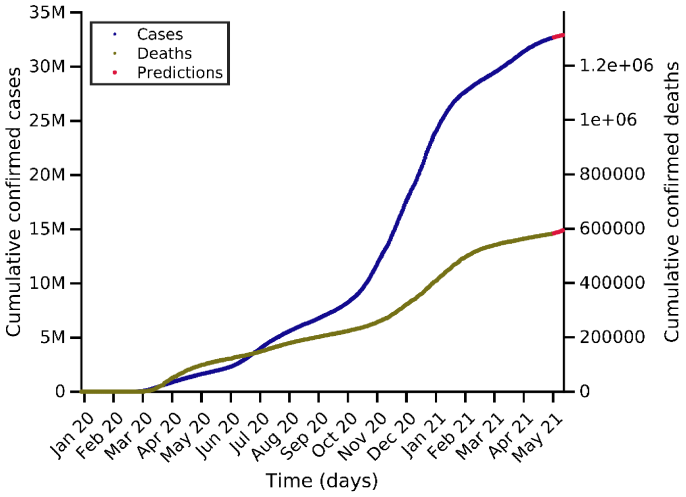






(2) Analysis and prediction of COVID-19 for other countries

USA 19-05-2021. Pop: 331.0M. Cumulative incidence: 9872/10⁵

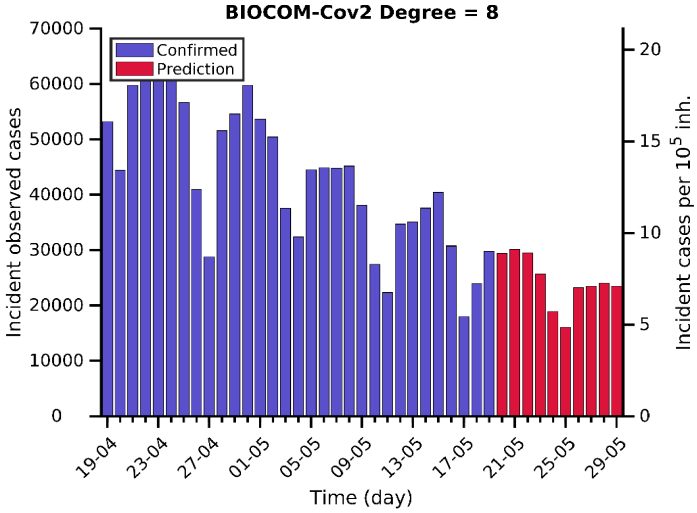


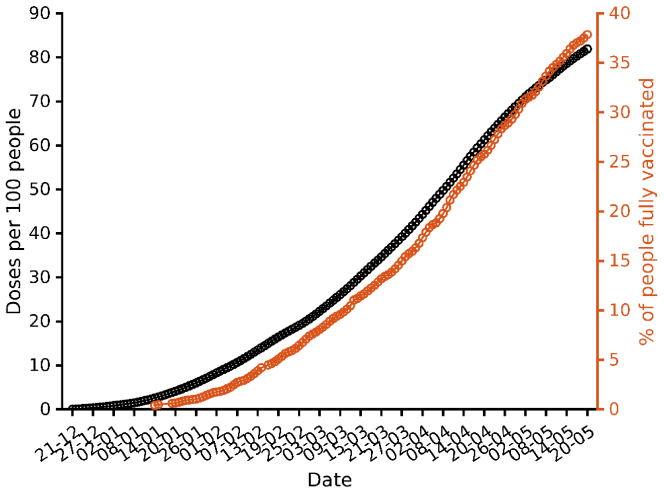
Predictions for next days

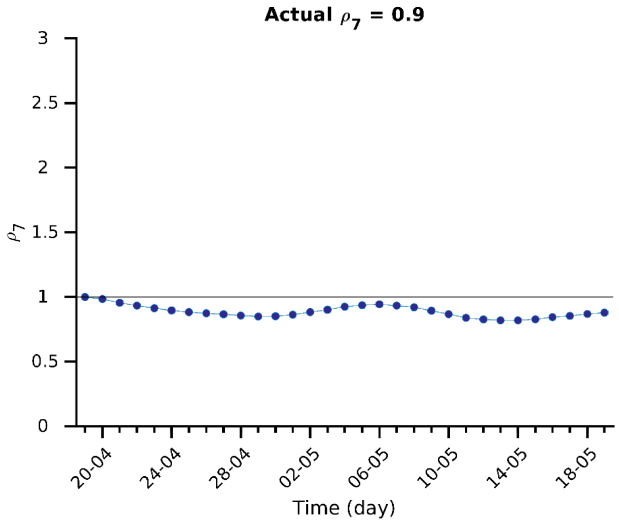
Day	Number of cases
22-05-2021	32765972 (+89018)
26-05-2021	32849886 (+172932)
29-05-2021	32920886 (+243932)

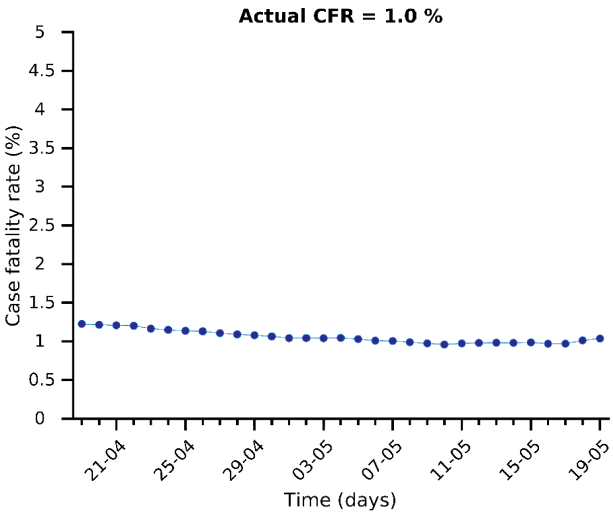
Current indicators

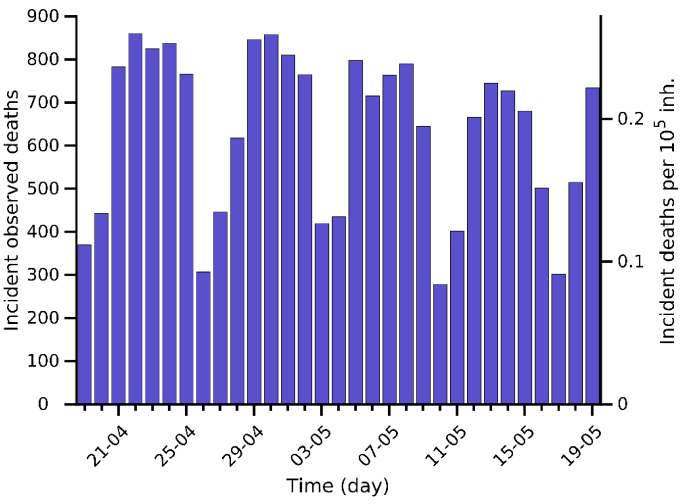
	A14	EPG	CFR	N7	D7
Today	143	125	1.04 %	30794	601
A Week ago	178	147	0.98 %	36766	609
Maximum	1005	1102	4.95 %	249337	3409

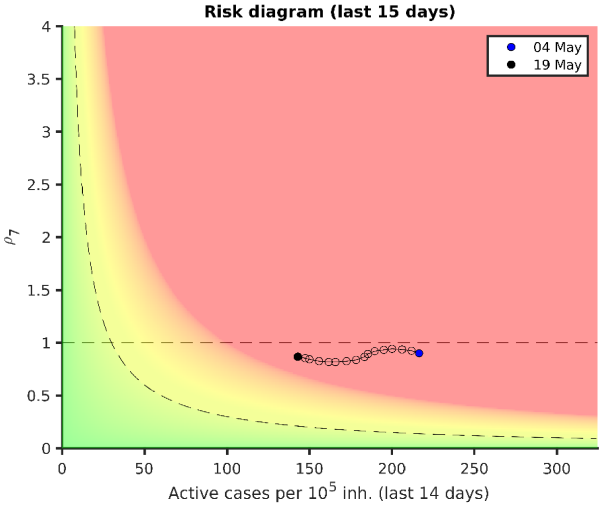




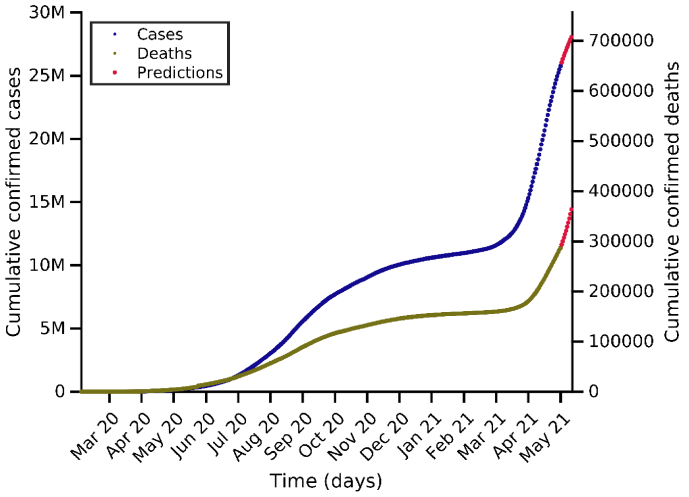








India 19-05-2021. Pop: 1380.0M. Cumulative incidence: 1868/10⁵

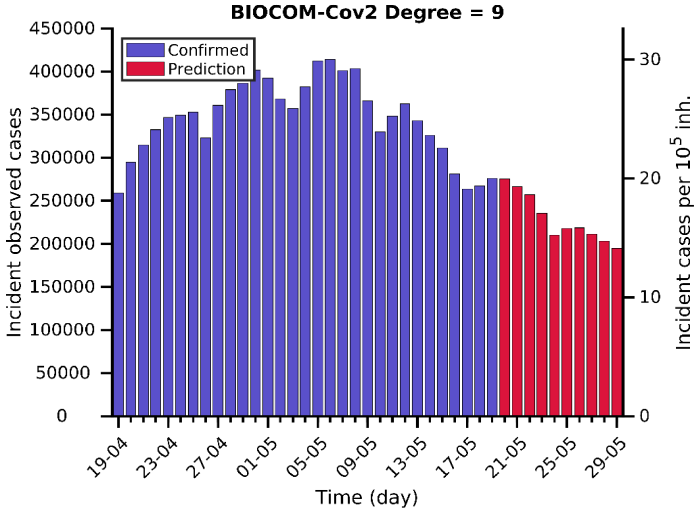


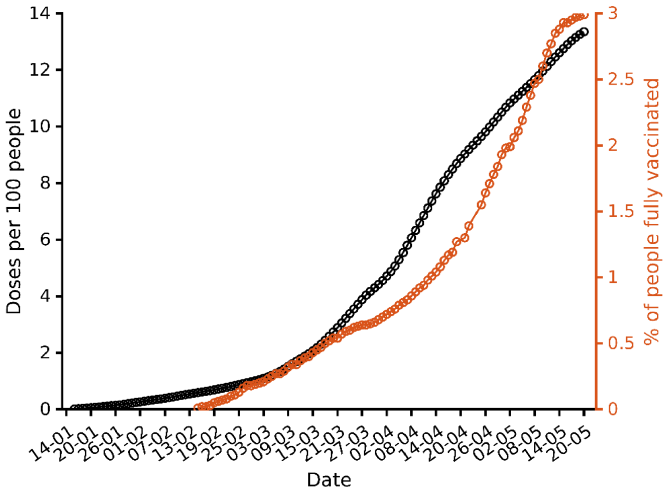
Predictions for next days

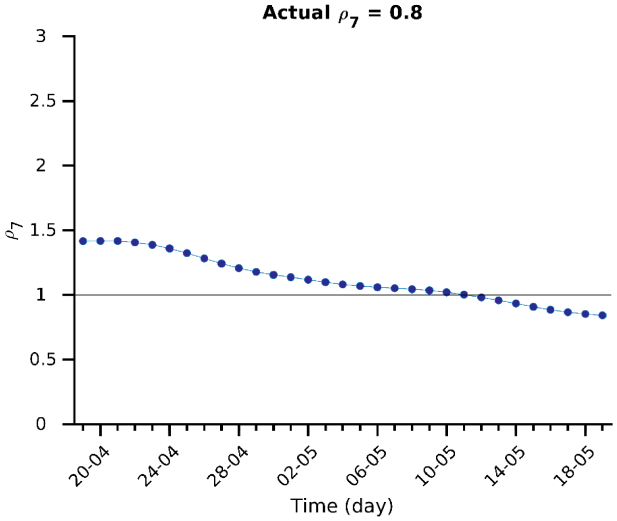
Day	Number of cases
22-05-2021	26571525 (+799085)
26-05-2021	27454258 (+1681818)
29-05-2021	28063502 (+2291062)

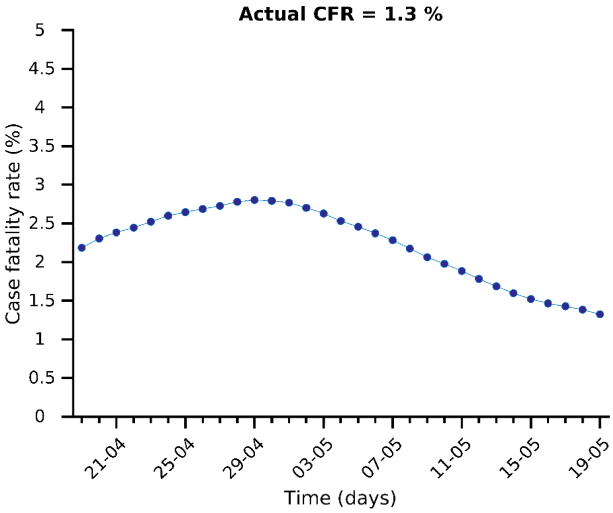
Current indicators

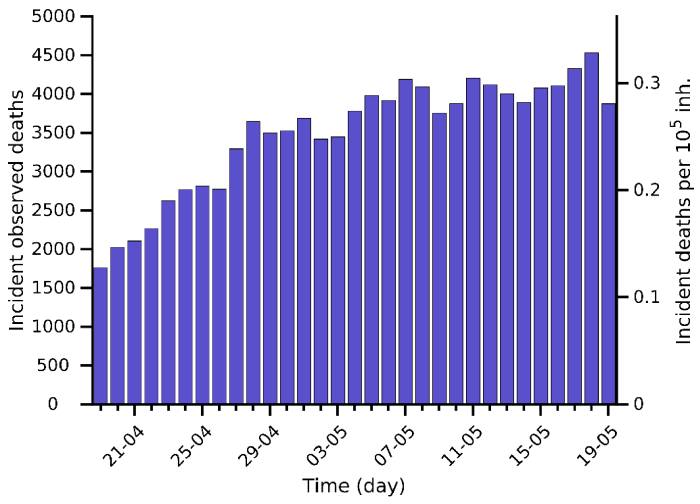
	A14	EPG	CFR	N7	D7
Today	340	286	1.32 %	295539	4115
A Week ago	386	379	1.78 %	375179	4021
Maximum	388	404	4.40 %	391280	4150

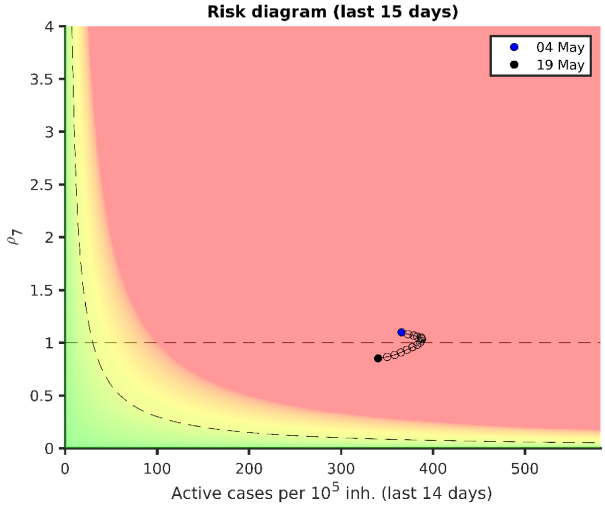




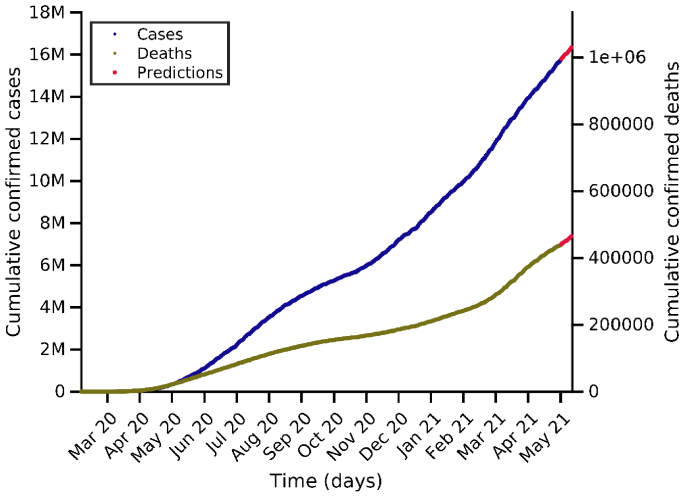








Brazil 19-05-2021. Pop: 212.6M. Cumulative incidence: 7402/10^5

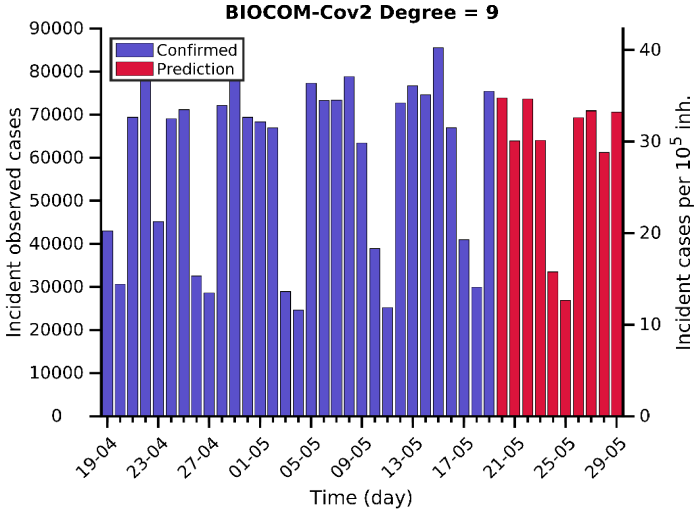


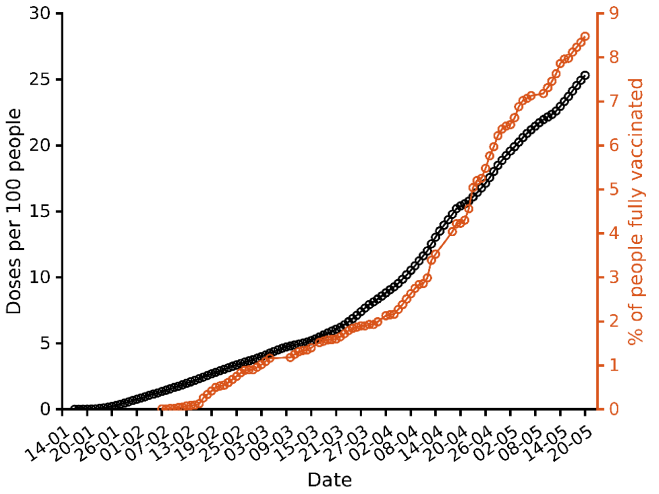
Predictions for next days

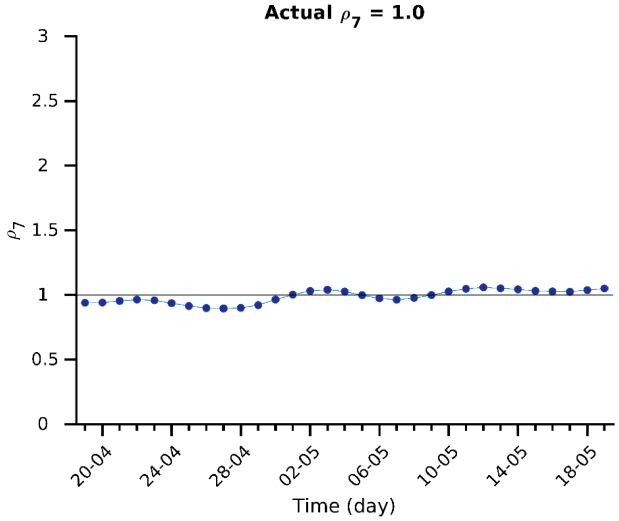
Day	Number of cases
22-05-2021	15944287 (+211451)
26-05-2021	16138010 (+405174)
29-05-2021	16340796 (+607960)

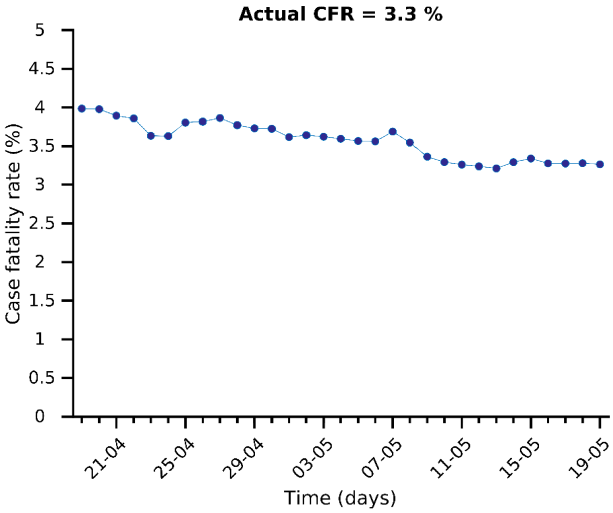
Current indicators

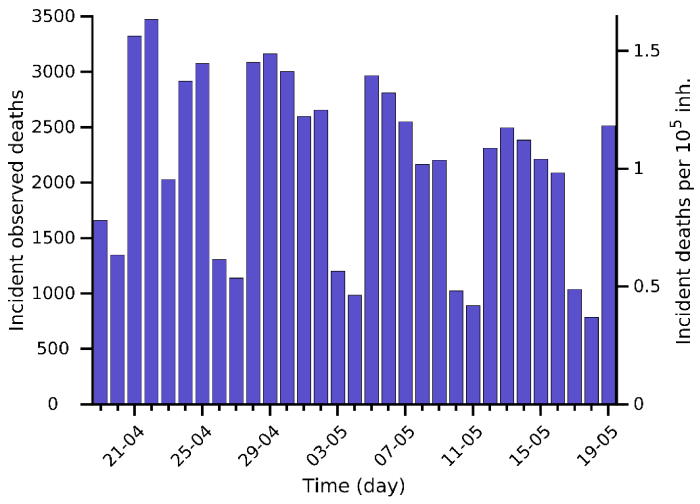
	A14	EPG	CFR	N7	D7
Today	412	432	3.26 %	64304	1930
A Week ago	396	419	3.24 %	60831	1993
Maximum	498	525	4.84 %	77129	3124

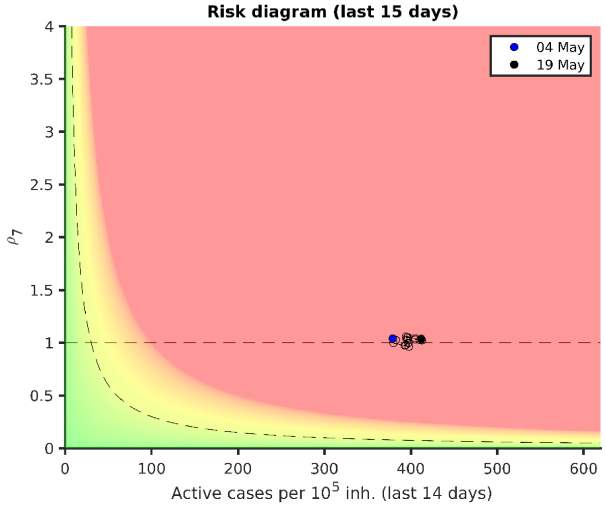




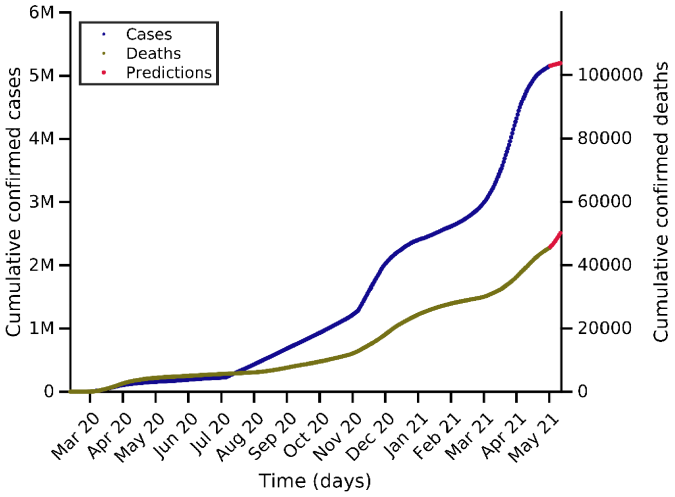








Turkey 19-05-2021. Pop: 84.3M. Cumulative incidence: $6108/10^5$

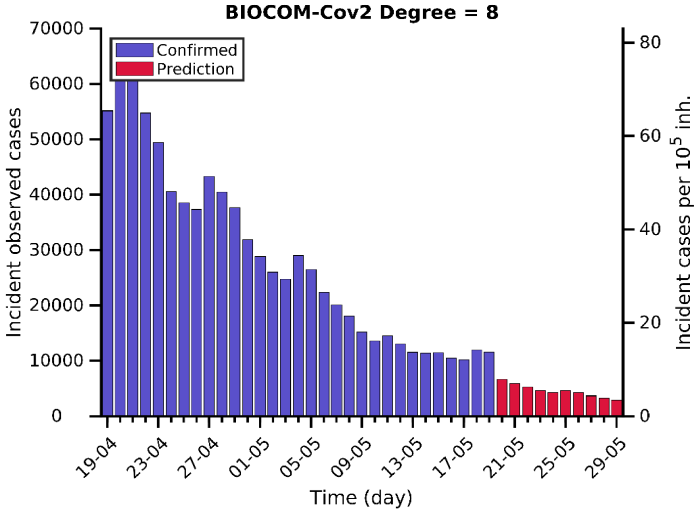


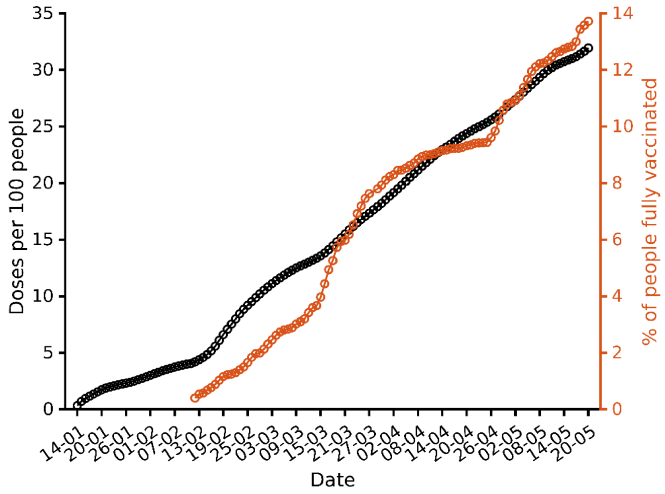
Predictions for next days

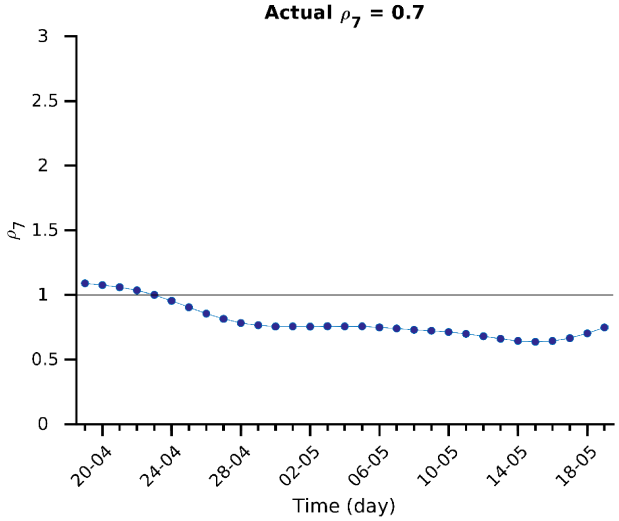
Day	Number of cases
22-05-2021	5168925 (+17887)
26-05-2021	5186664 (+35626)
29-05-2021	5196521 (+45483)

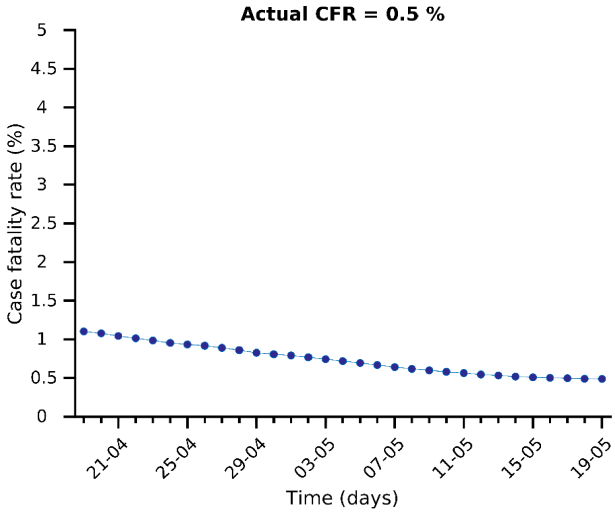
Current indicators

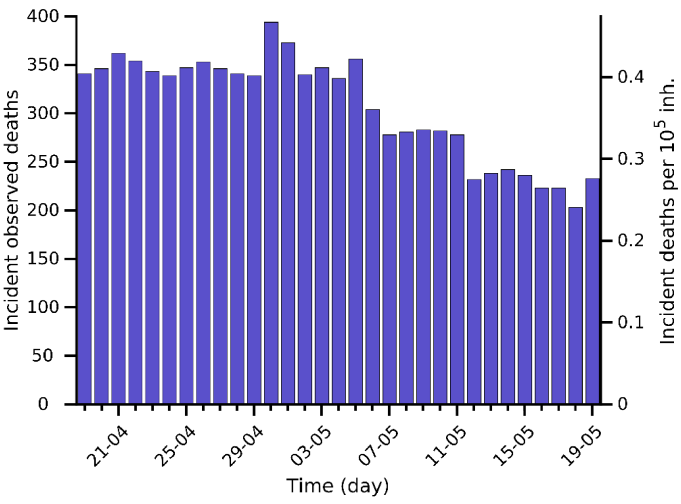
	A14	EPG	CFR	N7	D7
Today	232	173	0.49 %	11225	228
A Week ago	381	259	0.54 %	16695	277
Maximum	964	1028	4.93 %	60266	356

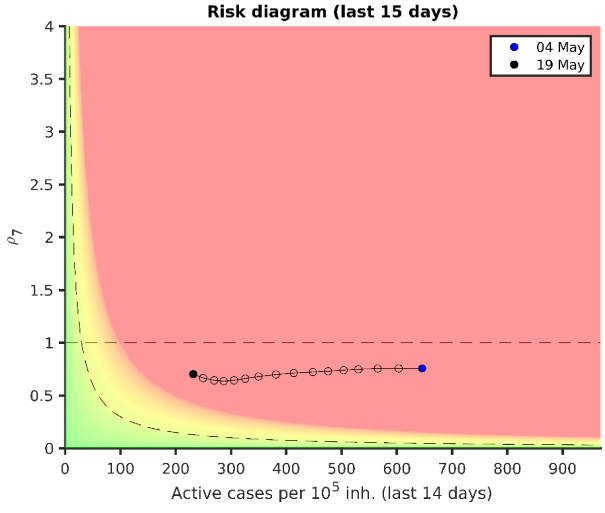




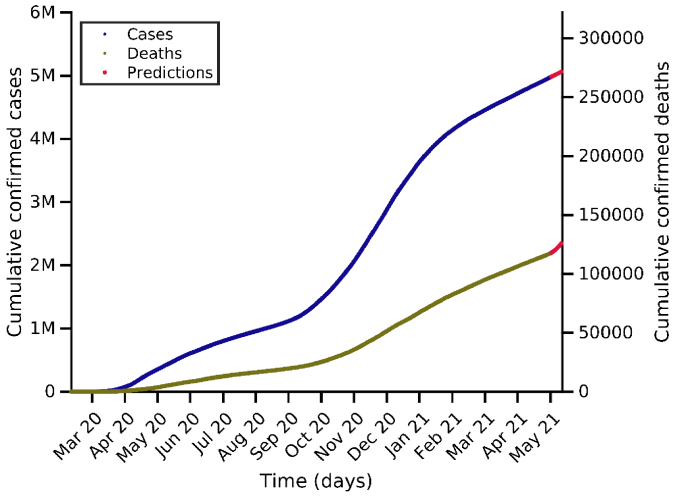








Russia 19-05-2021. Pop: 145.9M. Cumulative incidence: 3409/10⁵

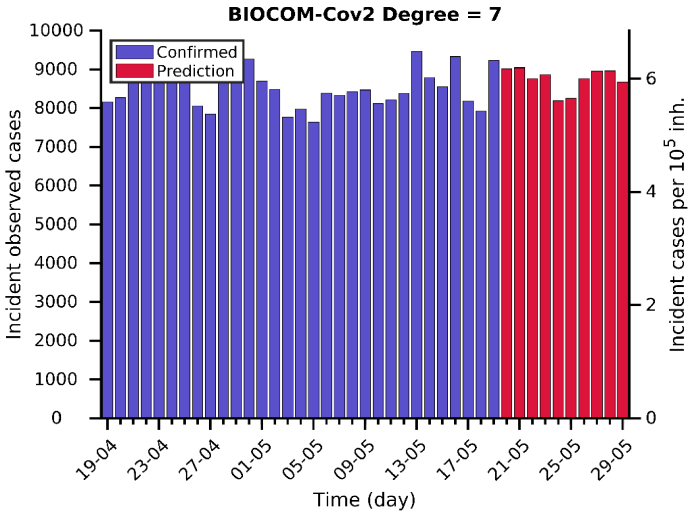


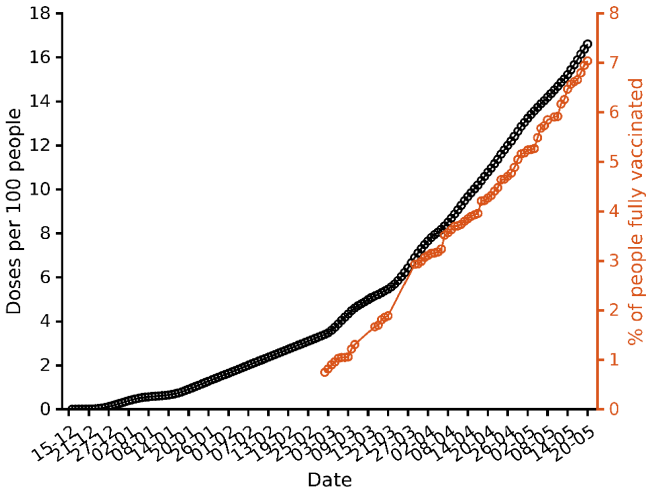
Predictions for next days

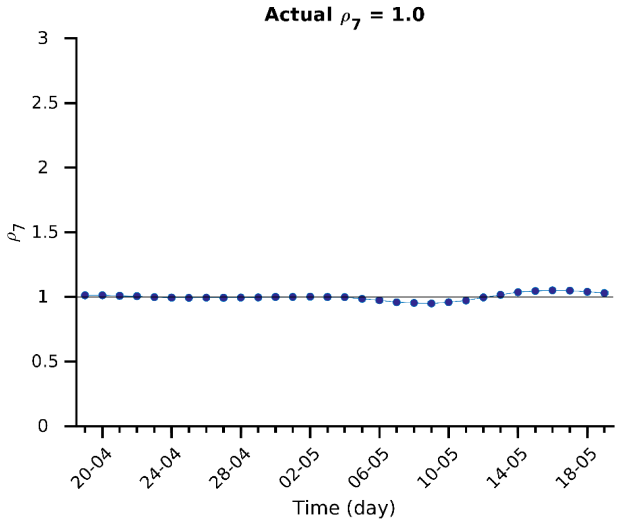
Day	Number of cases
22-05-2021	5001728 (+26820)
26-05-2021	5035798 (+60890)
29-05-2021	5062386 (+87478)

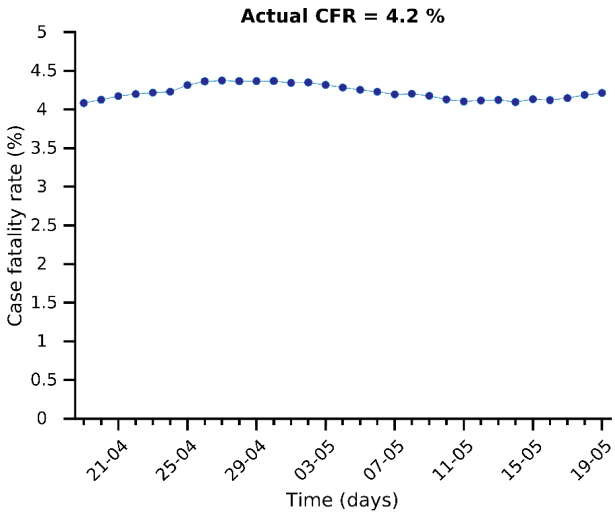
Current indicators

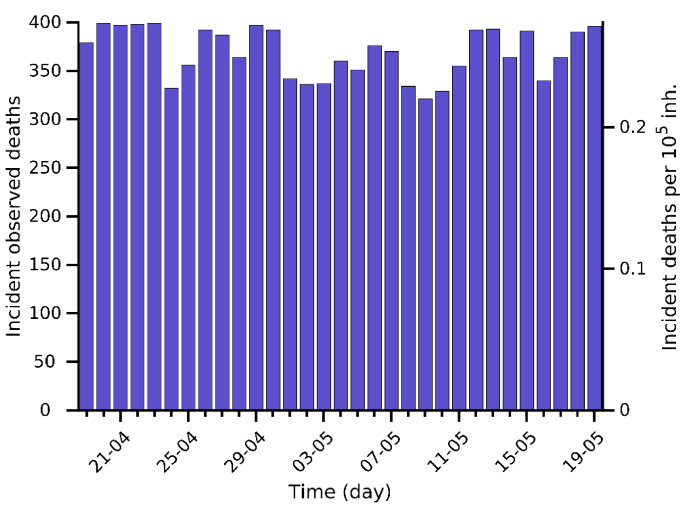
	A14	EPG	CFR	N7	D7
Today	82	85	4.21 %	8781	377
A Week ago	80	80	4.12 %	8330	354
Maximum	272	281	4.72 %	28934	566

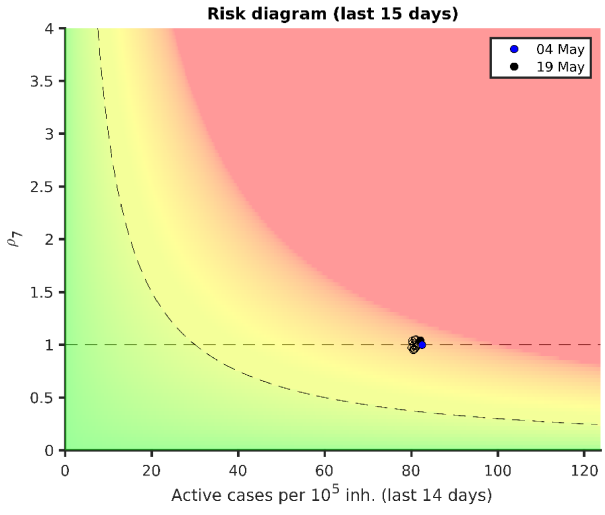




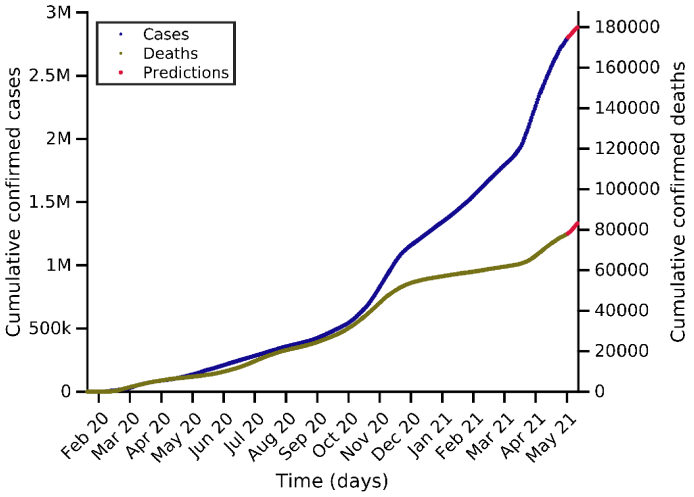








Iran 19-05-2021. Pop: 84.0M. Cumulative incidence: 3324/10⁵

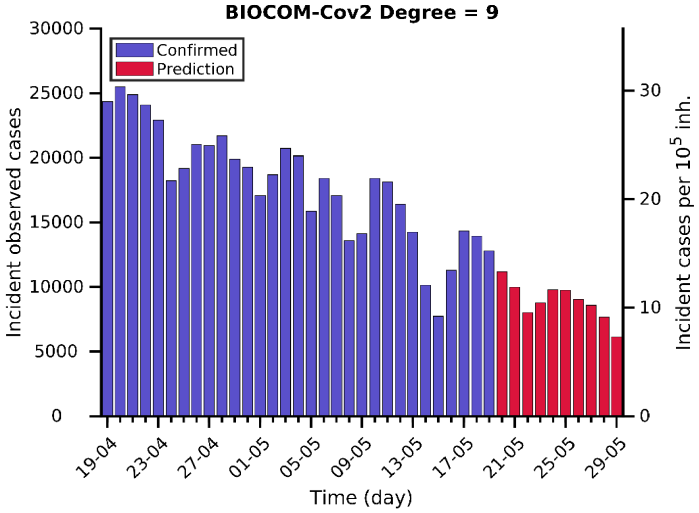


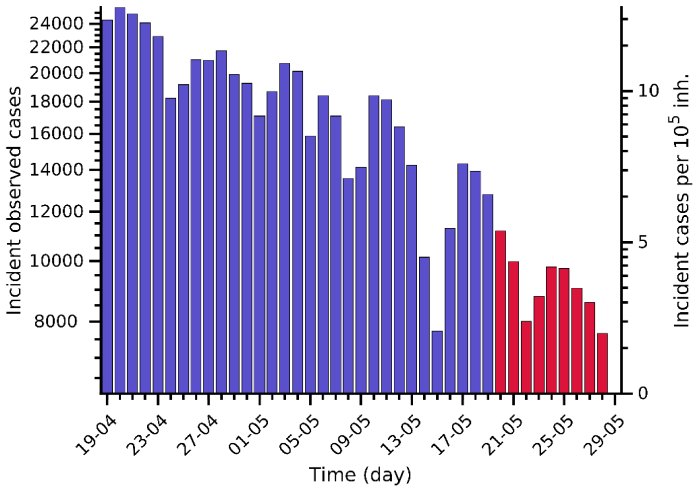
Predictions for next days

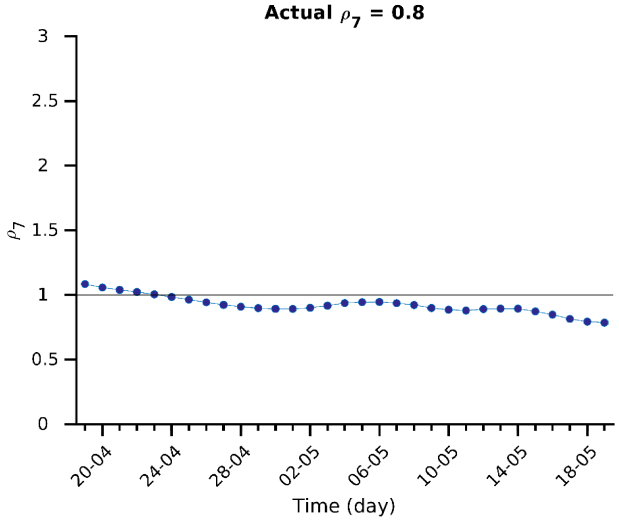
Day	Number of cases
22-05-2021	2821378 (+29174)
26-05-2021	2858729 (+66525)
29-05-2021	2881112 (+88908)

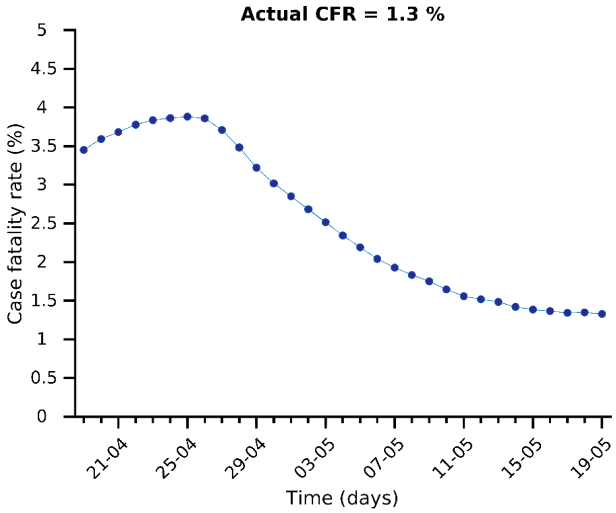
Current indicators

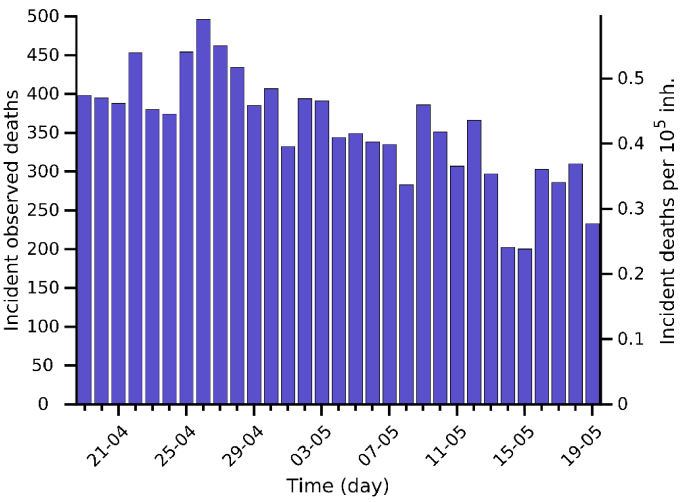
	A14	EPG	CFR	N7	D7
Today	239	188	1.33 %	12063	262
A Week ago	295	263	1.52 %	16593	338
Maximum	392	435	4.99 %	24102	473

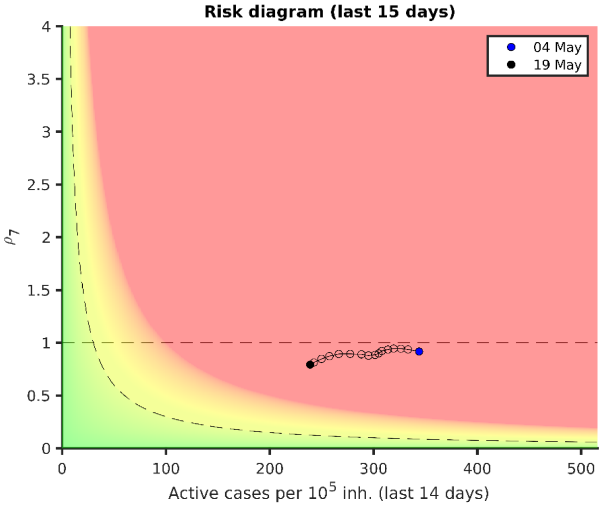




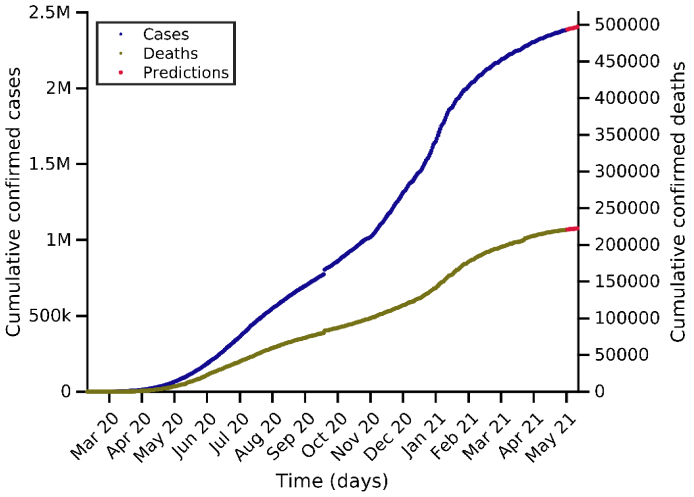








Mexico 19-05-2021. Pop: 128.9M. Cumulative incidence: 1850/10⁵

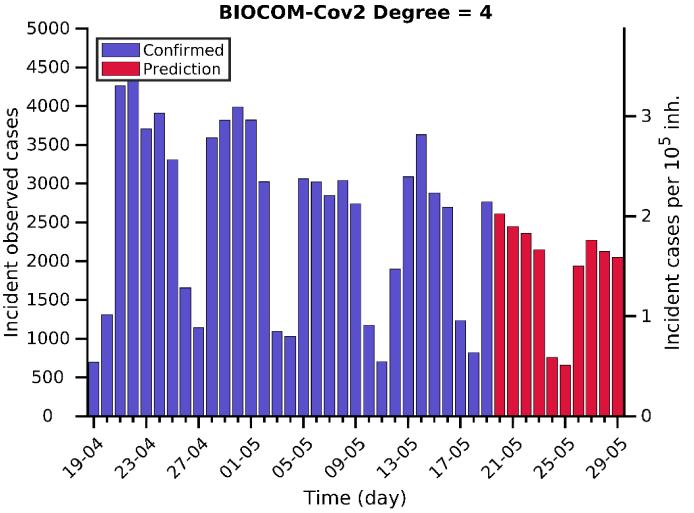


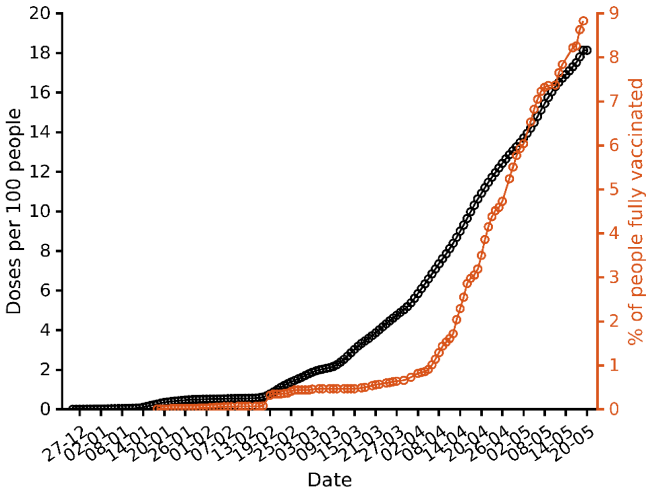
Predictions for next days

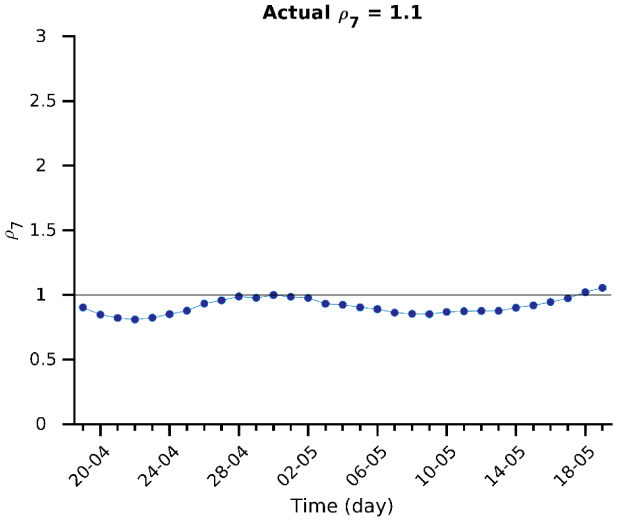
Day	Number of cases
22-05-2021	2392928 (+7416)
26-05-2021	2398426 (+12914)
29-05-2021	2404873 (+19361)

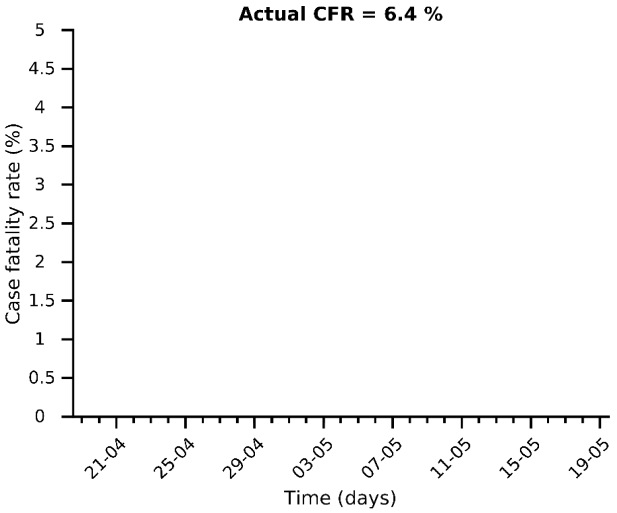
Current indicators

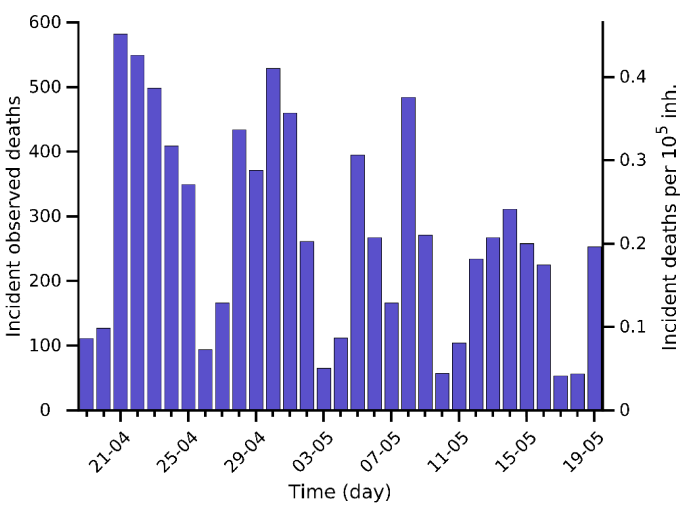
	A14	EPG	CFR	N7	D7
Today	25	27	6.40 %	2446	203
A Week ago	27	24	6.89 %	2204	226
Maximum	184	199	0.00 %	17559	1324

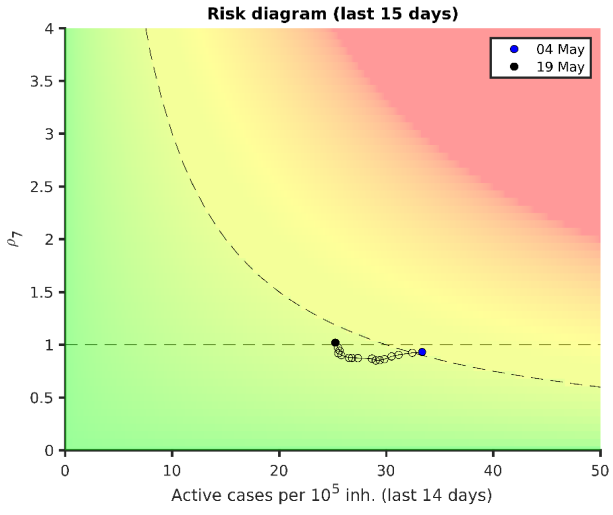




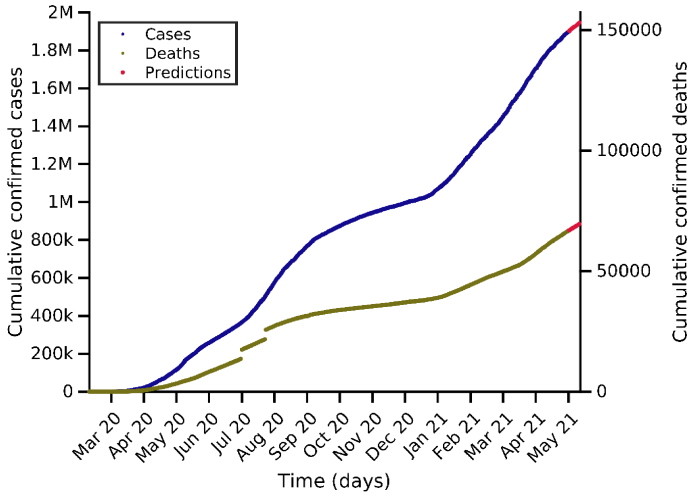








Peru 19-05-2021. Pop: 33.0M. Cumulative incidence: 5756/10⁵

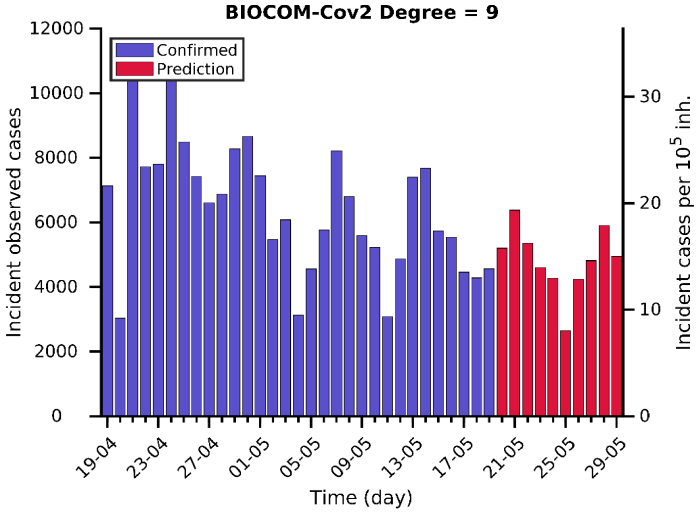


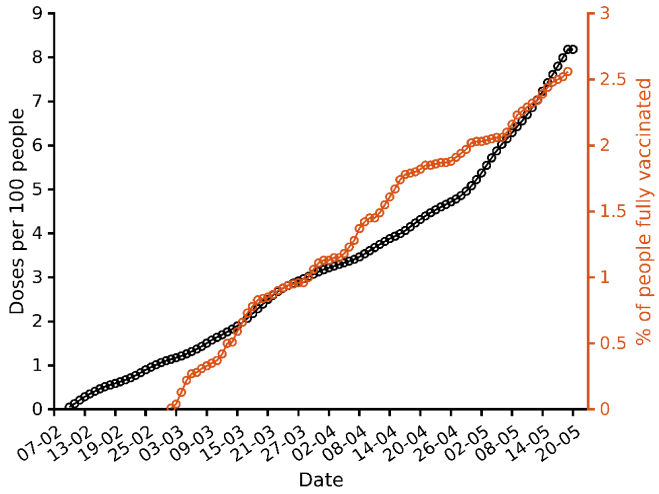
Predictions for next days

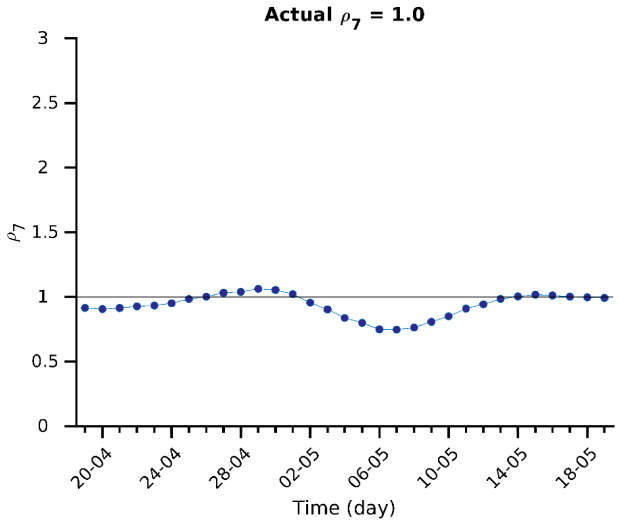
Day	Number of cases
22-05-2021	1914839 (+16939)
26-05-2021	1930603 (+32703)
29-05-2021	1946266 (+48366)

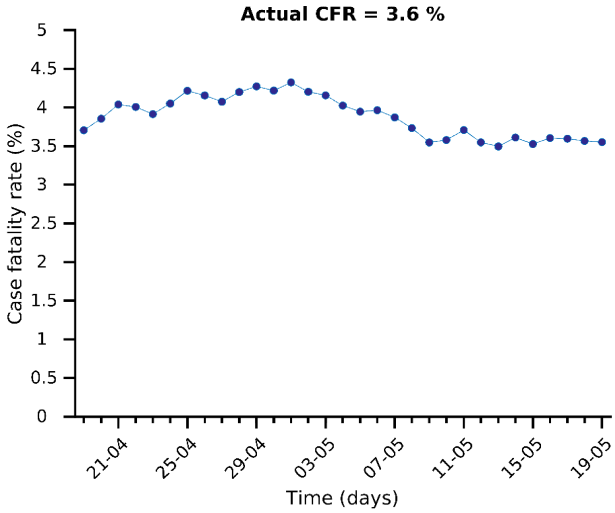
Current indicators

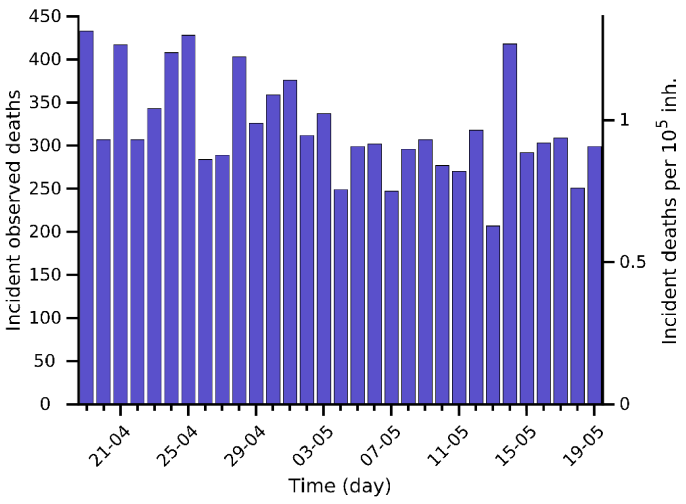
	A14	EPG	CFR	N7	D7
Today	240	238	3.55 %	5666	297
A Week ago	252	238	3.55 %	5650	288
Maximum	375	411	4.98 %	9401	747

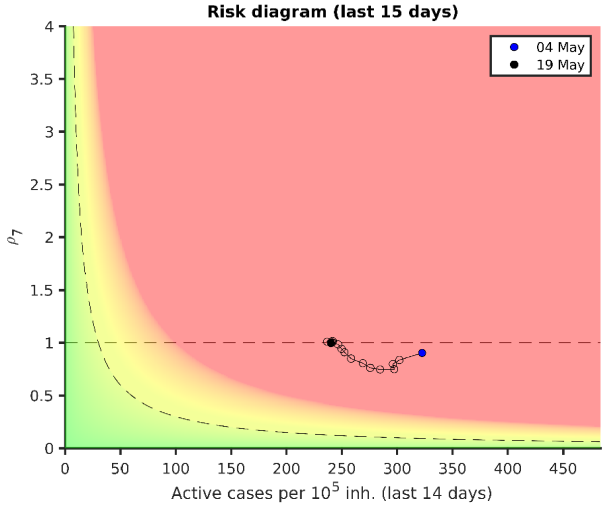




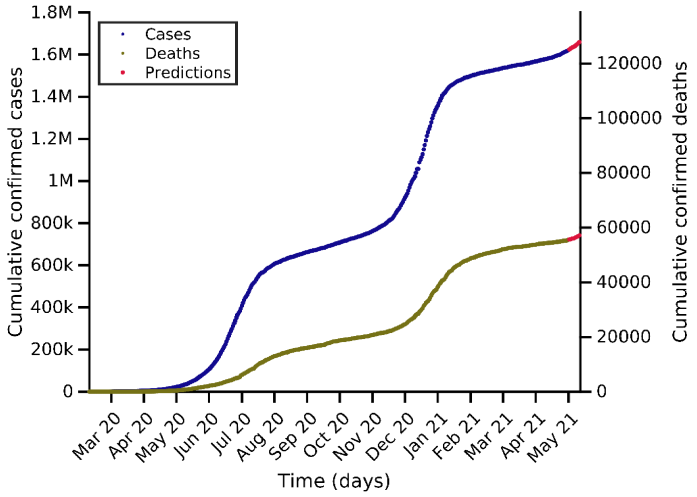








South Africa 19-05-2021. Pop: 59.3M. Cumulative incidence: 2734/10⁵

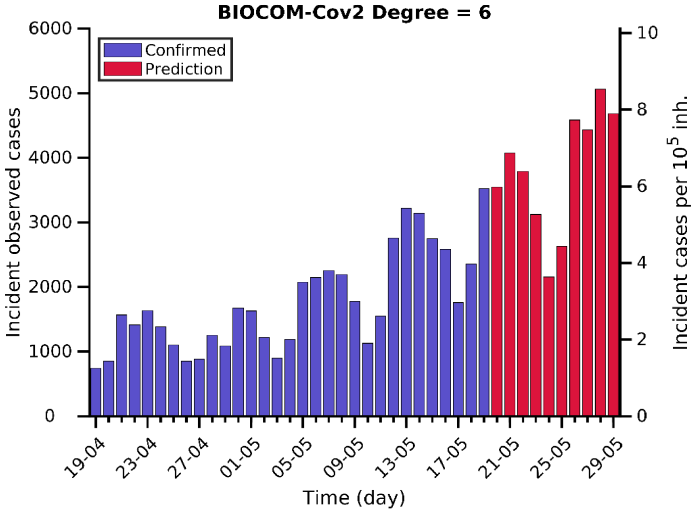


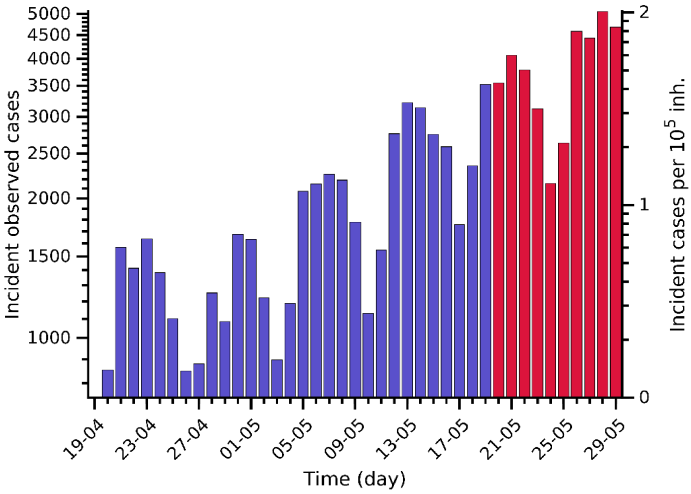
Predictions for next days

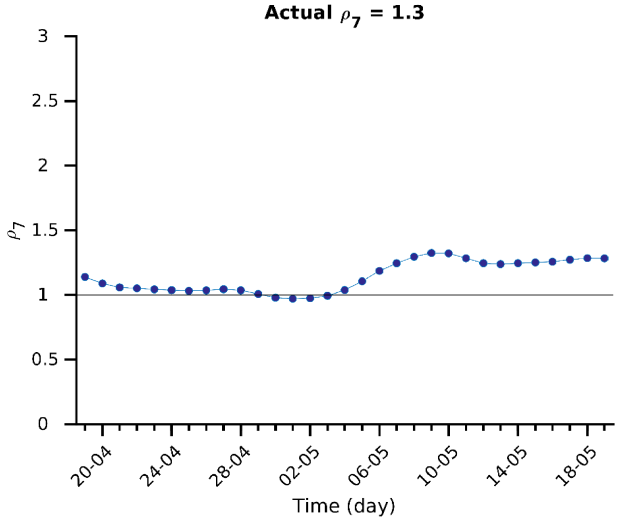
Day	Number of cases
22-05-2021	1632775 (+11413)
26-05-2021	1645269 (+23907)
29-05-2021	1659449 (+38087)

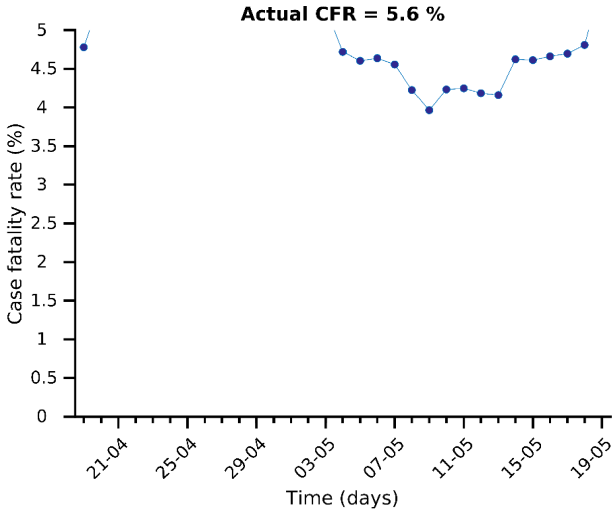
Current indicators

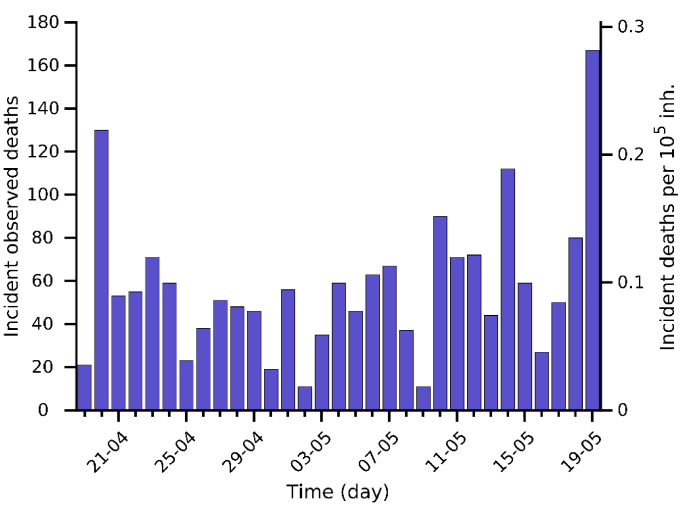
	A14	EPG	CFR	N7	D7
Today	56	72	5.62 %	2762	77
A Week ago	40	50	4.18 %	1973	59
Maximum	428	511	4.99 %	19287	578

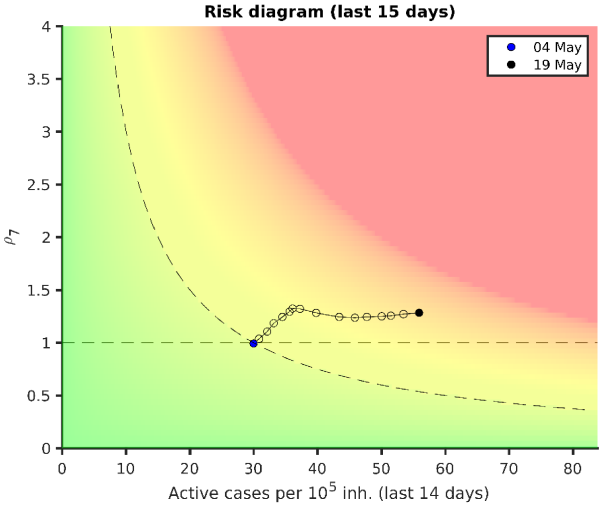




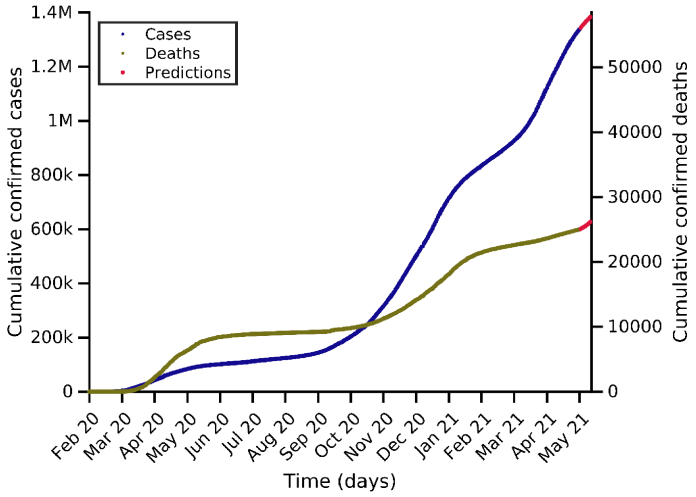








Canada 19-05-2021. Pop: 37.7M. Cumulative incidence: 3545/10⁵

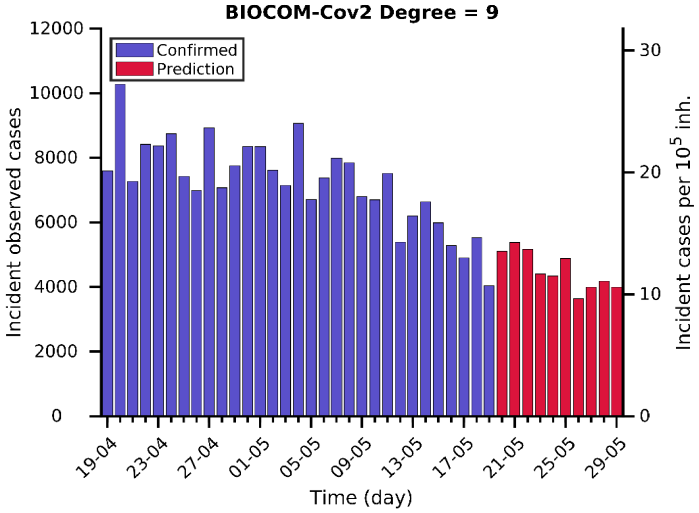


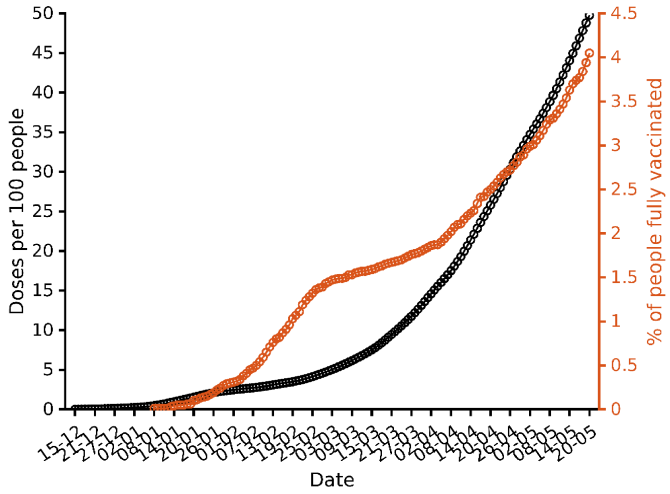
Predictions for next days

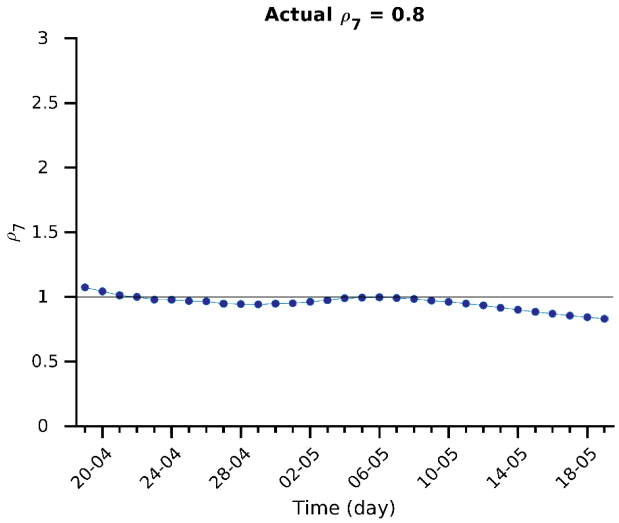
Day	Number of cases
22-05-2021	1353796 (+15655)
26-05-2021	1371057 (+32916)
29-05-2021	1383220 (+45079)

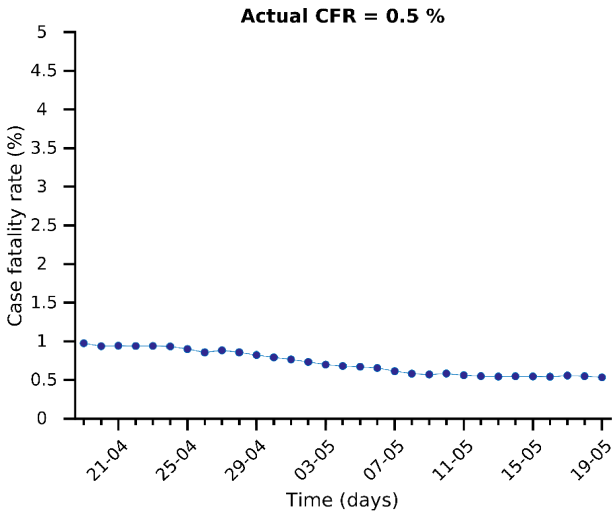
Current indicators

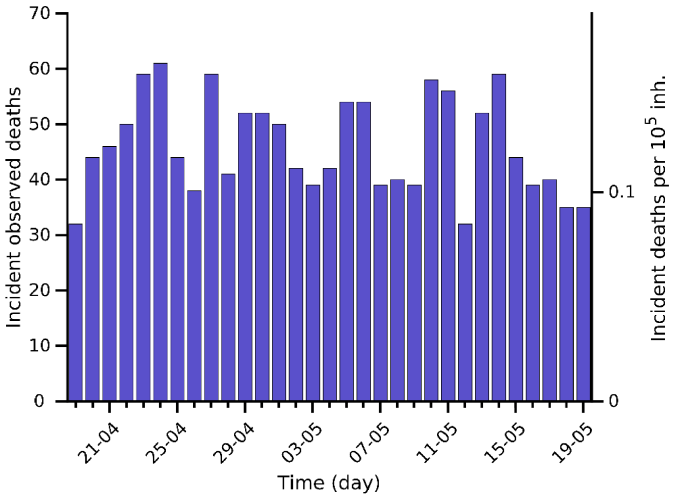
	A14	EPG	CFR	N7	D7
Today	234	194	0.53 %	5510	43
A Week ago	277	259	0.55 %	7089	45
Maximum	317	342	4.63 %	8767	178

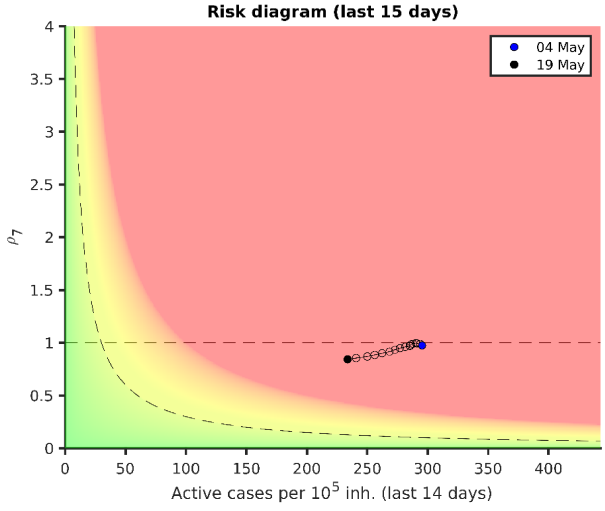




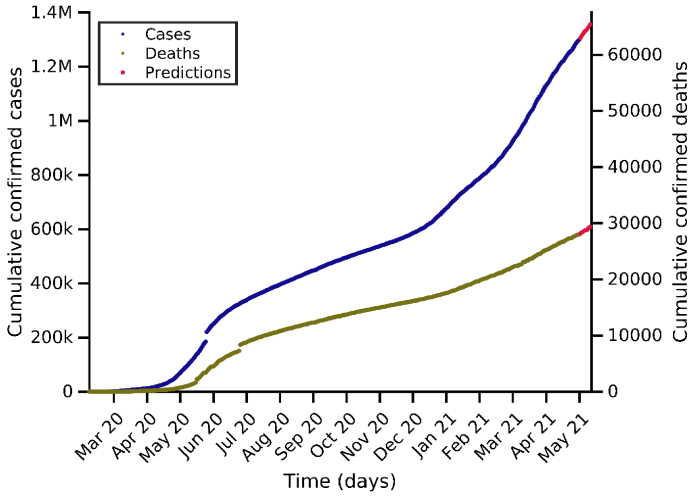








Chile 19-05-2021. Pop: 19.1M. Cumulative incidence: 6804/10^5

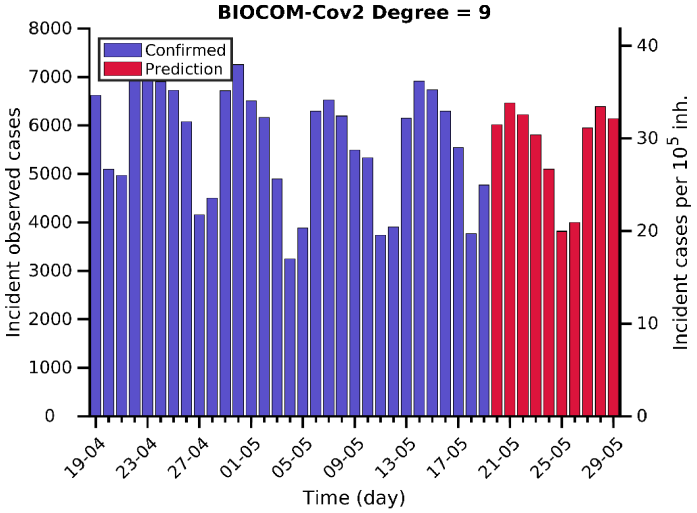


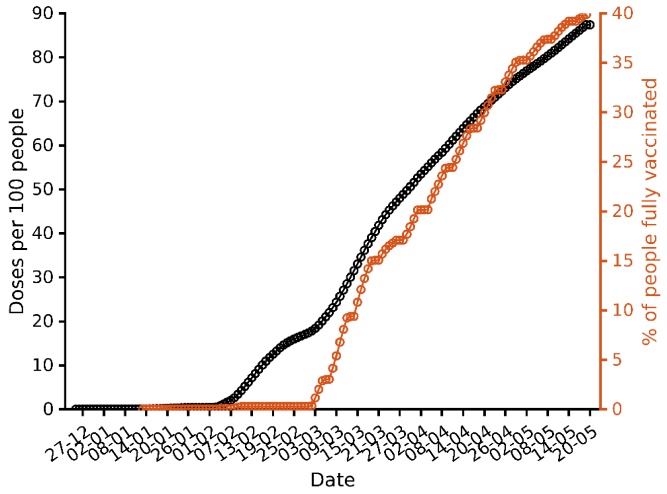
Predictions for next days

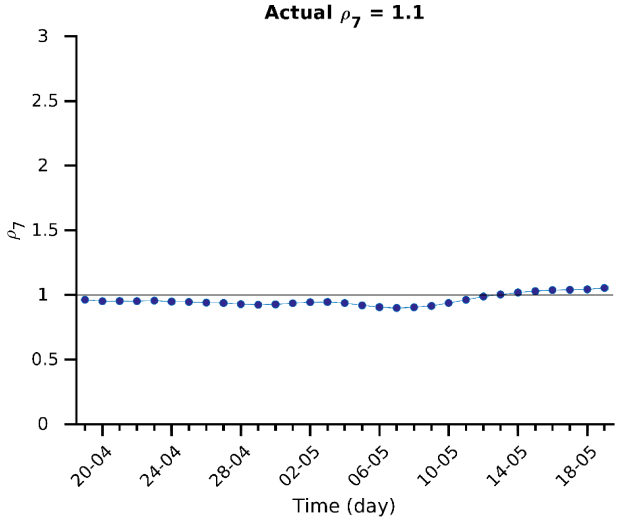
Day	Number of cases
22-05-2021	1319334 (+18705)
26-05-2021	1338050 (+37421)
29-05-2021	1356529 (+55900)

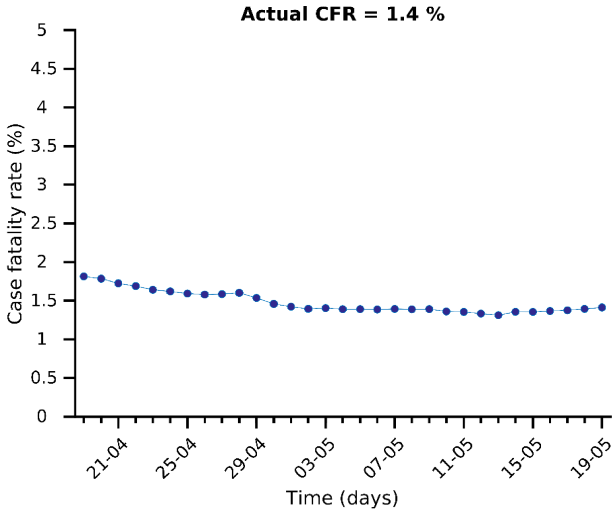
Current indicators

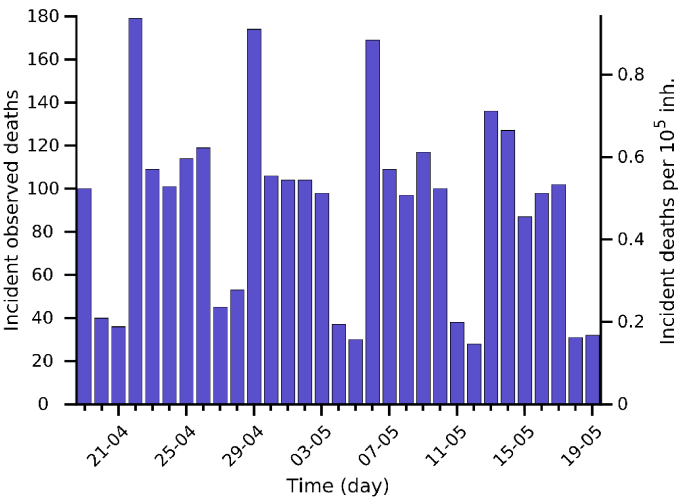
	A14	EPG	CFR	N7	D7
Today	406	428	1.41 %	5740	88
A Week ago	398	393	1.33 %	5357	94
Maximum	570	980	4.98 %	10305	241

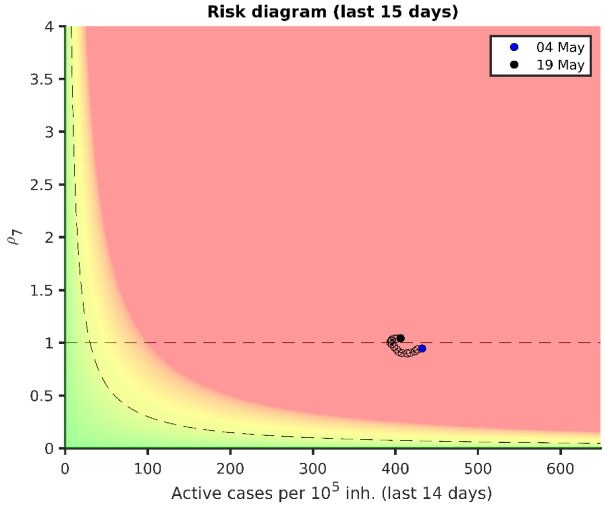




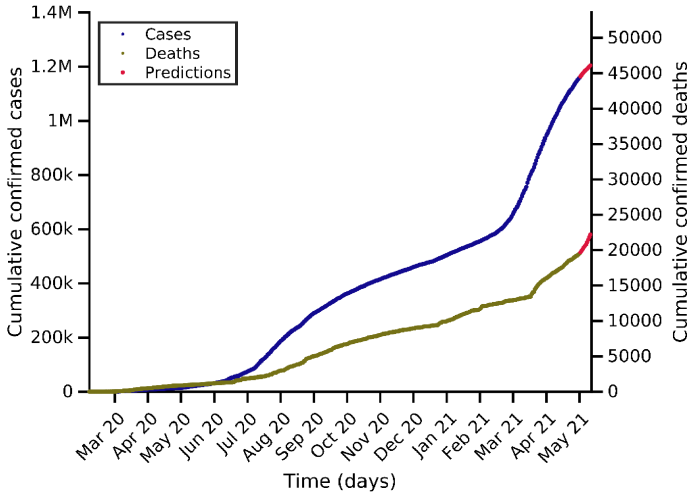








Philippines 19-05-2021. Pop: 109.6M. Cumulative incidence: 1058/10⁵

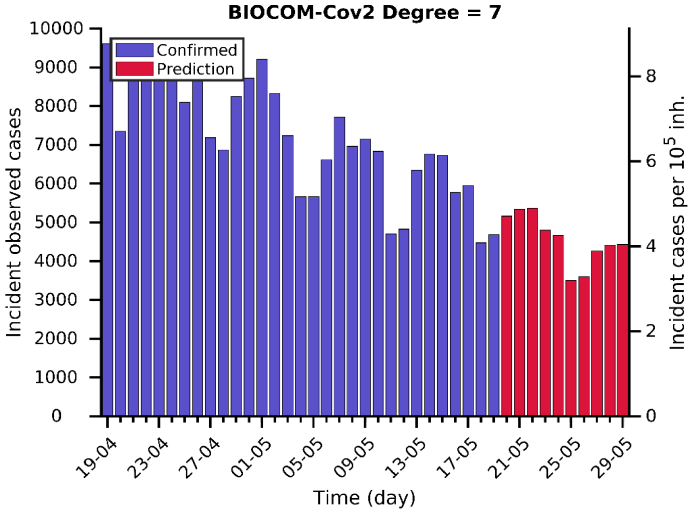


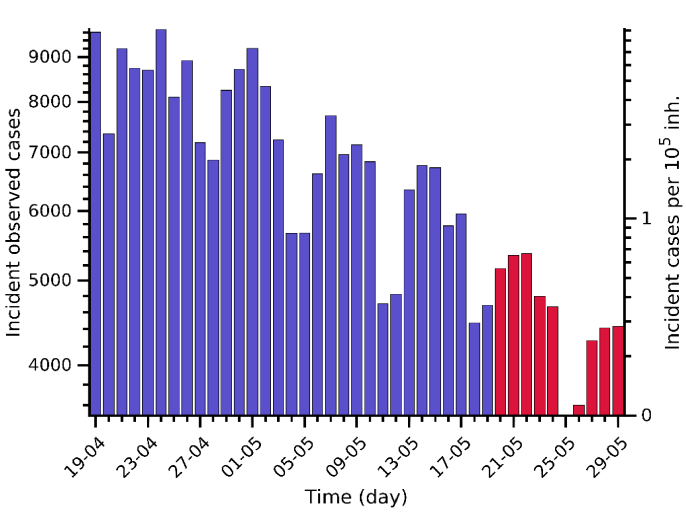
Predictions for next days

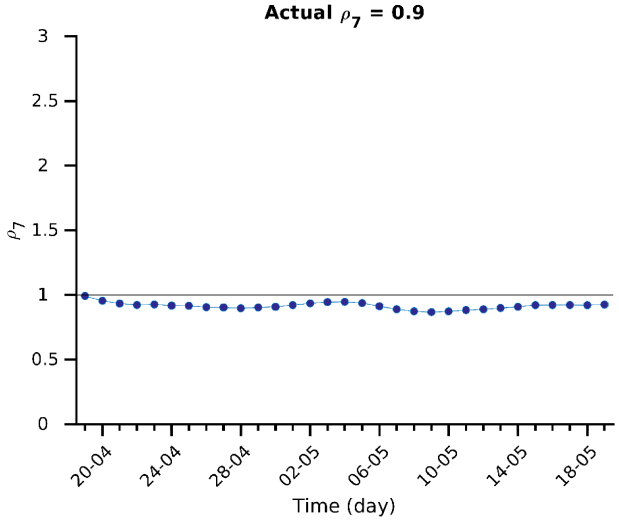
Day	Number of cases
22-05-2021	1174921 (+15866)
26-05-2021	1191483 (+32428)
29-05-2021	1204594 (+45539)

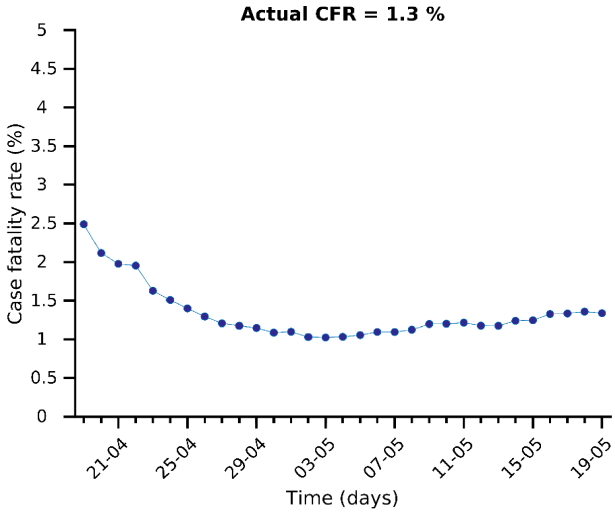
Current indicators

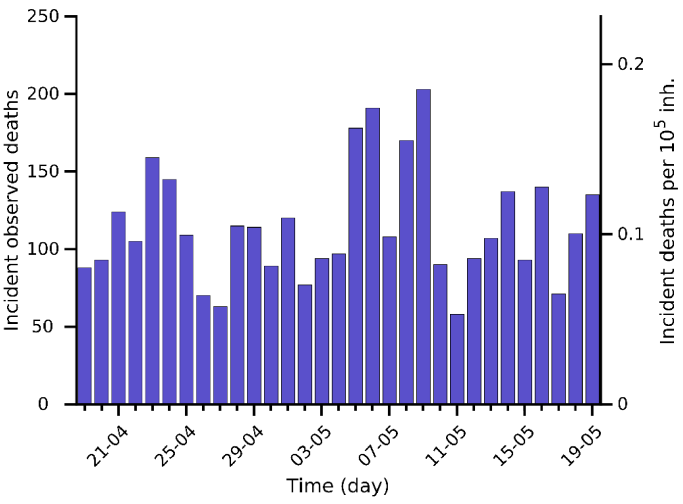
	A14	EPG	CFR	N7	D7
Today	78	72	1.34 %	5817	113
A Week ago	89	79	1.18 %	6401	131
Maximum	135	143	4.97 %	10845	245

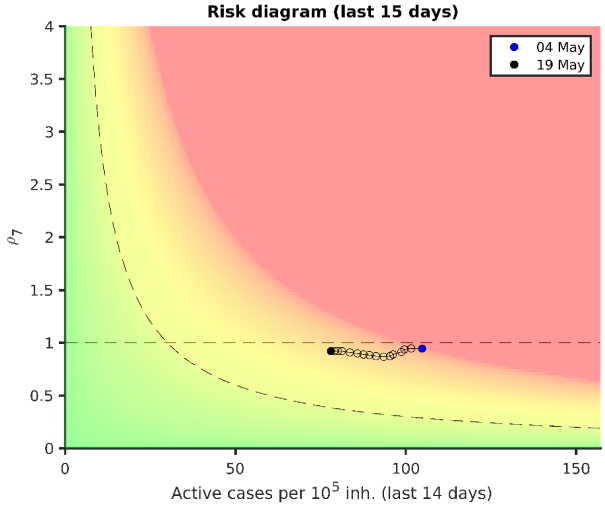




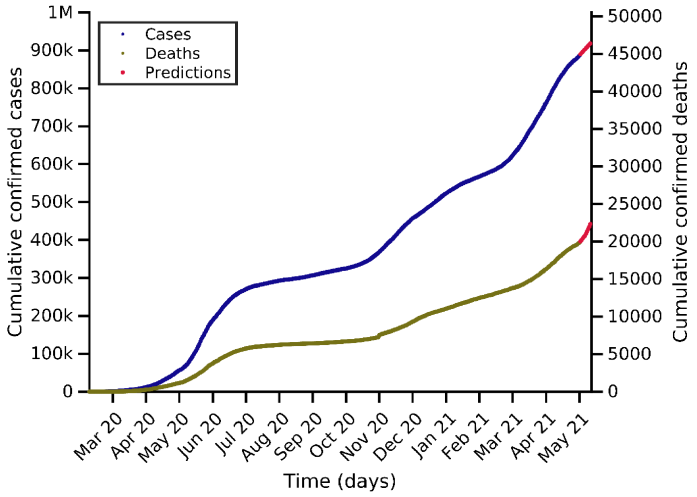








Pakistan 19-05-2021. Pop: 220.9M. Cumulative incidence: 401/10⁵

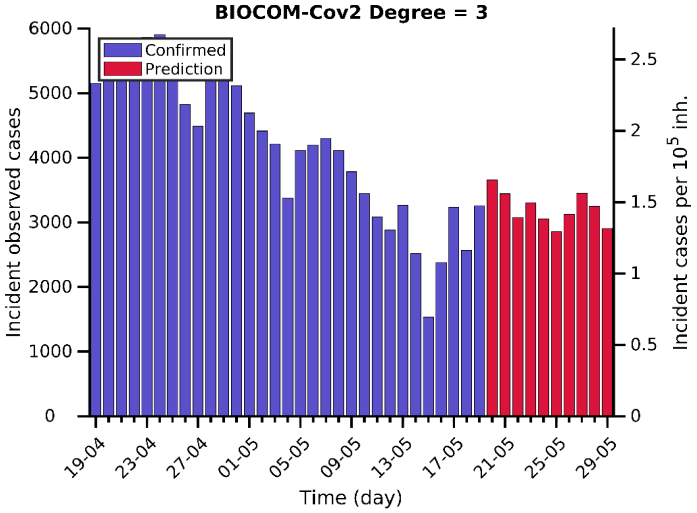


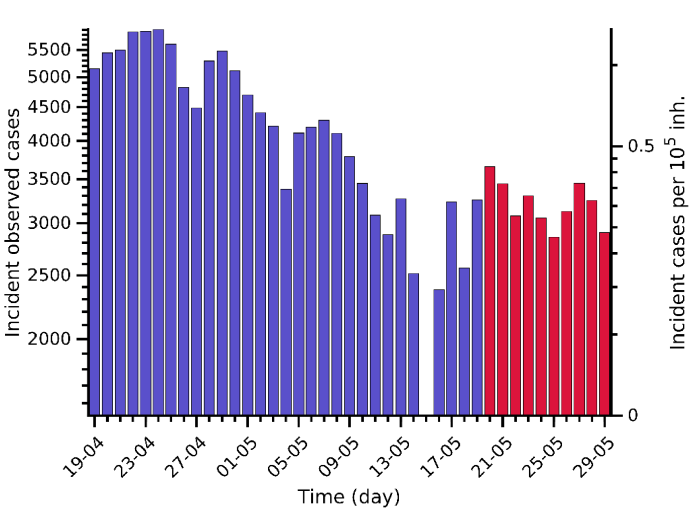
Predictions for next days

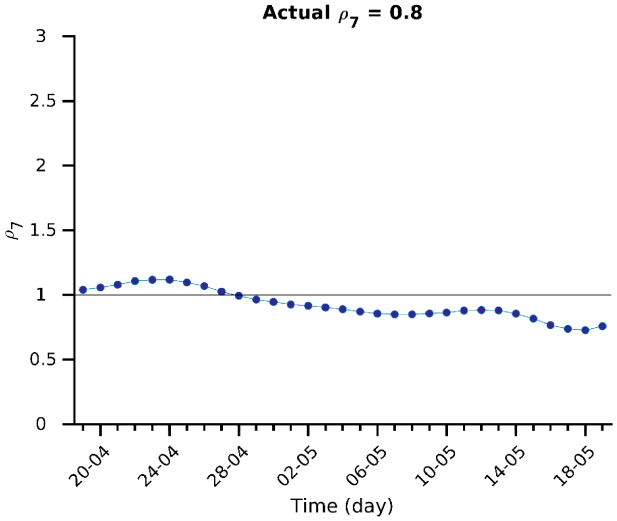
Day	Number of cases
22-05-2021	896360 (+10176)
26-05-2021	908699 (+22515)
29-05-2021	918303 (+32119)

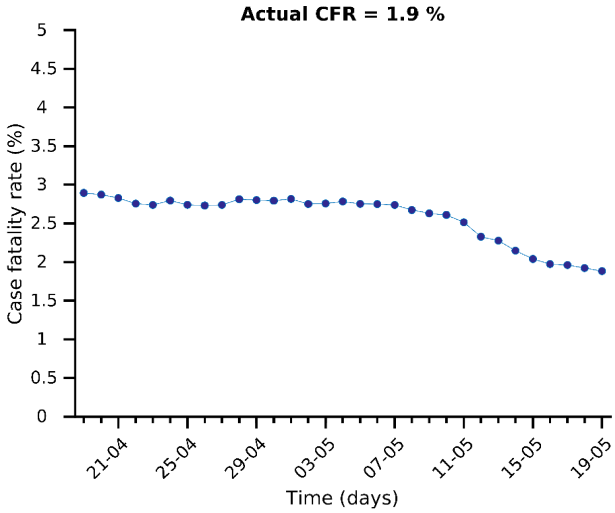
Current indicators

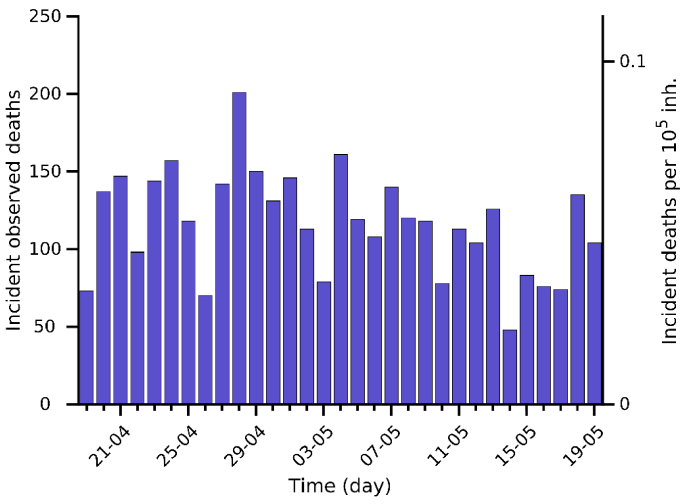
	A14	EPG	CFR	N7	D7
Today	20	15	1.88 %	2678	92
A Week ago	26	23	2.33 %	3686	112
Maximum	35	40	4.90 %	5865	140

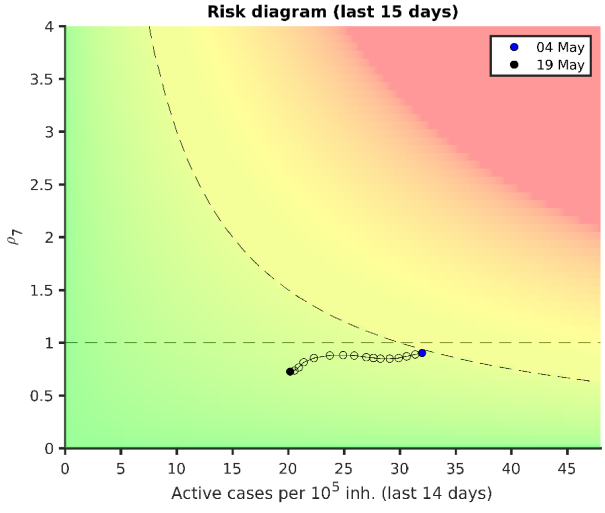




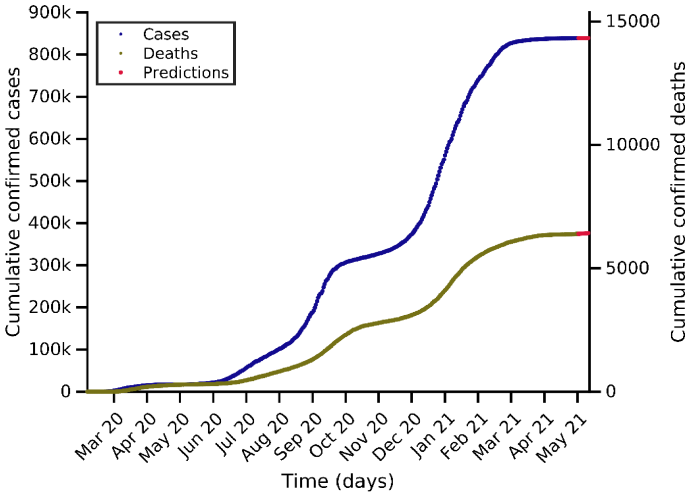








Israel 19-05-2021. Pop: 8.7M. Cumulative incidence: 9695/10⁵

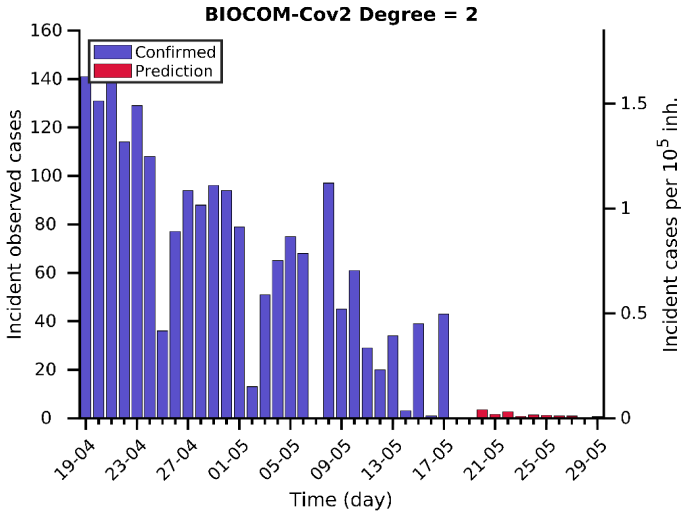


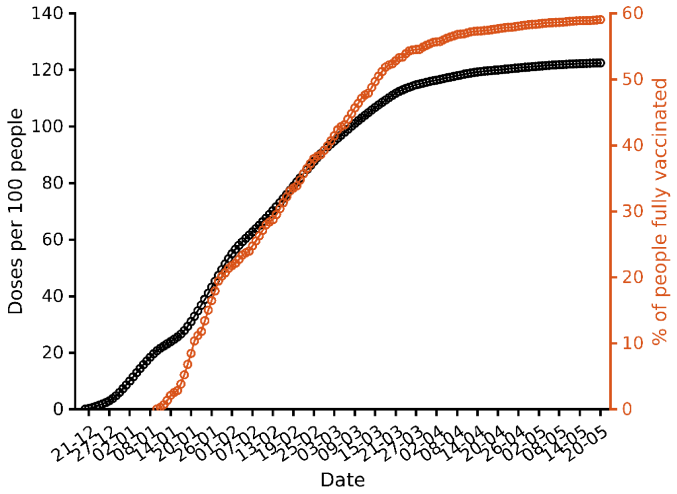
Predictions for next days

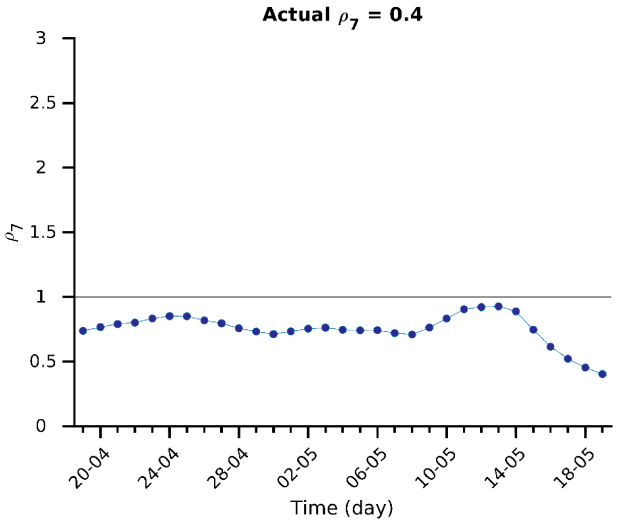
Day	Number of cases
22-05-2021	839170 (+8)
26-05-2021	839174 (+12)
29-05-2021	839176 (+14)

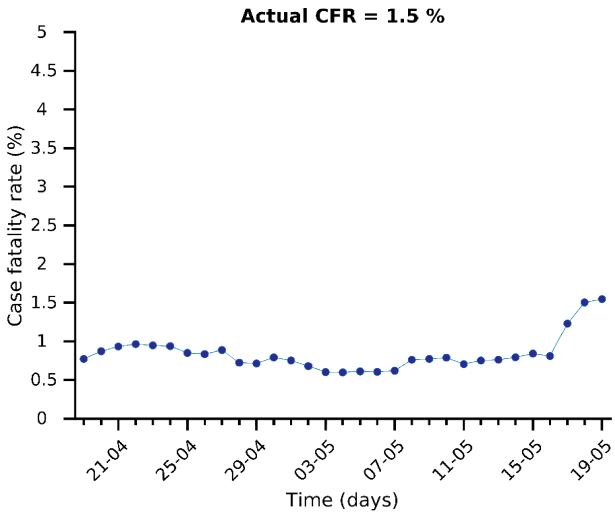
Current indicators

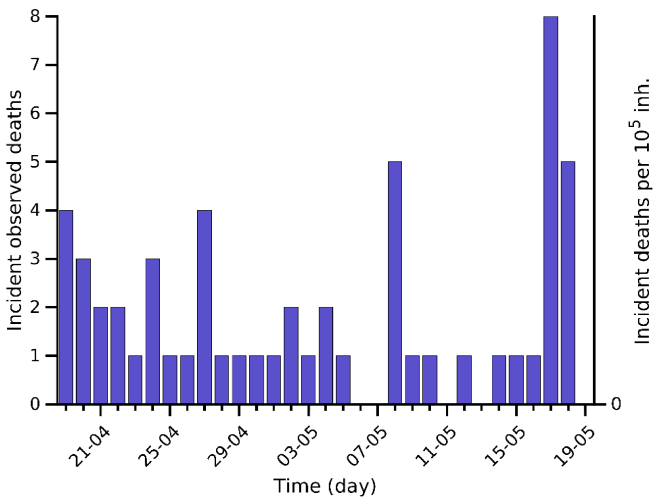
	A14	EPG	CFR	N7	D7
Today	5	2	1.55 %	17	2
A Week ago	9	8	0.75 %	46	1
Maximum	1293	1406	4.95 %	8329	59

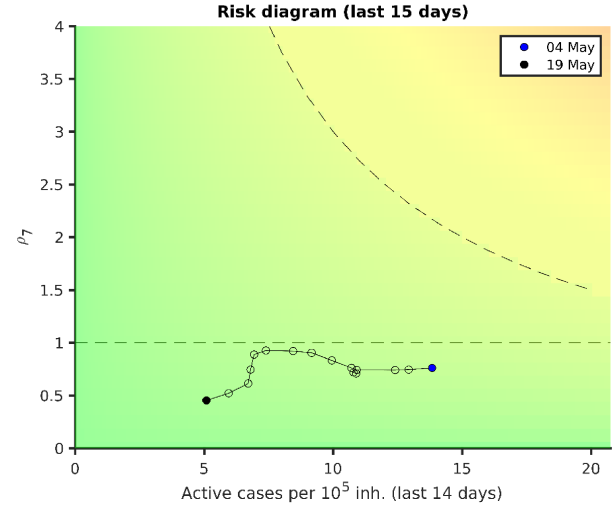




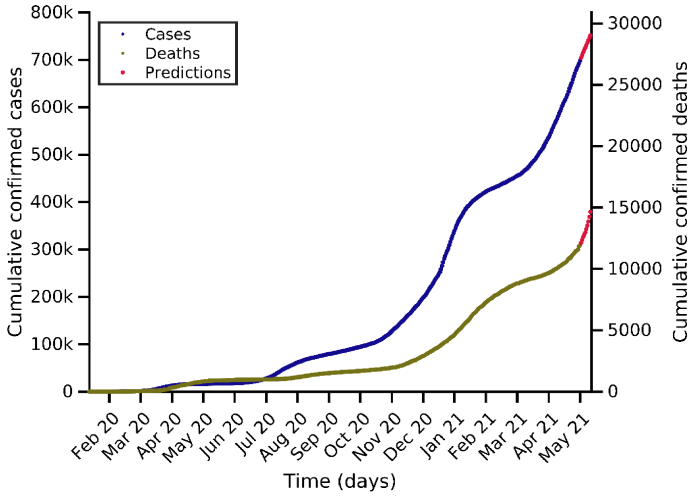








Japan 19-05-2021. Pop: 126.5M. Cumulative incidence: 552/10^5

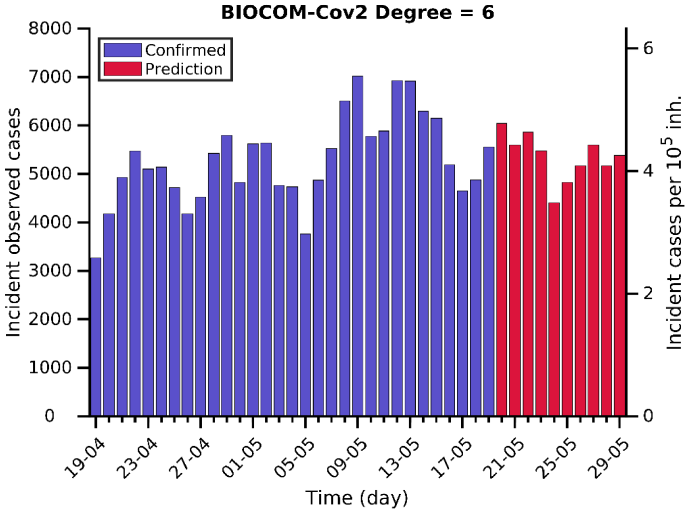


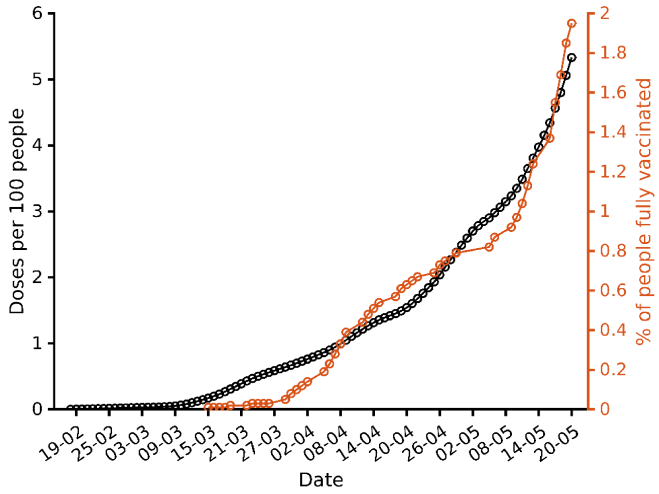
Predictions for next days

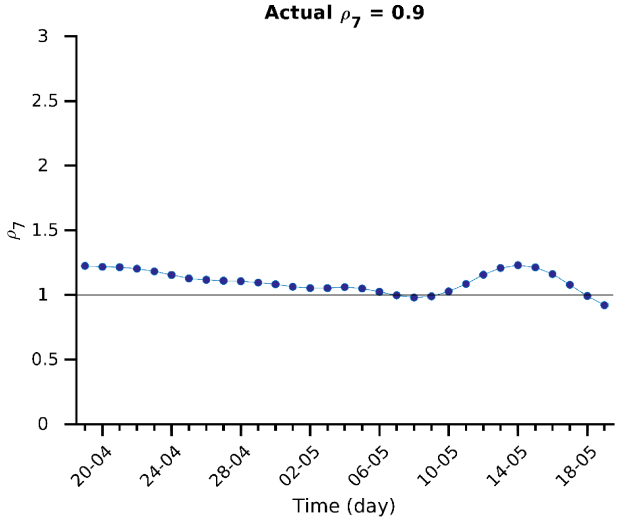
Day	Number of cases
22-05-2021	715754 (+17500)
26-05-2021	735633 (+37379)
29-05-2021	751782 (+53528)

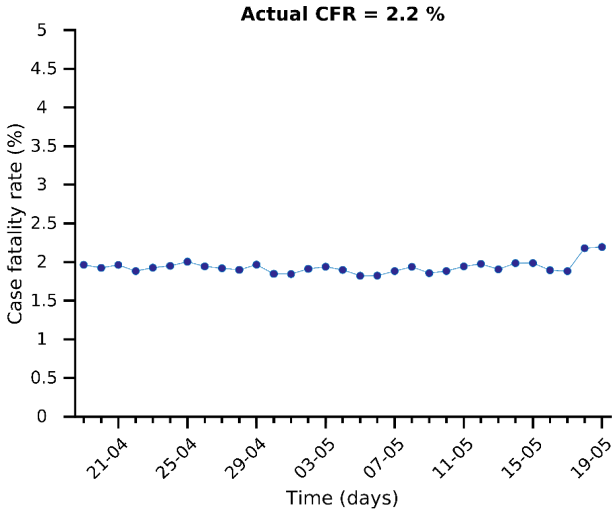
Current indicators

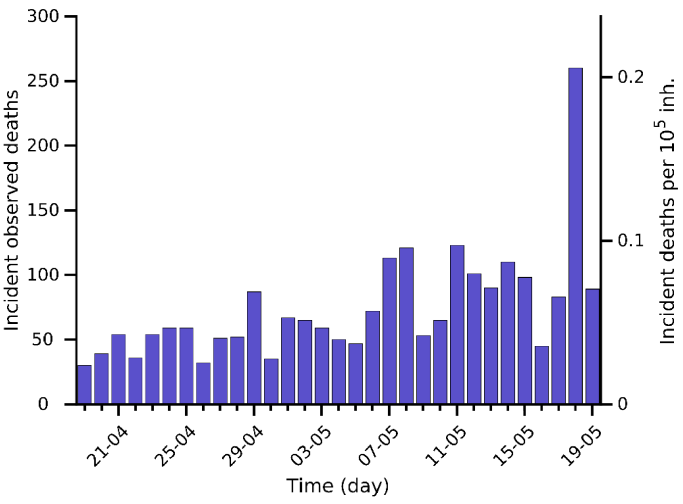
	A14	EPG	CFR	N7	D7
Today	65	60	2.19 %	5661	111
A Week ago	61	71	1.98 %	6072	93
Maximum	69	86	4.97 %	6474	112

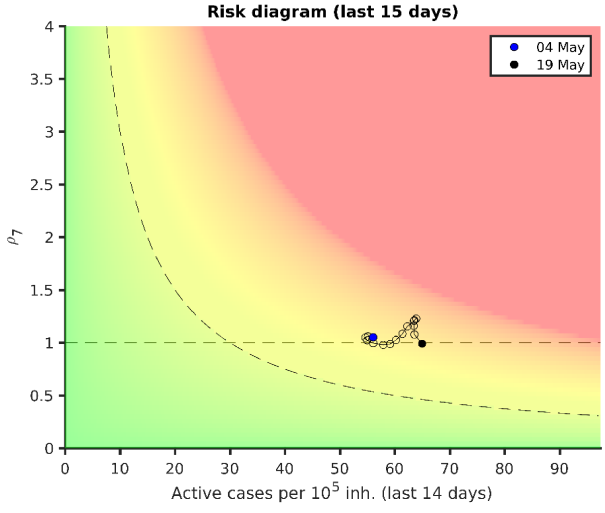




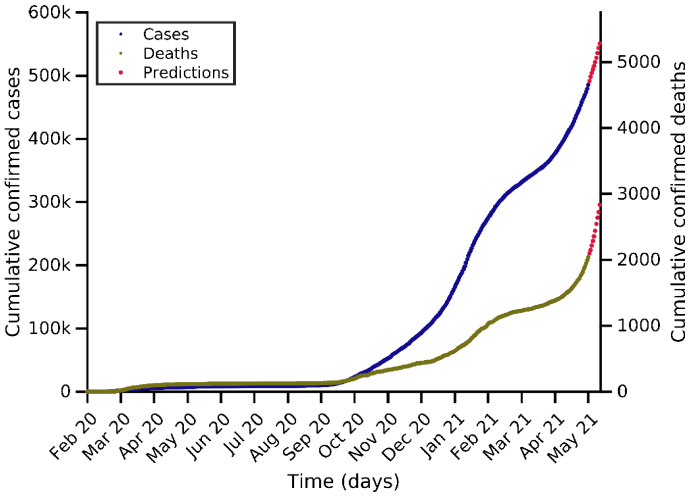








Malaysia 19-05-2021. Pop: 32.4M. Cumulative incidence: 1500/10^5

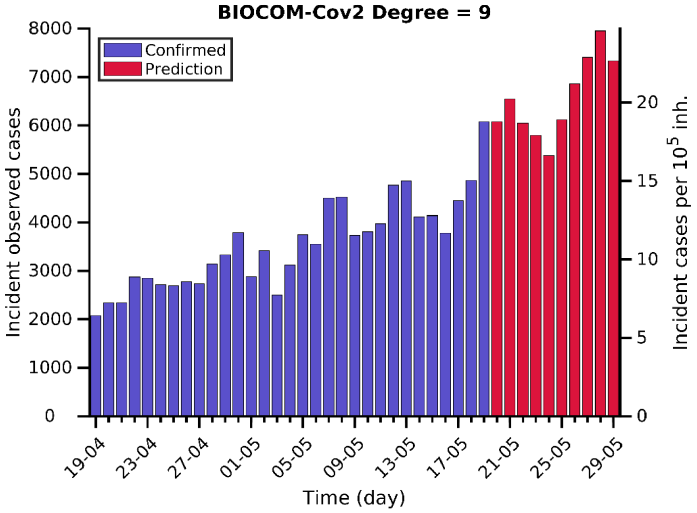


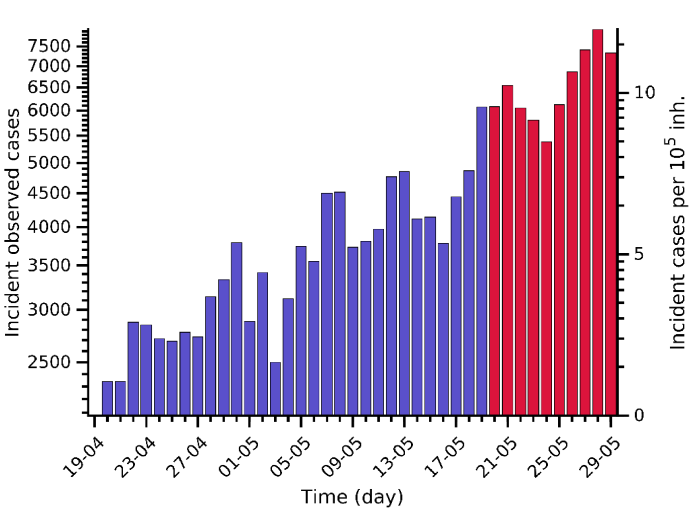
Predictions for next days

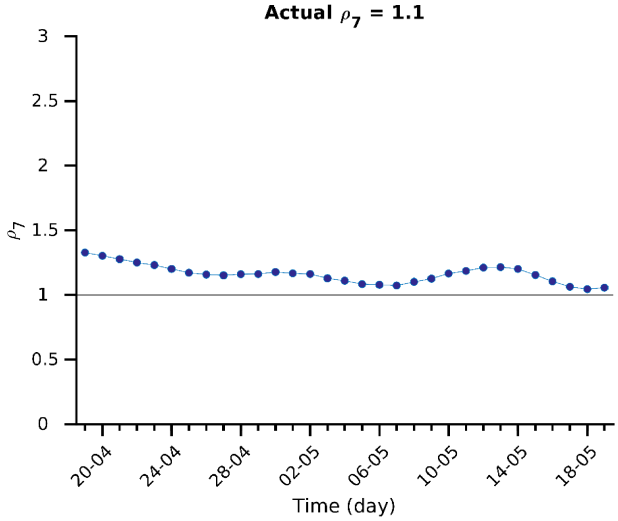
Day	Number of cases
22-05-2021	504169 (+18673)
26-05-2021	528333 (+42837)
29-05-2021	551027 (+65531)

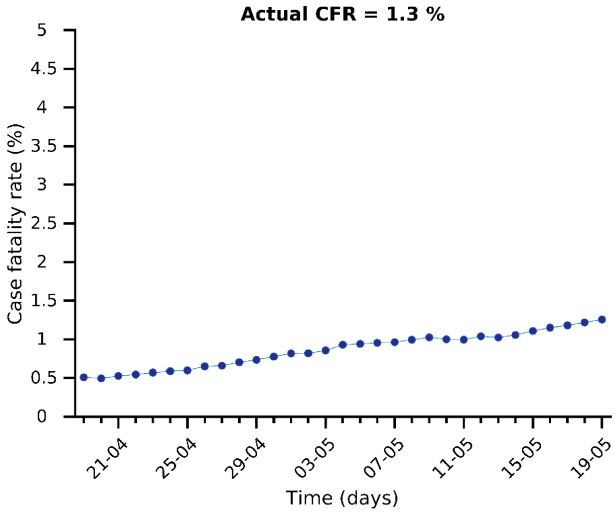
Current indicators

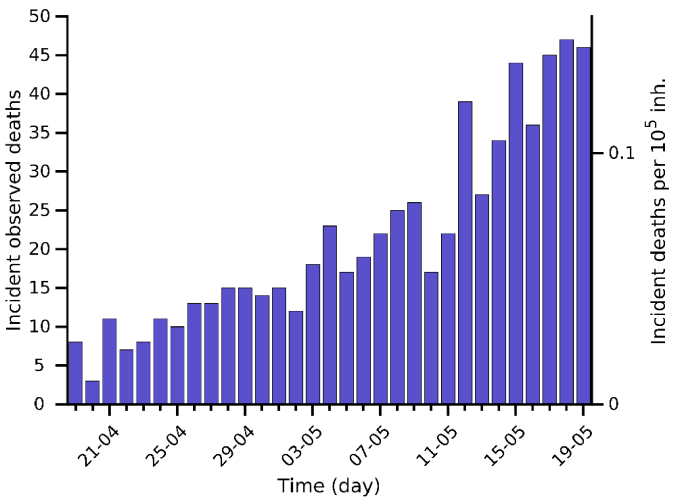
	A14	EPG	CFR	N7	D7
Today	189	199	1.26 %	4611	40
A Week ago	160	193	1.04 %	4121	24
Maximum	189	225	4.98 %	4754	40

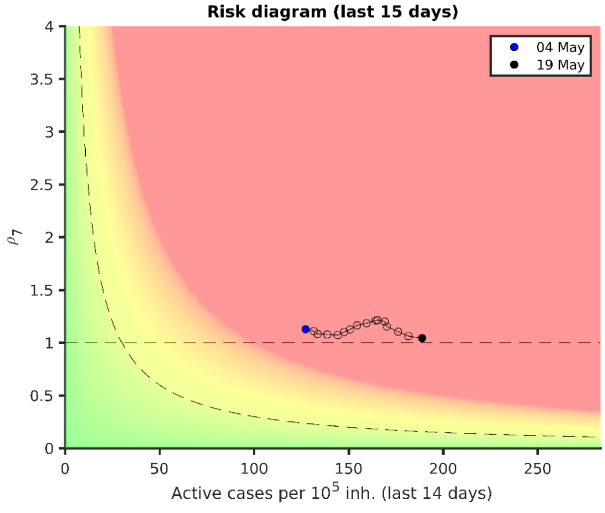




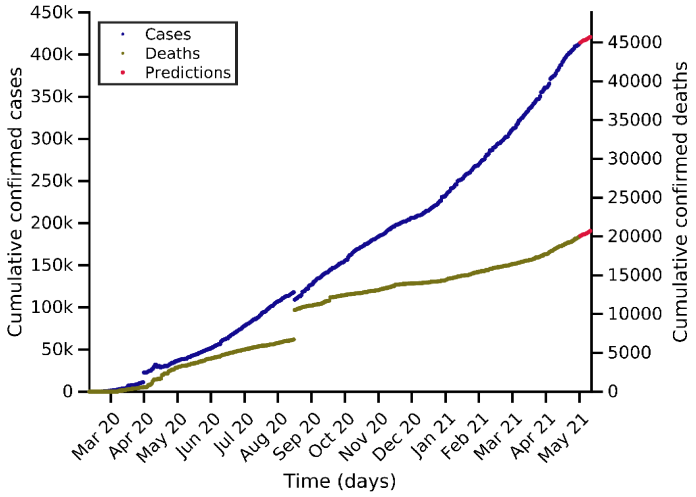








Ecuador 19-05-2021. Pop: 17.6M. Cumulative incidence: 2340/10^5

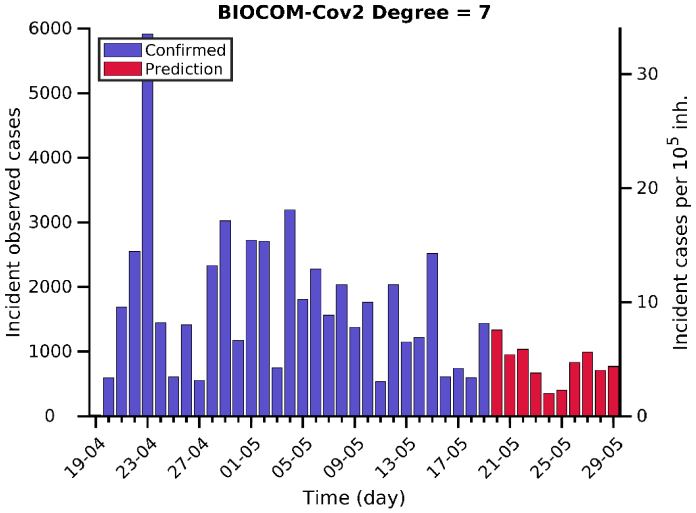


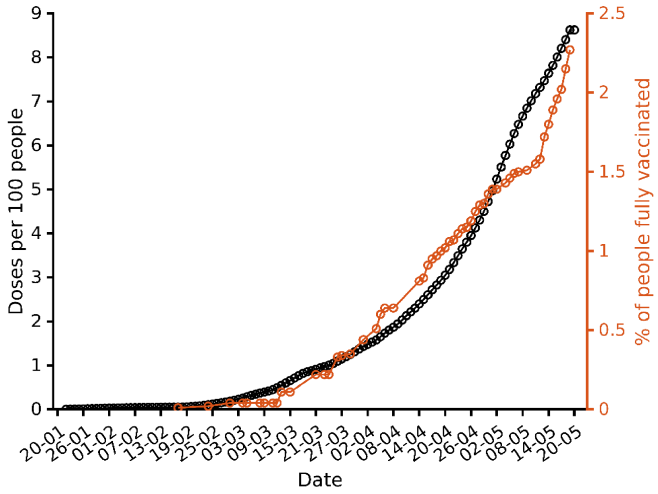
Predictions for next days

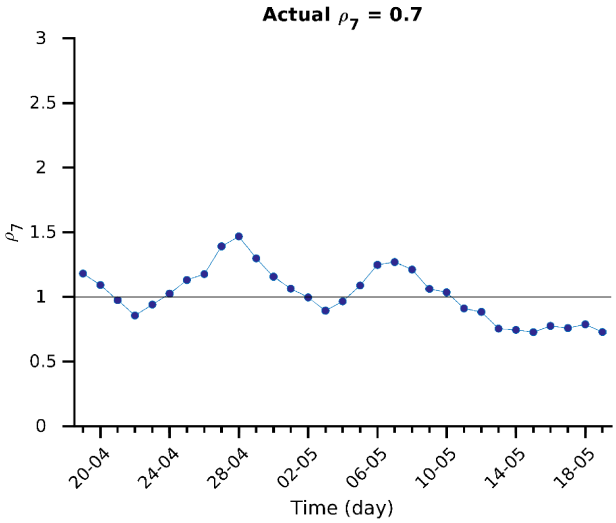
Day	Number of cases
22-05-2021	416230 (+3323)
26-05-2021	418483 (+5576)
29-05-2021	420956 (+8049)

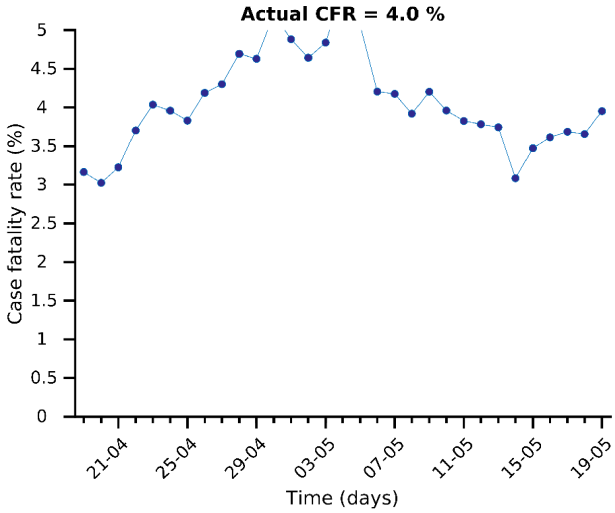
Current indicators

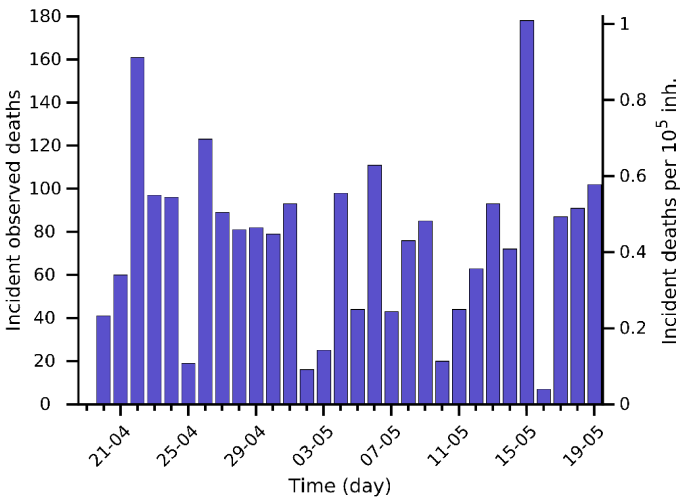
	A14	EPG	CFR	N7	D7
Today	113	82	3.95 %	1182	90
A Week ago	153	135	3.78 %	1655	63
Maximum	171	348	4.99 %	2273	587

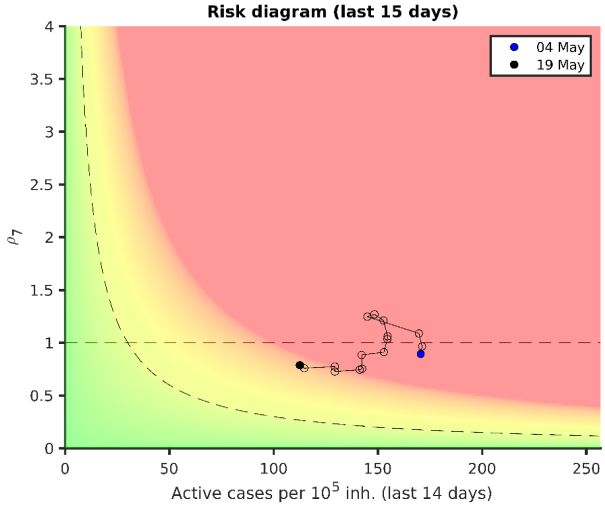




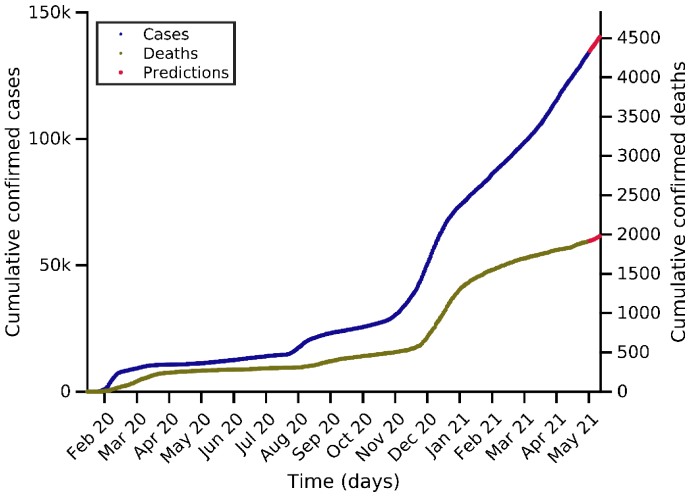








South Korea 19-05-2021. Pop: 51.3M. Cumulative incidence: 262/10^5

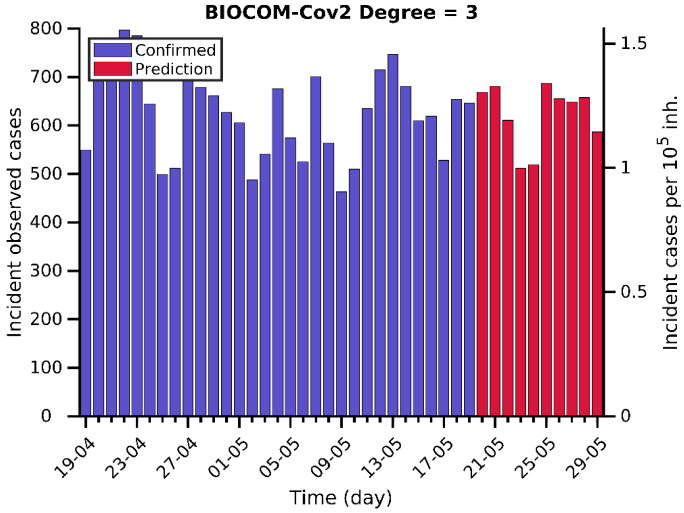


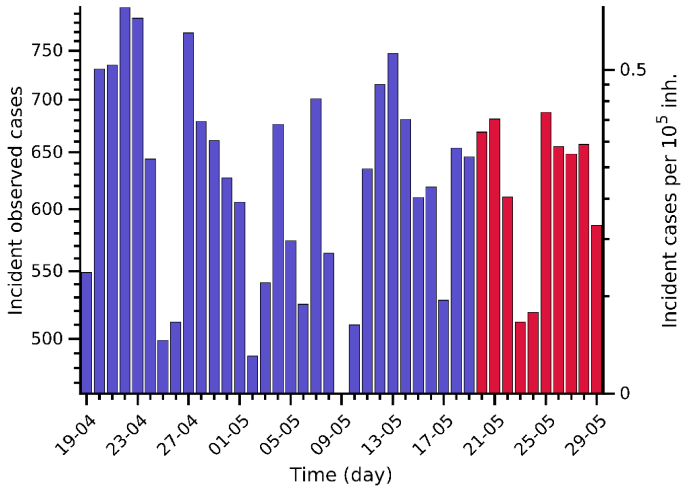
Predictions for next days

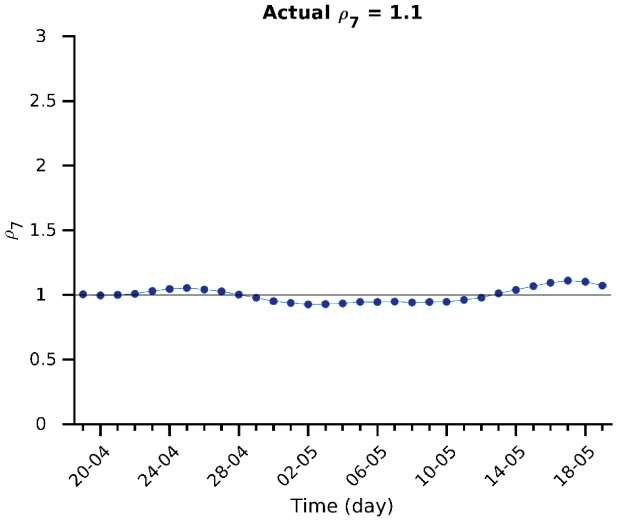
Day	Number of cases
22-05-2021	136077 (+1960)
26-05-2021	138451 (+4334)
29-05-2021	140343 (+6226)

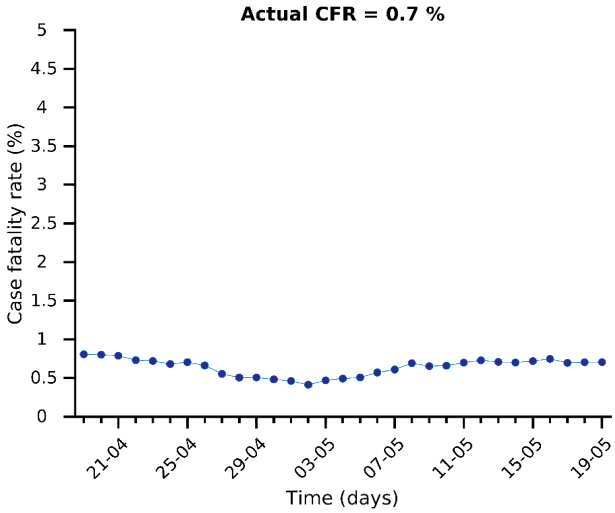
Current indicators

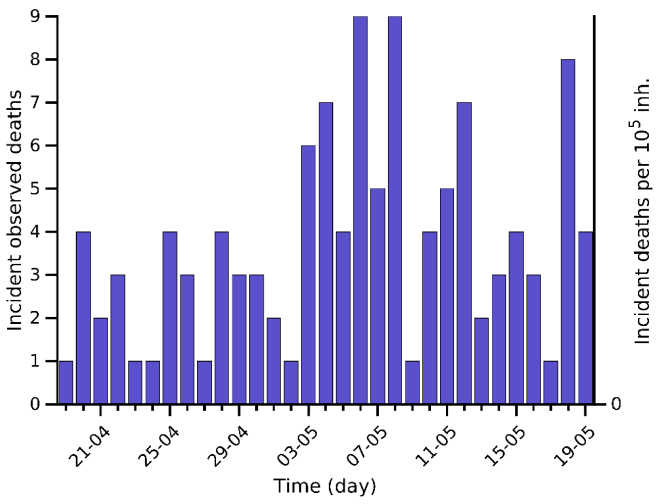
	A14	EPG	CFR	N7	D7
Today	17	18	0.70 %	641	4
A Week ago	16	16	0.73 %	588	6
Maximum	28	439	4.98 %	1047	23

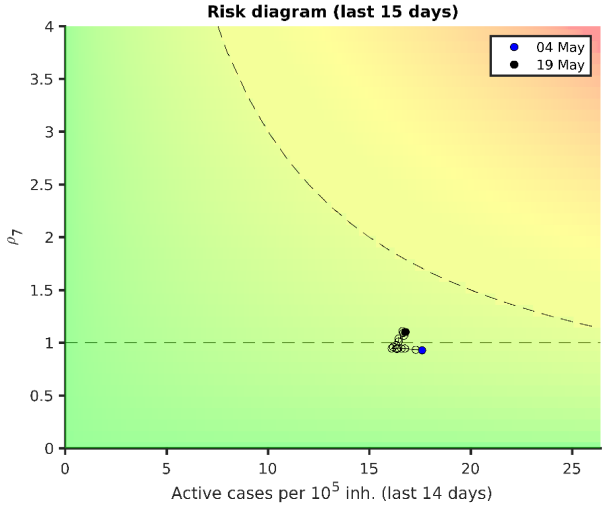




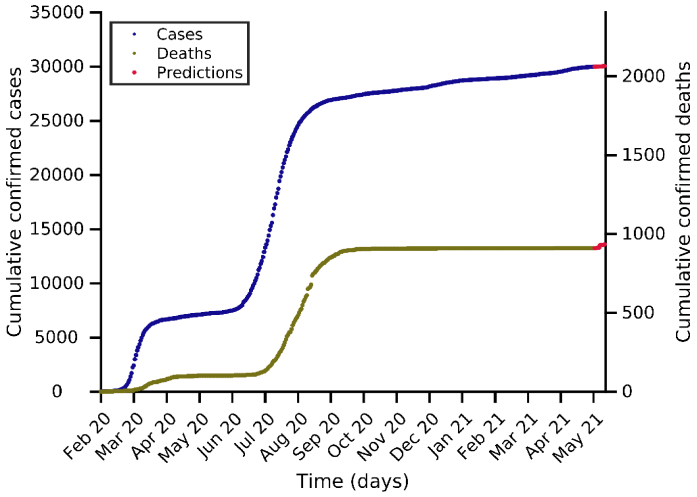








Australia 19-05-2021. Pop: 25.5M. Cumulative incidence: 118/10^5

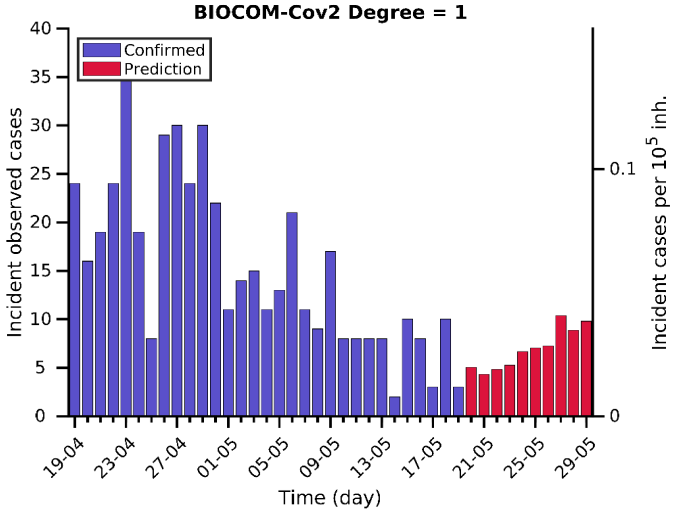


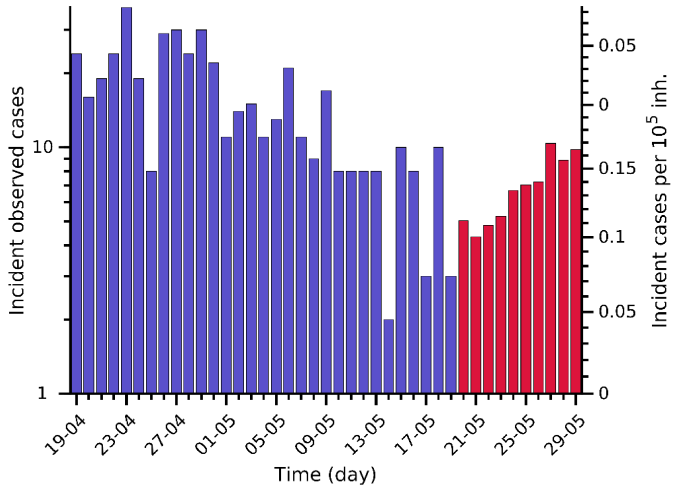
Predictions for next days

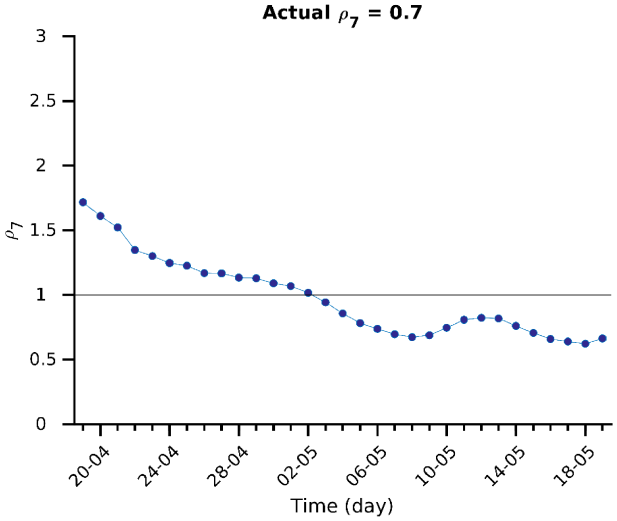
Day	Number of cases
22-05-2021	30005 (+14)
26-05-2021	30031 (+40)
29-05-2021	30060 (+69)

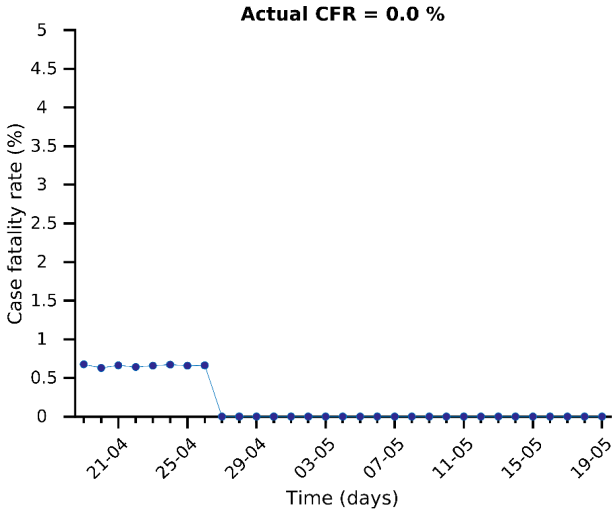
Current indicators

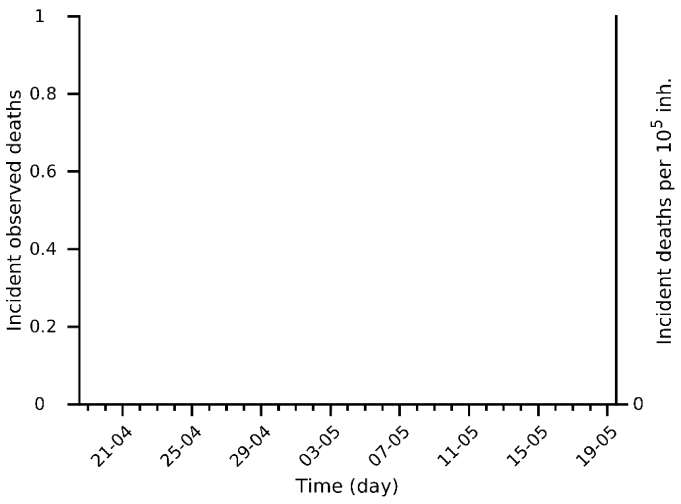
	A14	EPG	CFR	N7	D7
Today	0	0	0.00 %	6	0
A Week ago	1	1	0.00 %	12	0
Maximum	26	36	5.00 %	552	22

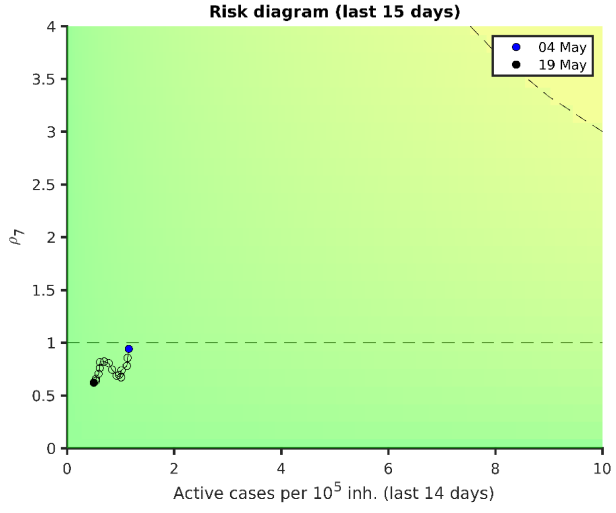






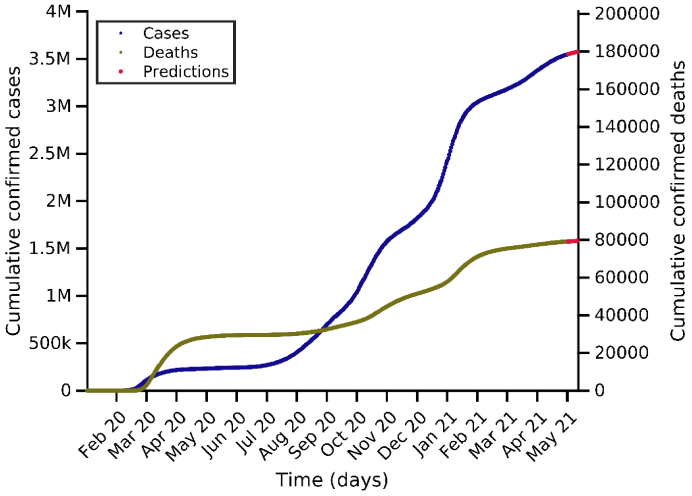






(4) Analysis and prediction of COVID-19 for Spain and its regions

Spain 16-05-2021. Pop: 47.0M. Cumulative incidence: 7541/10⁵



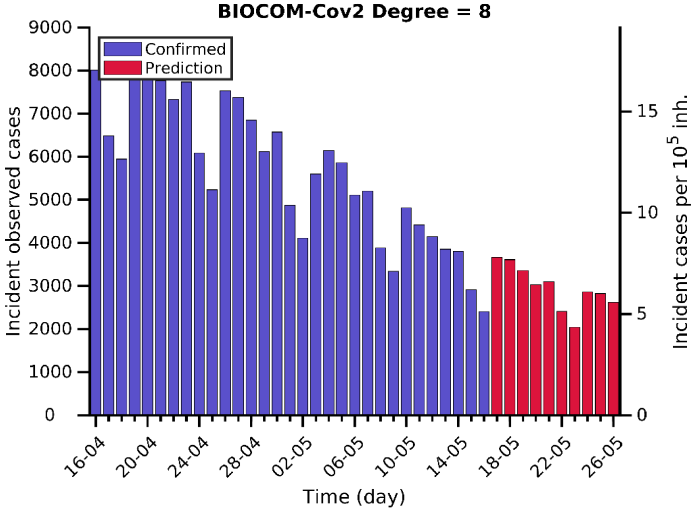
Predictions for next days

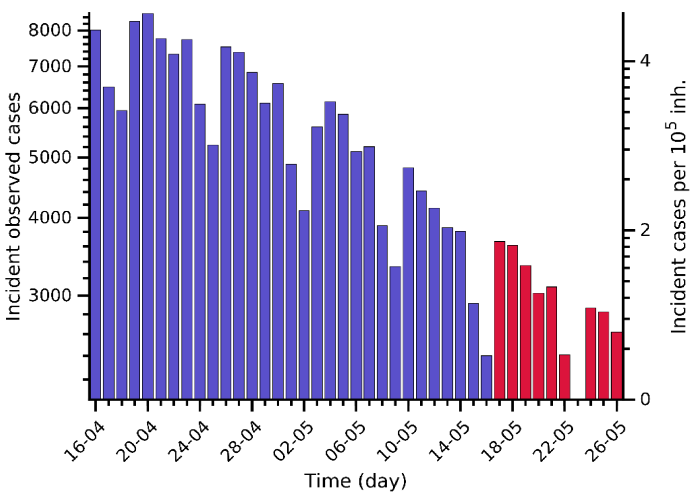
Day	Number of cases
19-05-2021	3556962 (+10630)
23-05-2021	3567540 (+21208)
26-05-2021	3575851 (+29519)

Current indicators

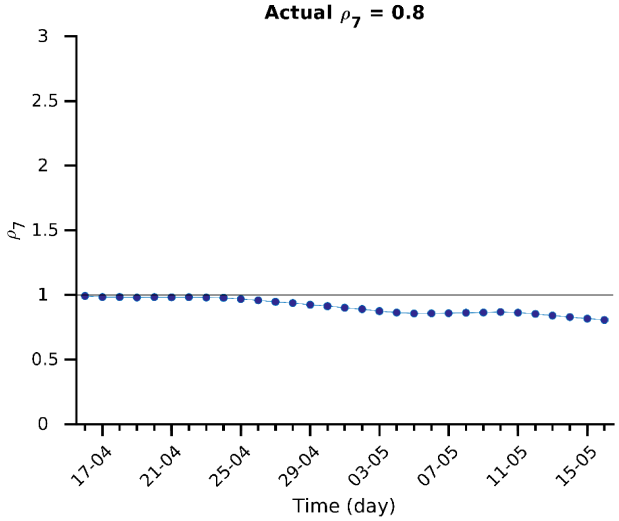
	A14	EPG	CFR	N7	D7
Today	131	105	0.62 %	3766	38
A Week ago	167	144	0.70 %	5021	54
Maximum	1005	1078	4.86 %	34850	873

BIOCOM-Cov2 Degree = 8

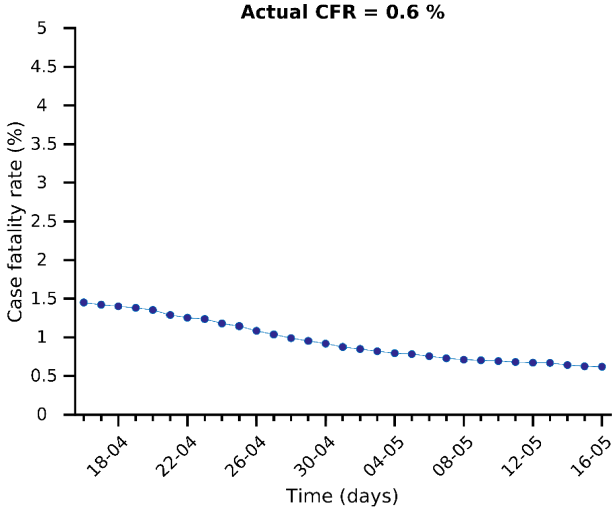


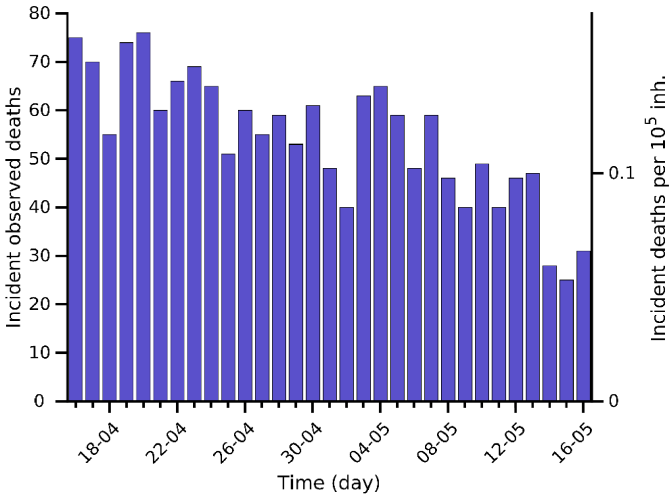


Actual ρ_7 = 0.8

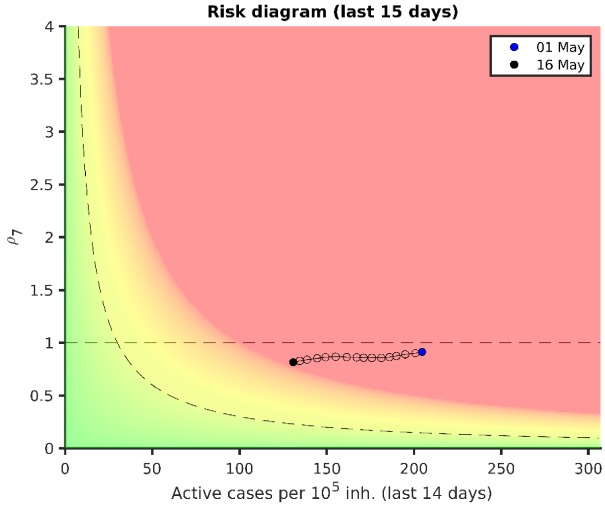


Actual CFR = 0.6 %

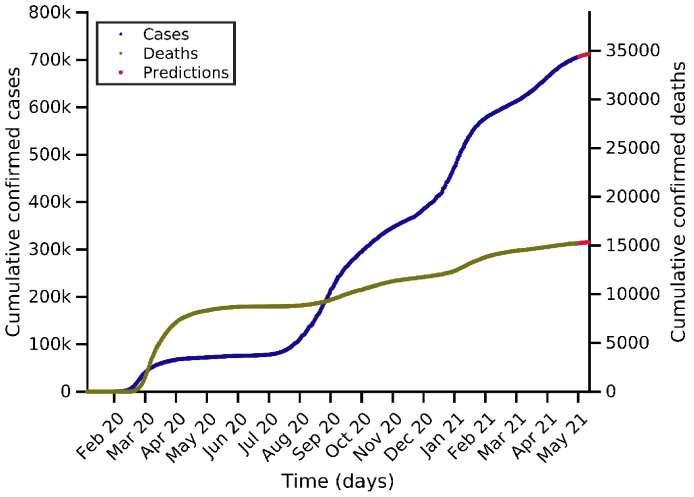




Risk diagram (last 15 days)



Madrid 16-05-2021. Pop: 6.7M. Cumulative incidence: 10595/10^5



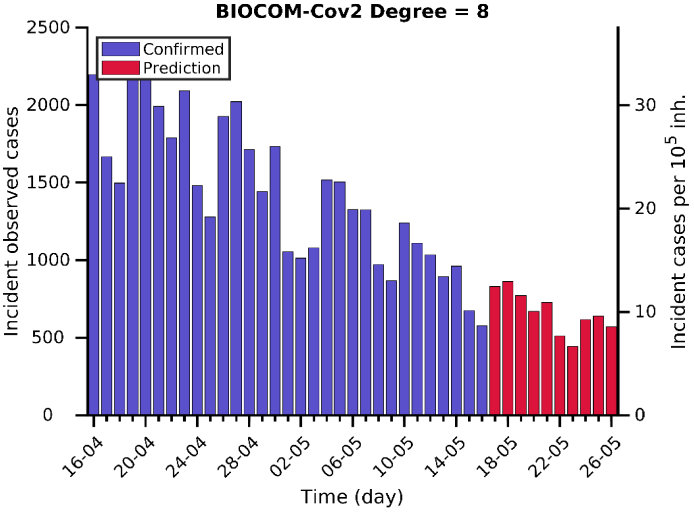
Predictions for next days

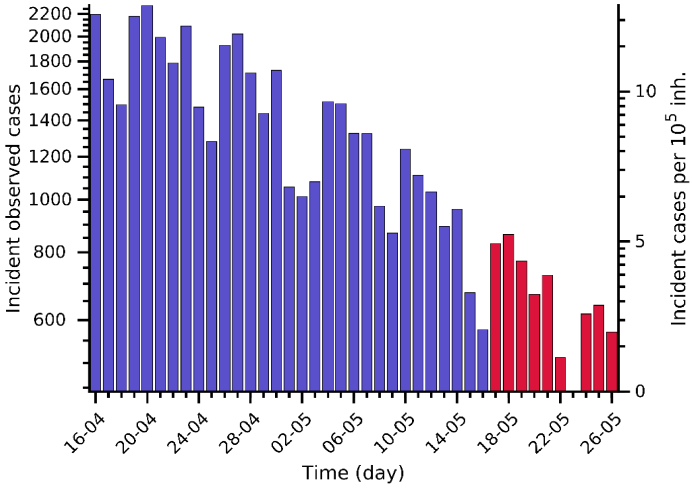
Day	Number of cases
19-05-2021	708424 (+2463)
23-05-2021	710774 (+4813)
26-05-2021	712599 (+6638)

Current indicators

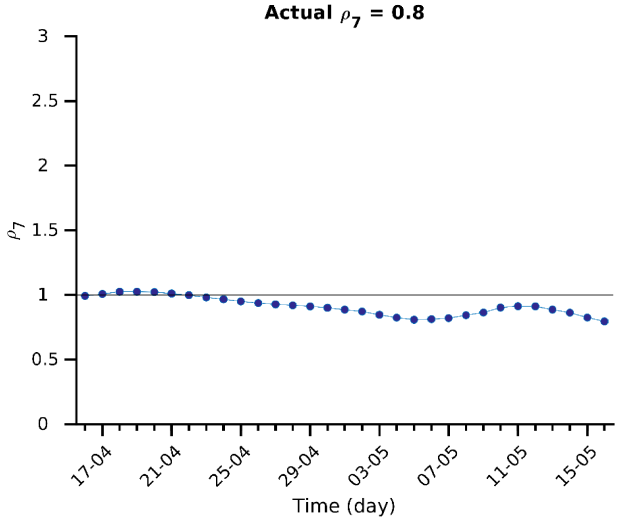
	A14	EPG	CFR	N7	D7
Today	226	180	0.51 %	927	8
A Week ago	293	253	0.62 %	1227	12
Maximum	1010	1131	4.97 %	4996	287

BIOCOM-Cov2 Degree = 8

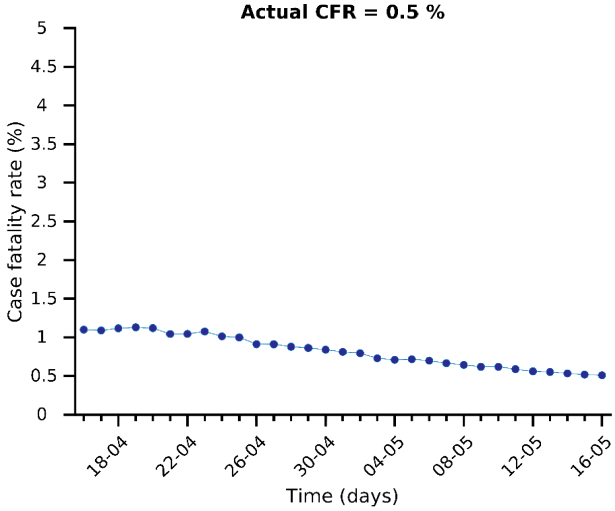


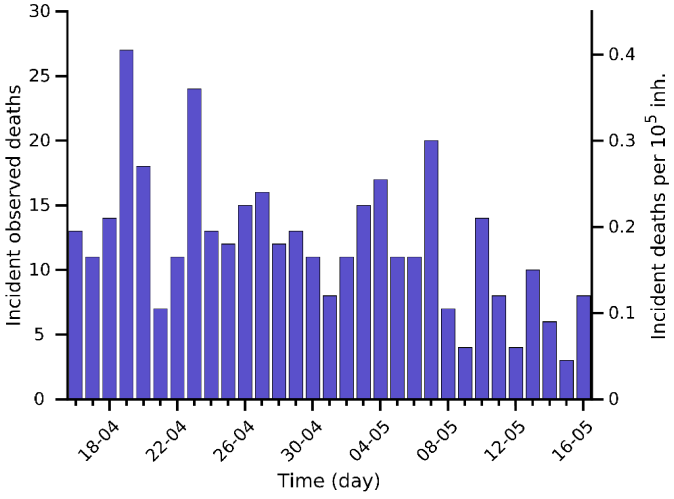


Actual ρ_7 = 0.8

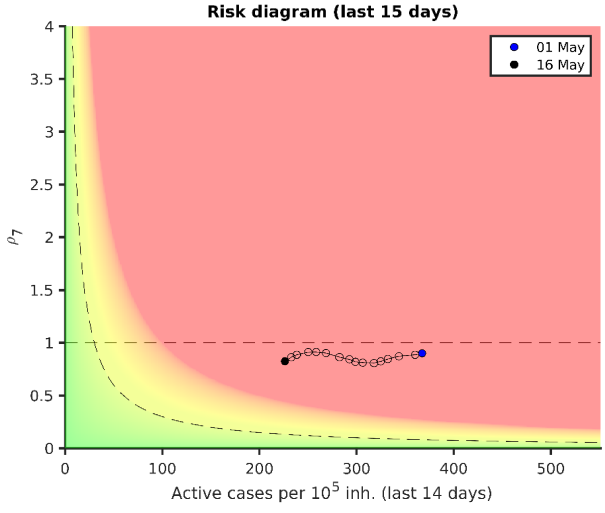


Actual CFR = 0.5 %

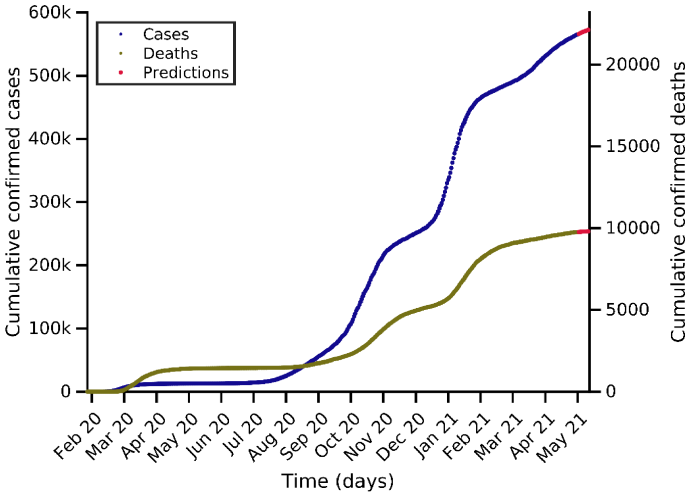




Risk diagram (last 15 days)



Andalucia 16-05-2021. Pop: 8.4M. Cumulative incidence: 6718/10^5

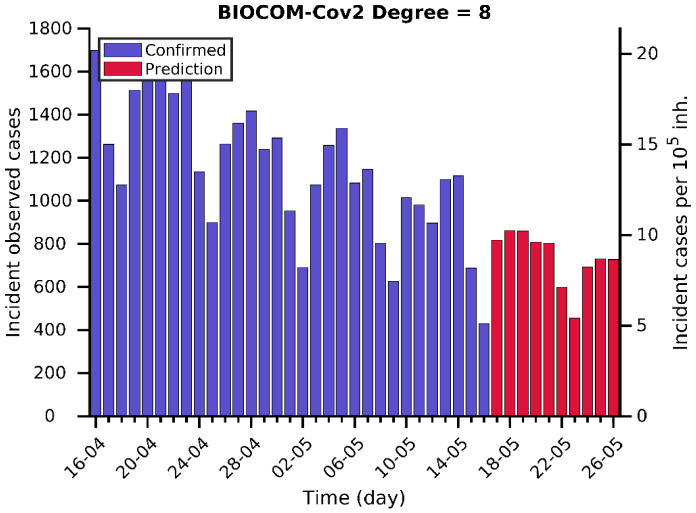


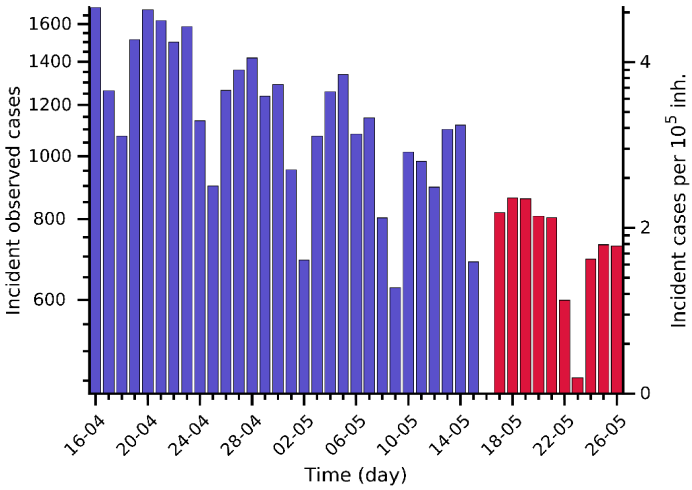
Predictions for next days

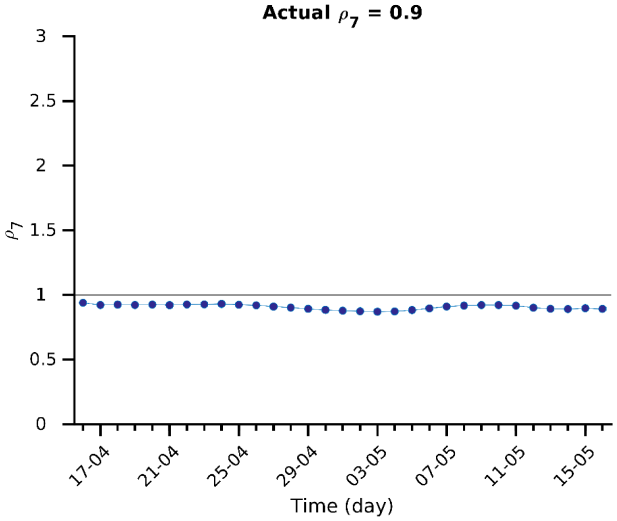
Day	Number of cases
19-05-2021	567846 (+2540)
23-05-2021	570512 (+5206)
26-05-2021	572662 (+7356)

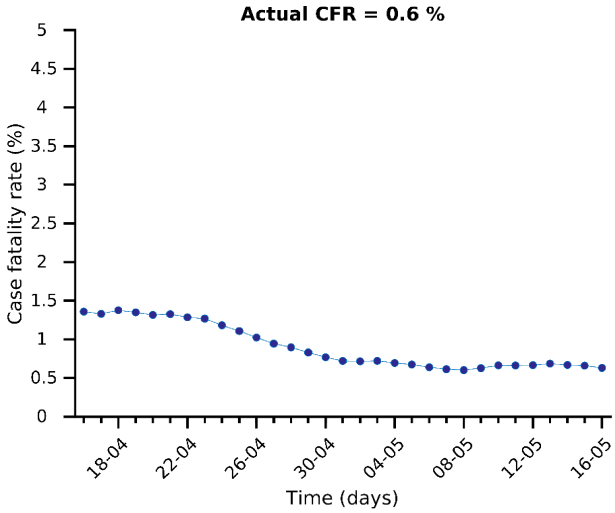
Current indicators

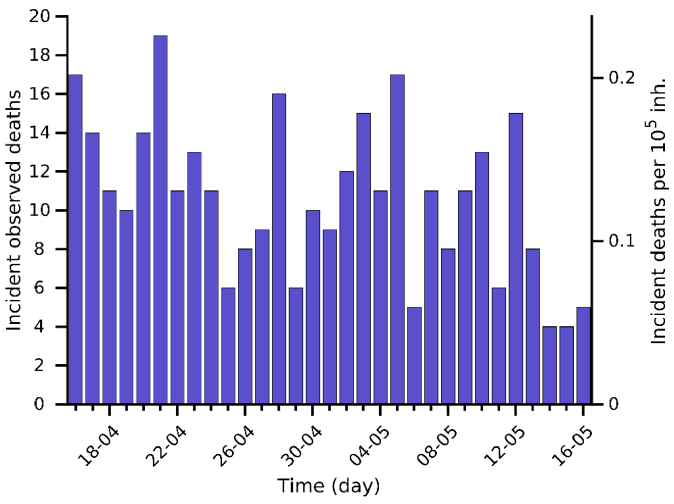
	A14	EPG	CFR	N7	D7
Today	161	144	0.63 %	890	8
A Week ago	185	170	0.63 %	1047	11
Maximum	1087	1191	4.88 %	6859	97

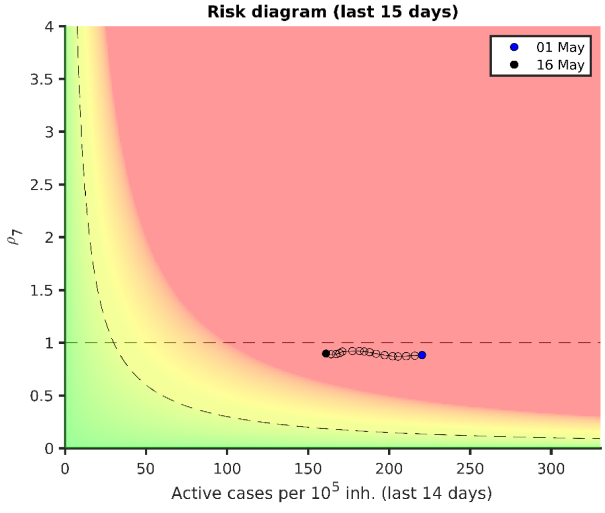




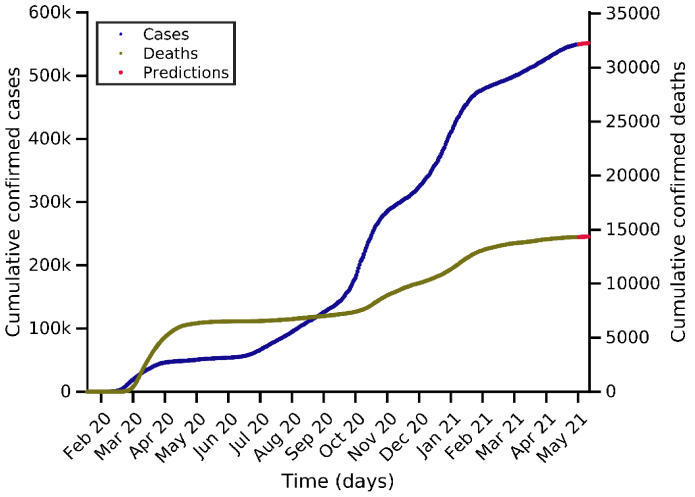








Catalunya 16-05-2021. Pop: 7.7M. Cumulative incidence: 7157/10^5



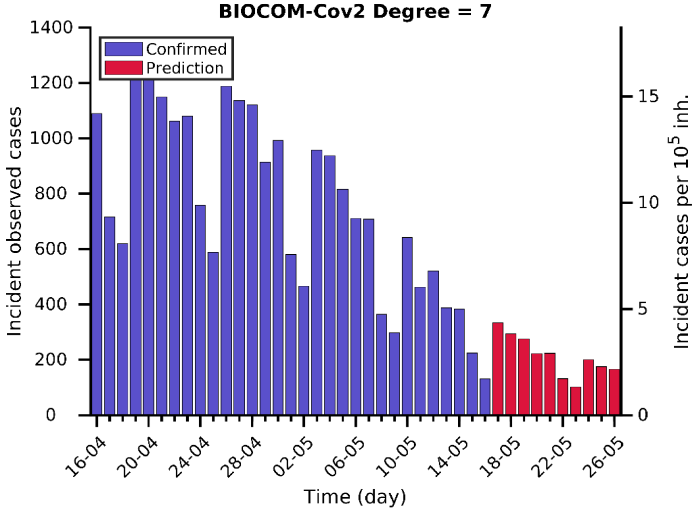
Predictions for next days

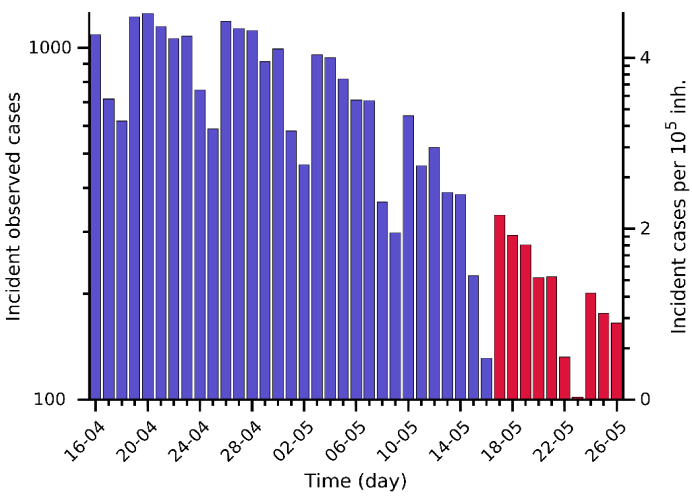
Day	Number of cases
19-05-2021	550223 (+903)
23-05-2021	550902 (+1582)
26-05-2021	551444 (+2124)

Current indicators

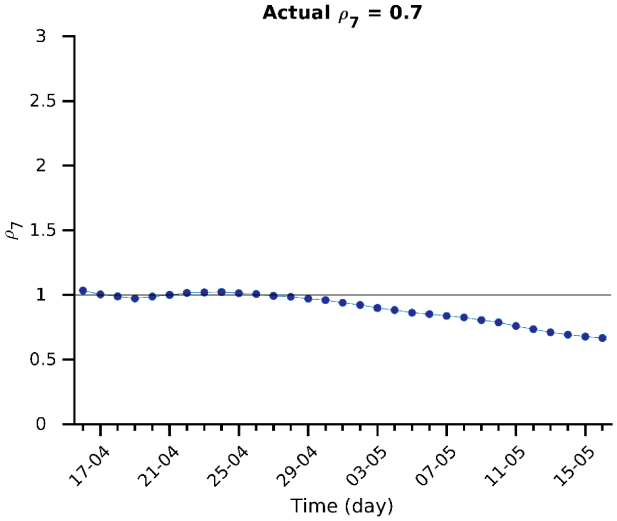
	A14	EPG	CFR	N7	D7
Today	98	66	0.55 %	393	3
A Week ago	146	117	0.81 %	685	8
Maximum	821	985	4.87 %	4732	193

BIOCOM-Cov2 Degree = 7

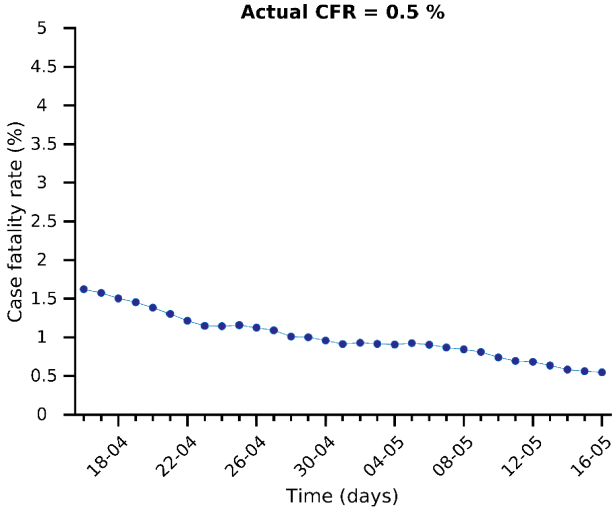


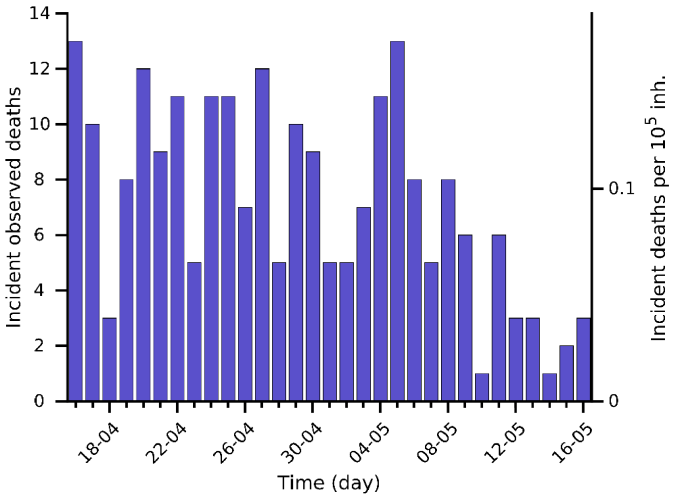


Actual ρ_7 = 0.7

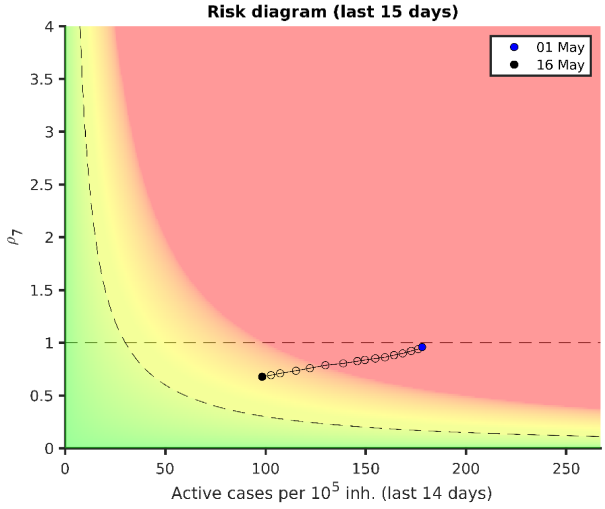


Actual CFR = 0.5 %

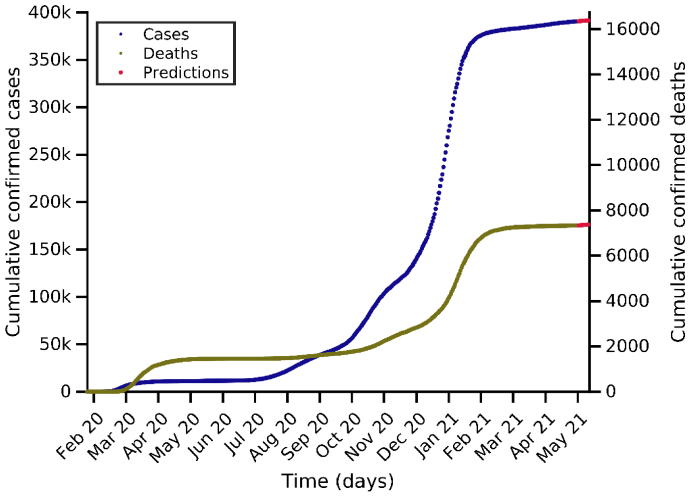




Risk diagram (last 15 days)



C Valenciana 16-05-2021. Pop: 5.0M. Cumulative incidence: 7809/10^5



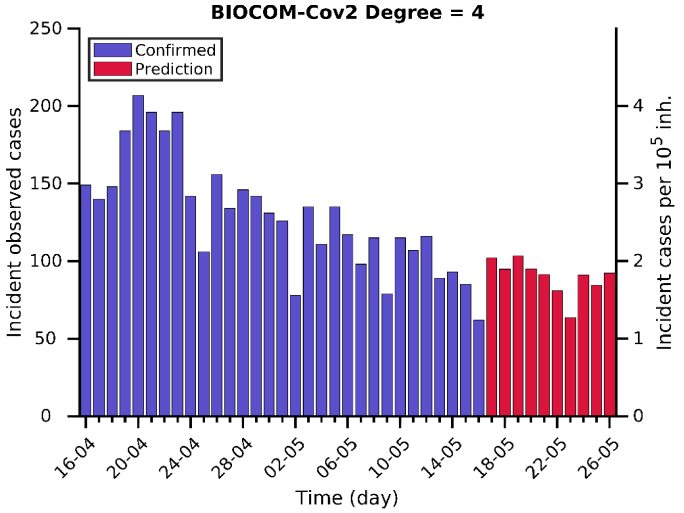
Predictions for next days

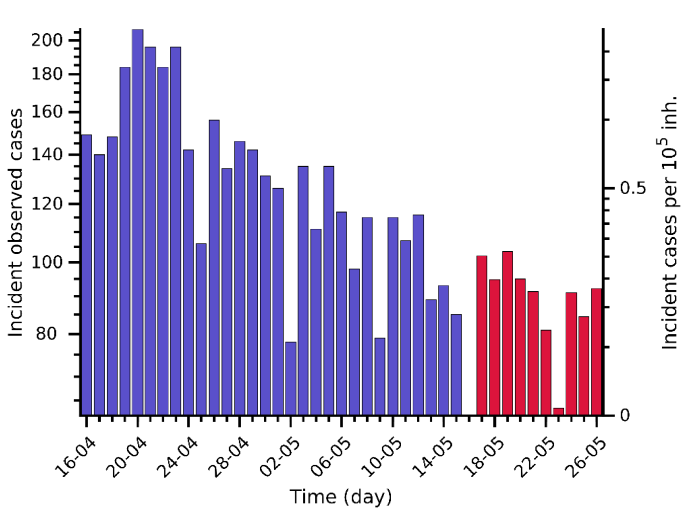
Day	Number of cases
19-05-2021	391029 (+300)
23-05-2021	391360 (+631)
26-05-2021	391628 (+899)

Current indicators

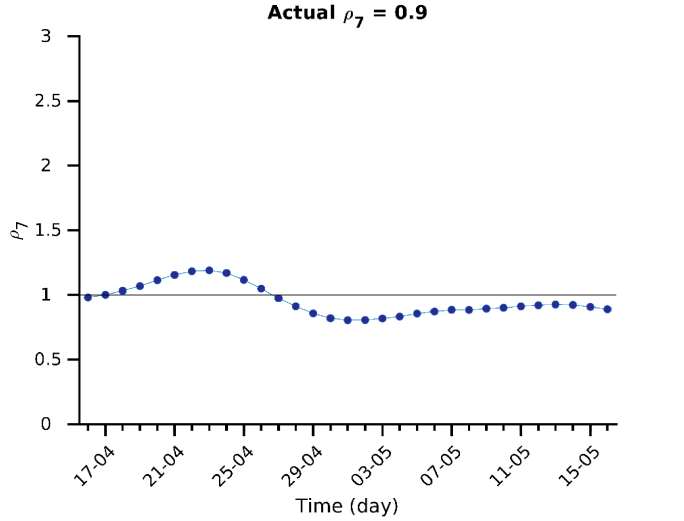
	A14	EPG	CFR	N7	D7
Today	29	26	0.62 %	95	1
A Week ago	34	30	0.73 %	113	1
Maximum	1988	2225	4.73 %	7371	121

BIOCOM-Cov2 Degree = 4

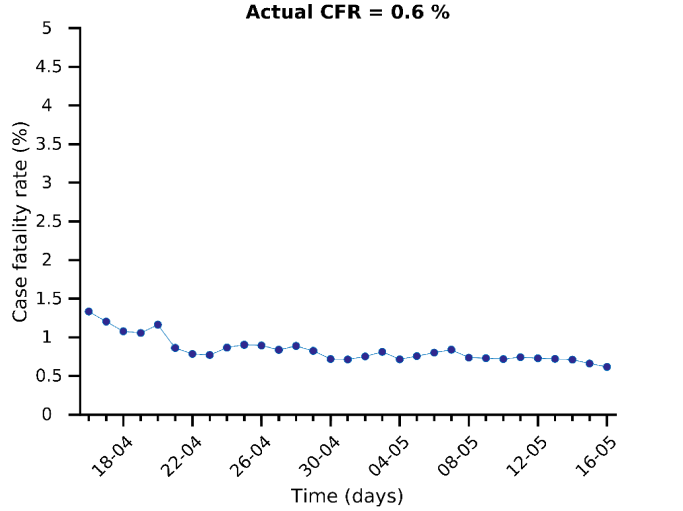


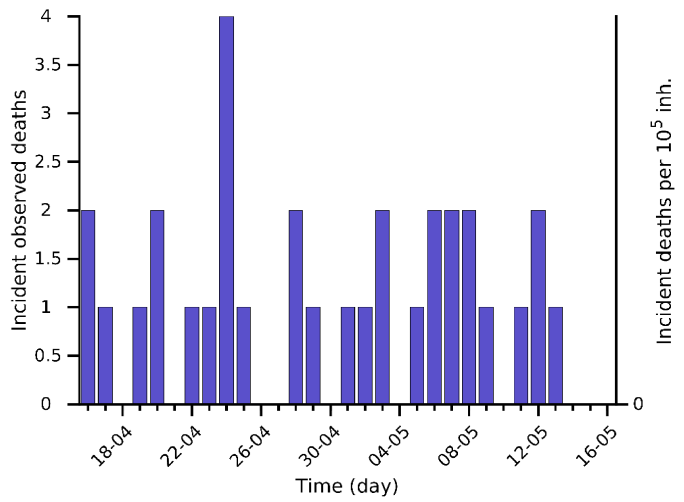


Actual ρ_7 = 0.9

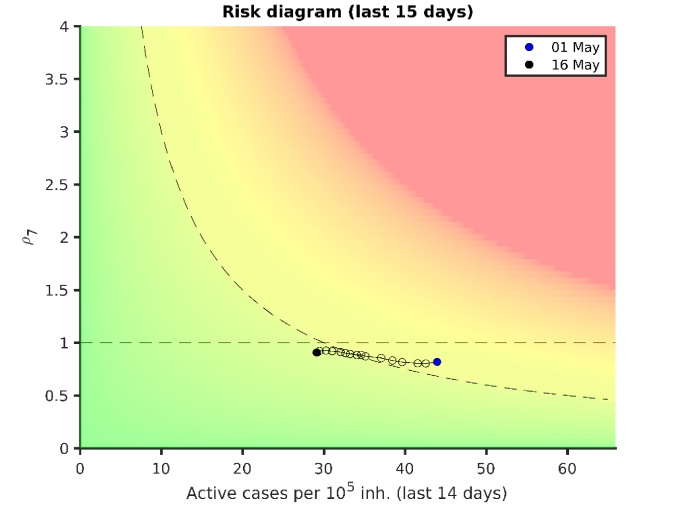


Actual CFR = 0.6 %

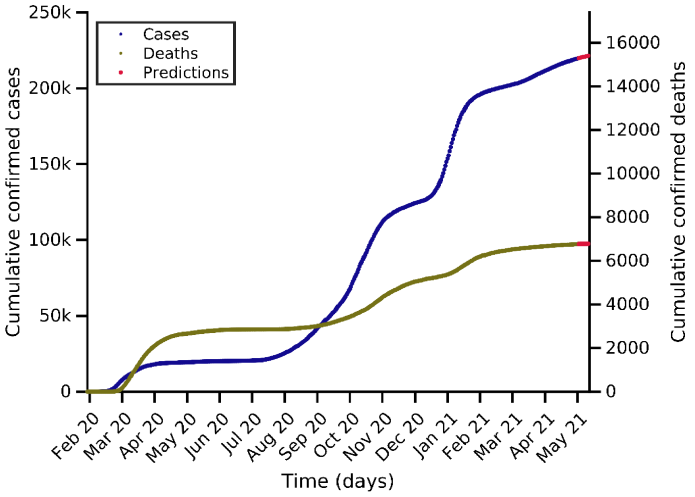




Risk diagram (last 15 days)



Castilla Leon 16-05-2021. Pop: 2.4M. Cumulative incidence: 9153/10^5

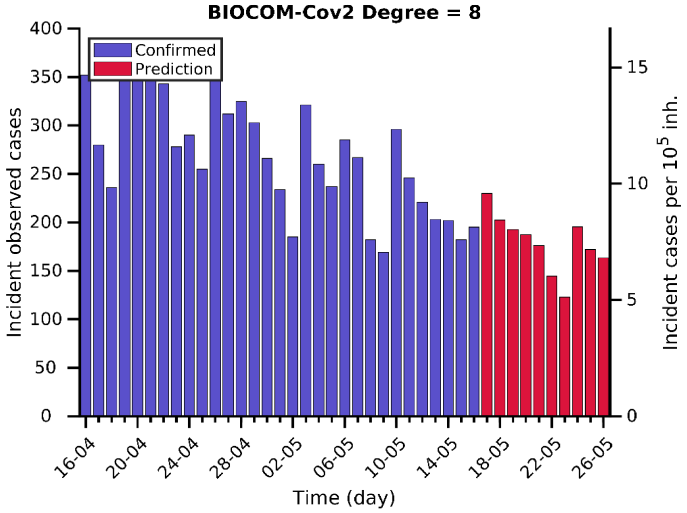


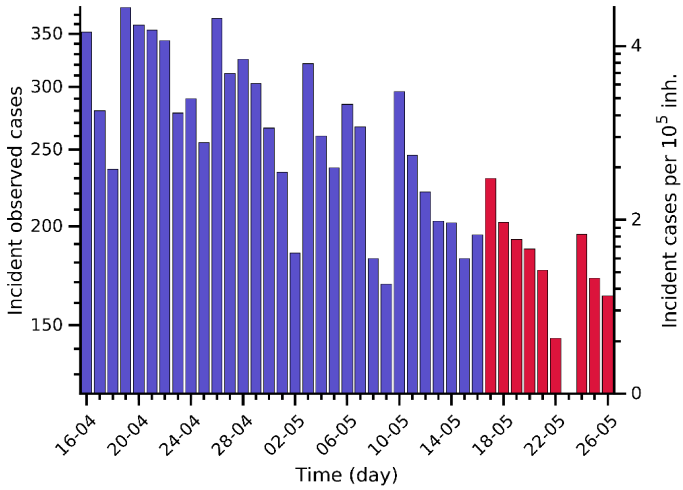
Predictions for next days

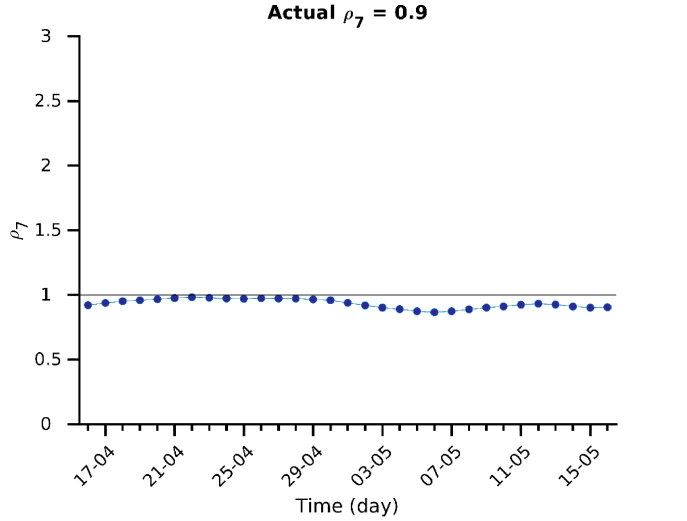
Day	Number of cases
19-05-2021	220267 (+625)
23-05-2021	220897 (+1255)
26-05-2021	221428 (+1786)

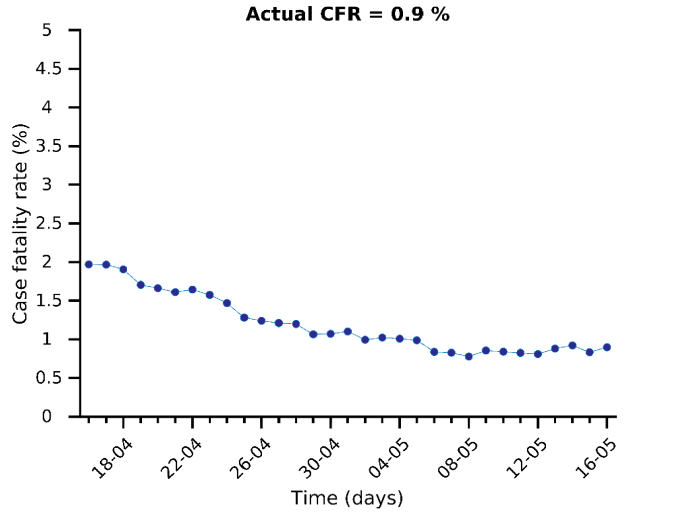
Current indicators

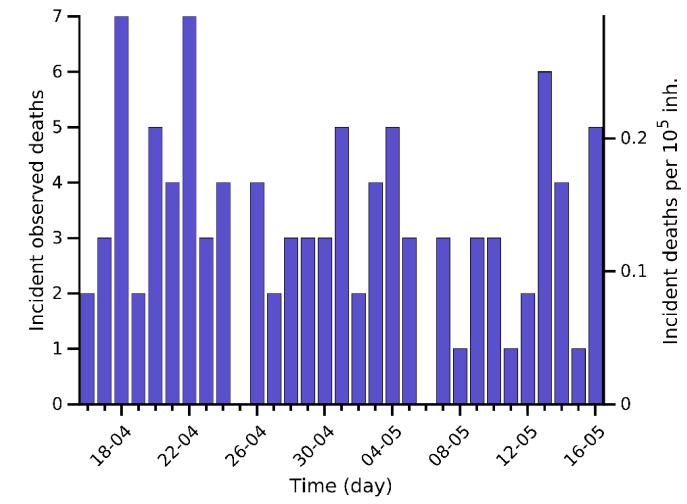
	A14	EPG	CFR	N7	D7
Today	136	123	0.90 %	221	3
A Week ago	155	139	0.85 %	246	3
Maximum	1393	1593	4.87 %	2508	81

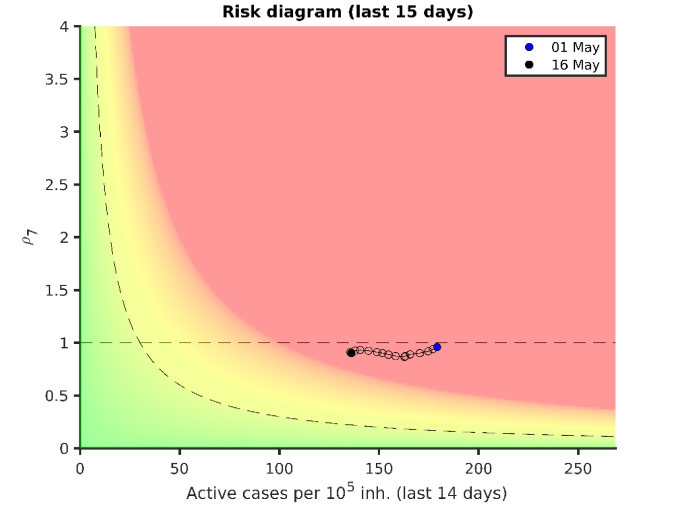




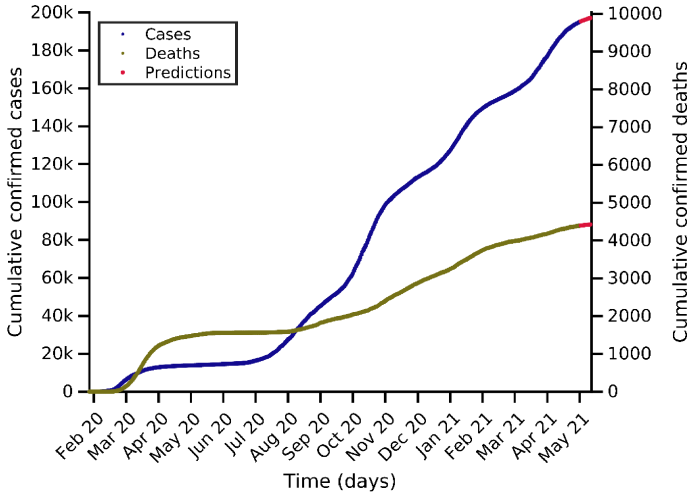








Euskadi 16-05-2021. Pop: 2.2M. Cumulative incidence: 8837/10^5

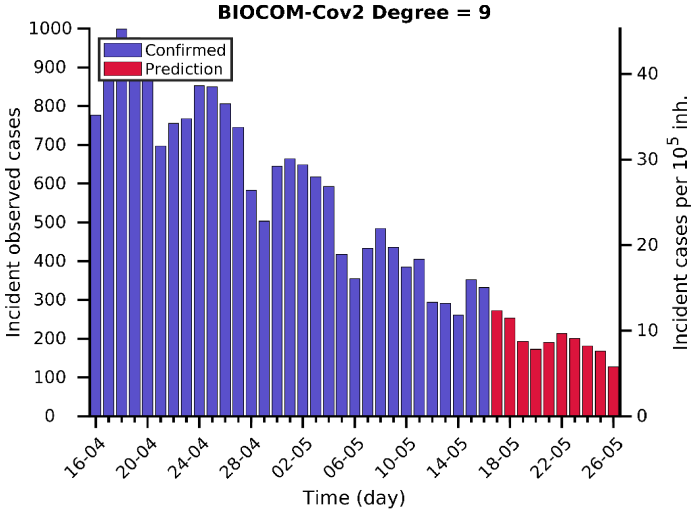


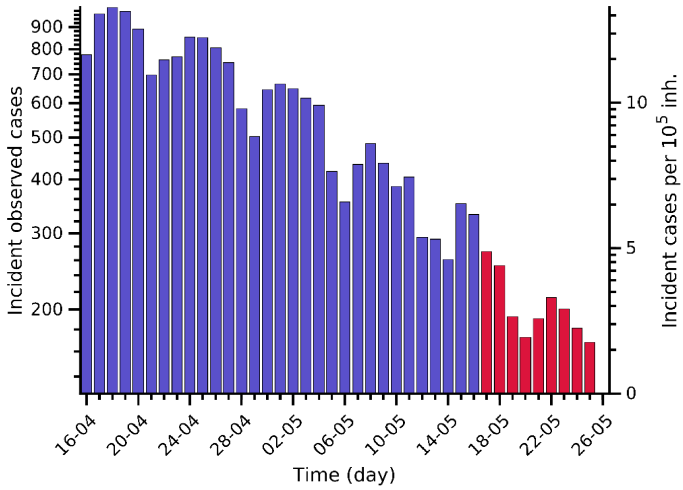
Predictions for next days

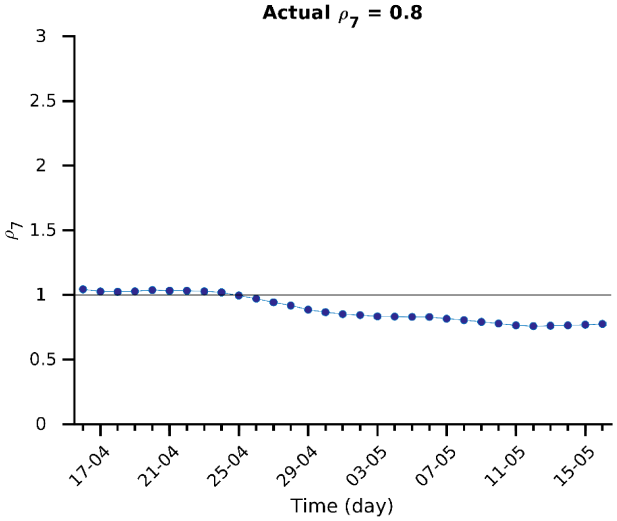
Day	Number of cases
19-05-2021	195817 (+718)
23-05-2021	196594 (+1495)
26-05-2021	197072 (+1973)

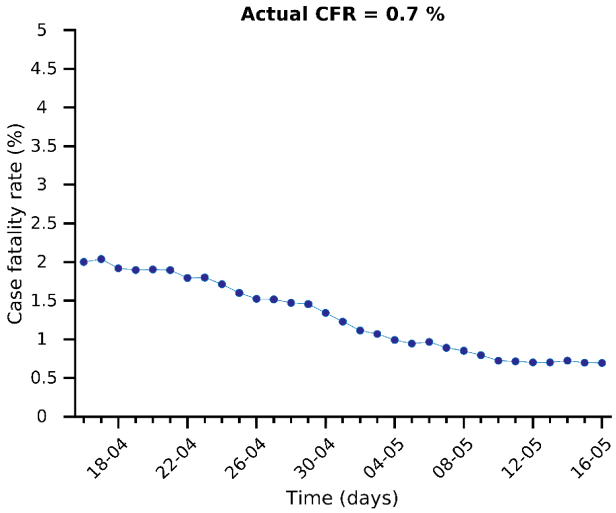
Current indicators

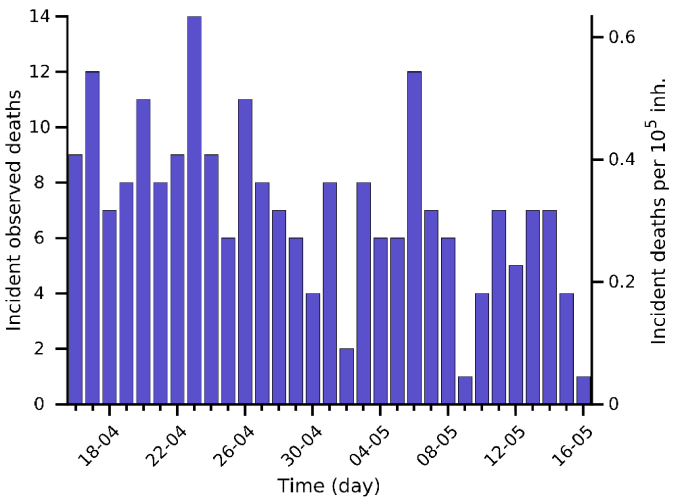
	A14	EPG	CFR	N7	D7
Today	256	199	0.69 %	331	5
A Week ago	359	284	0.79 %	476	7
Maximum	838	874	4.58 %	1356	48

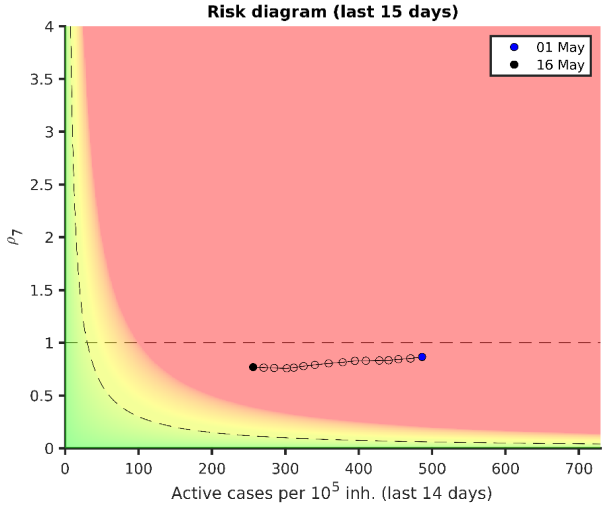




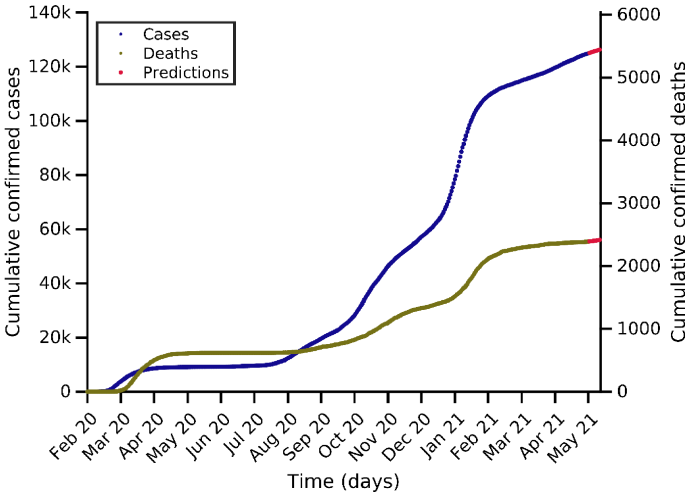








Galicia 16-05-2021. Pop: 2.7M. Cumulative incidence: 4627/10^5

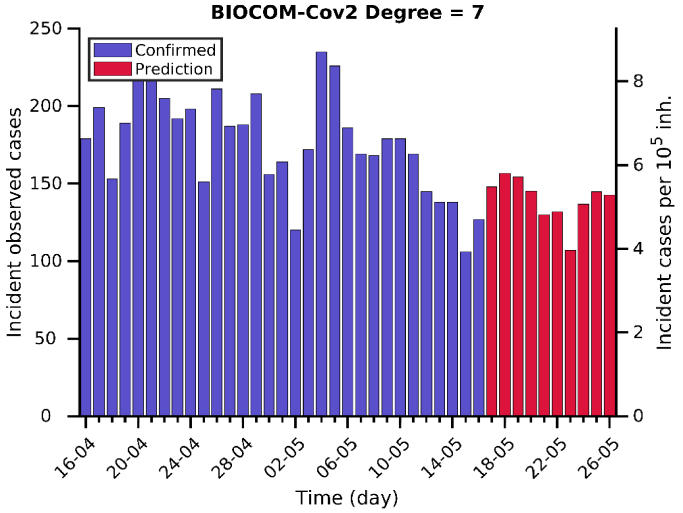


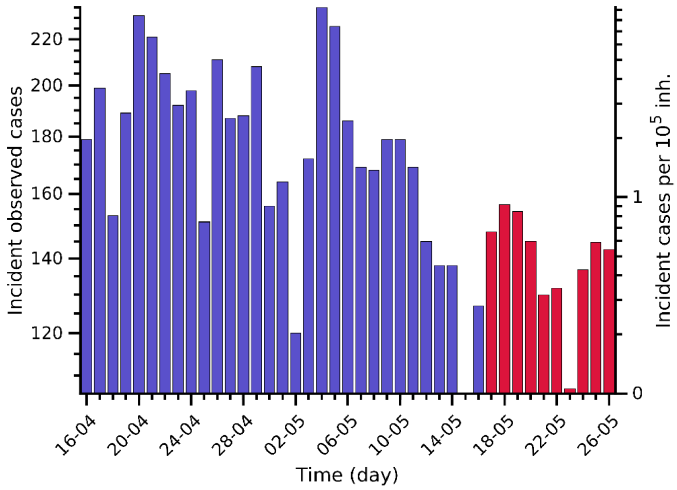
Predictions for next days

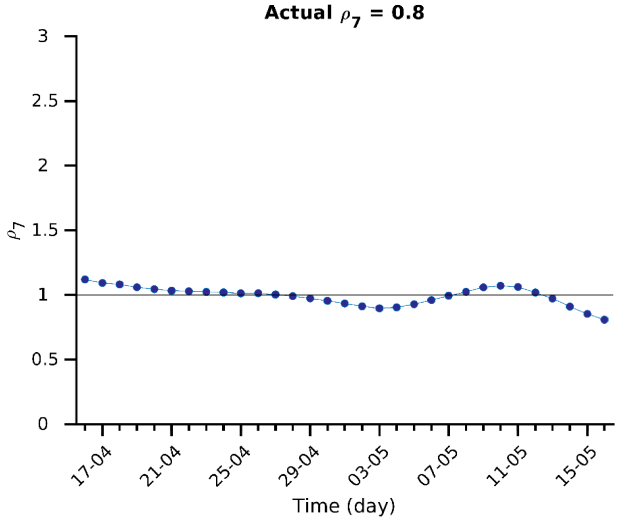
Day	Number of cases
19-05-2021	125376 (+459)
23-05-2021	125890 (+973)
26-05-2021	126314 (+1397)

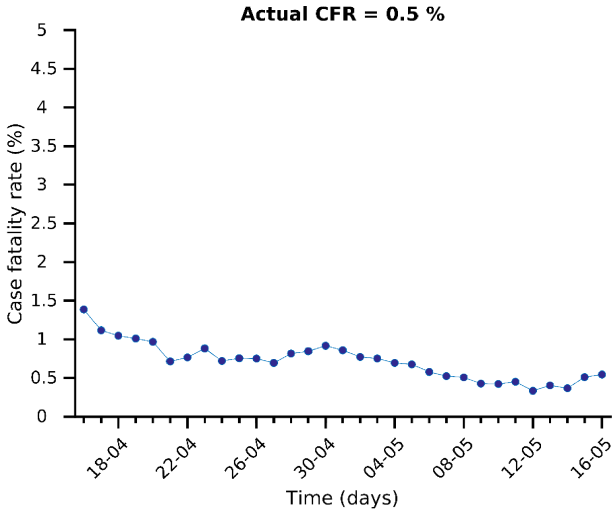
Current indicators

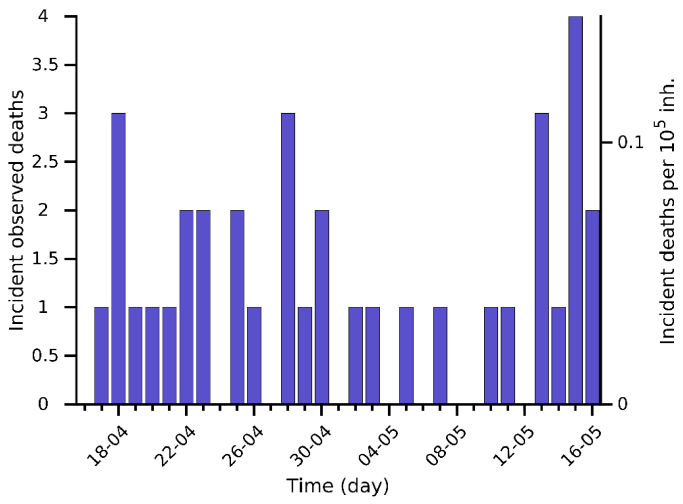
	A14	EPG	CFR	N7	D7
Today	87	70	0.54 %	143	2
A Week ago	95	101	0.43 %	191	0
Maximum	809	934	4.89 %	1681	26

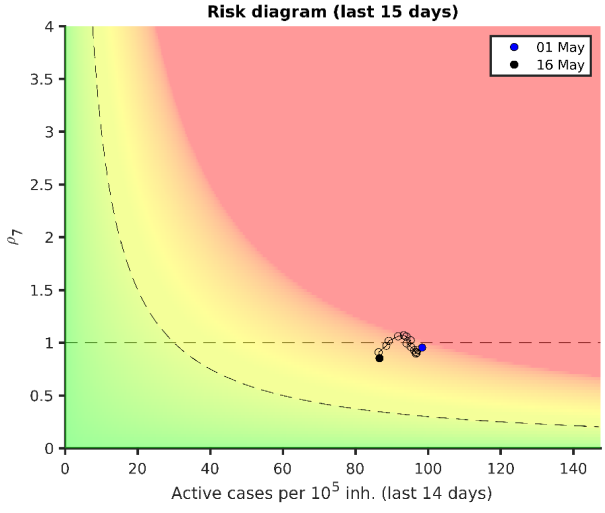




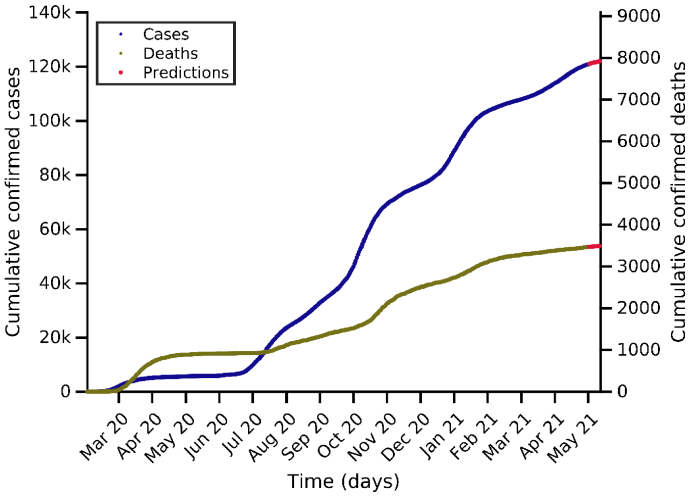








Aragon 16-05-2021. Pop: 1.3M. Cumulative incidence: 9164/10⁵

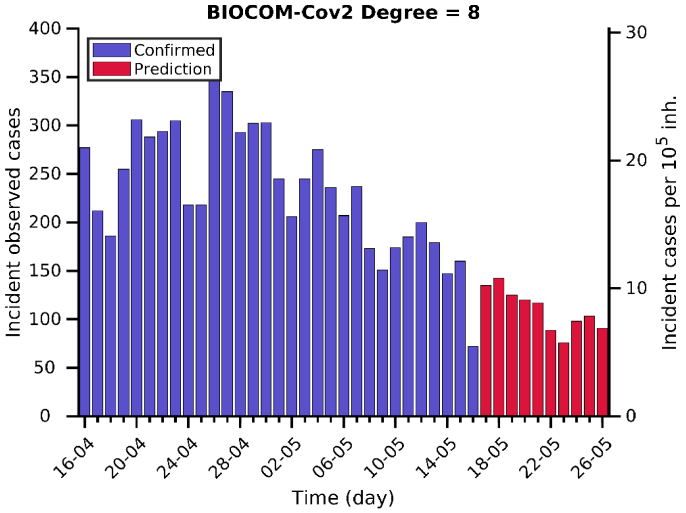


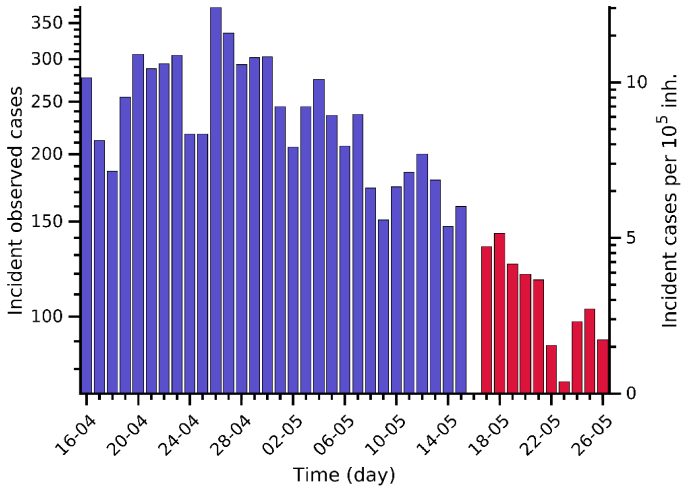
Predictions for next days

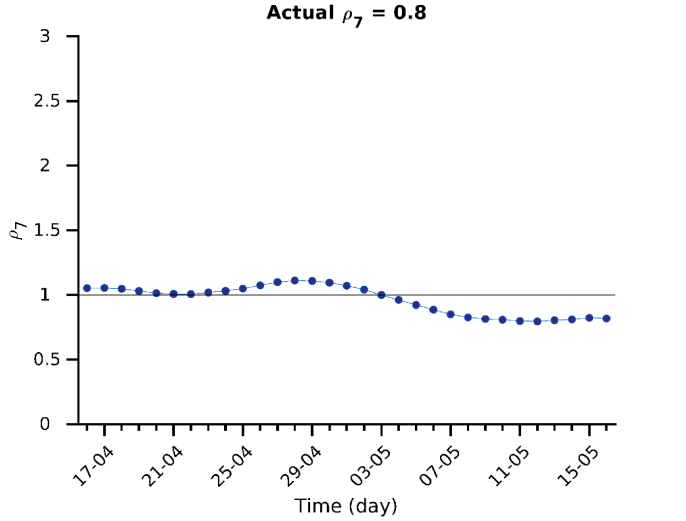
Day	Number of cases
19-05-2021	121300 (+403)
23-05-2021	121700 (+803)
26-05-2021	121992 (+1095)

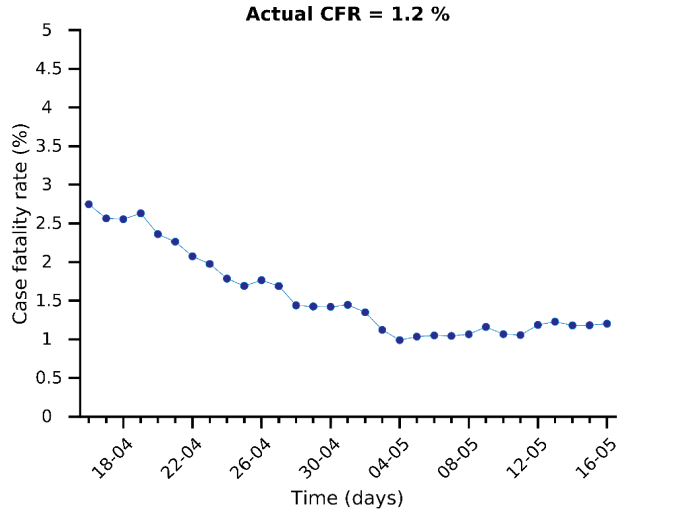
Current indicators

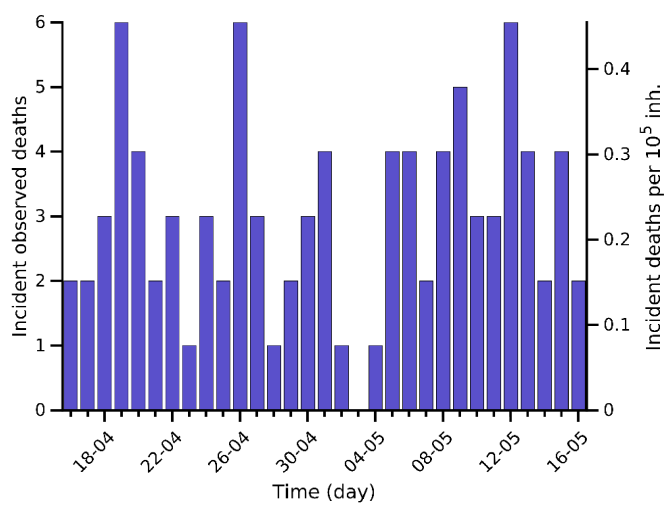
	A14	EPG	CFR	N7	D7
Today	200	164	1.20 %	160	3
A Week ago	272	221	1.16 %	218	3
Maximum	1047	1212	4.60 %	1033	30

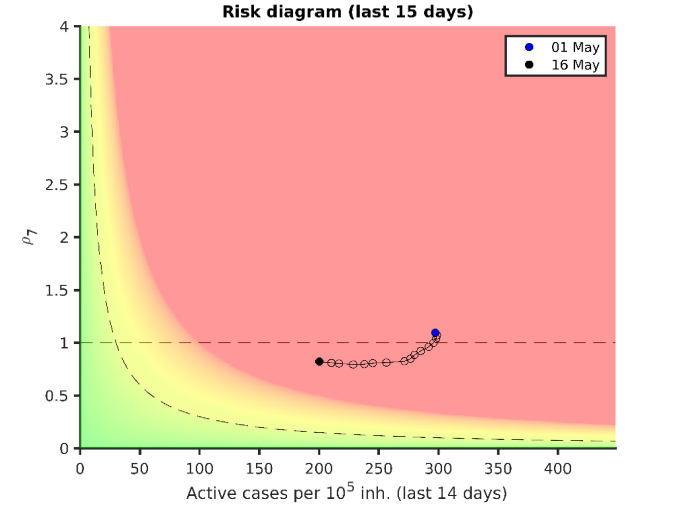




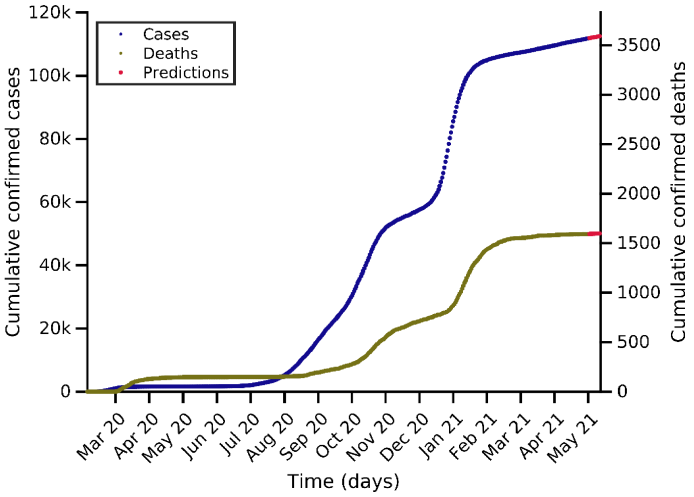








Murcia 16-05-2021. Pop: 1.5M. Cumulative incidence: 7484/10⁵

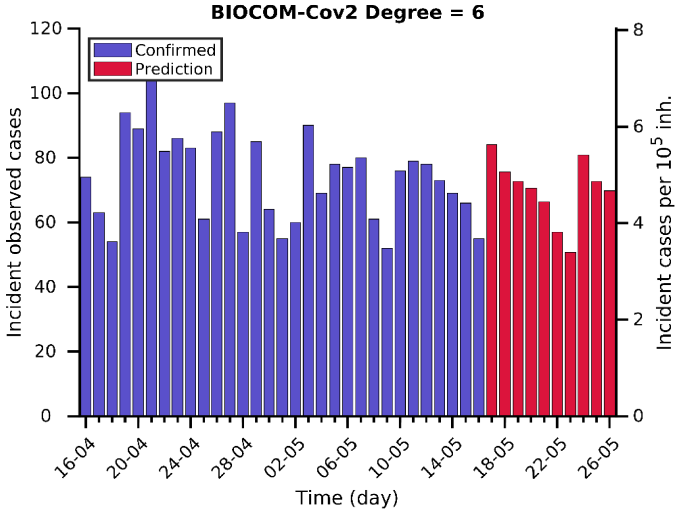


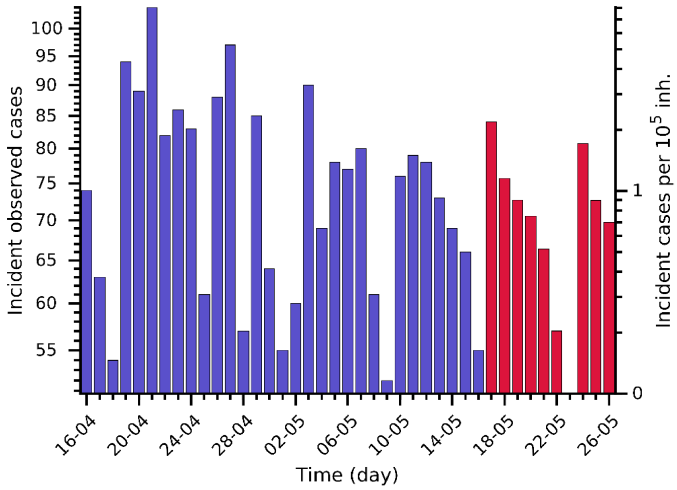
Predictions for next days

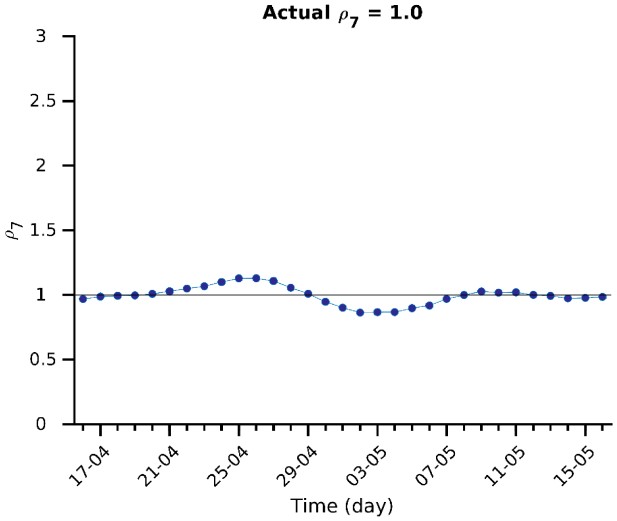
Day	Number of cases
19-05-2021	112036 (+232)
23-05-2021	112281 (+477)
26-05-2021	112504 (+700)

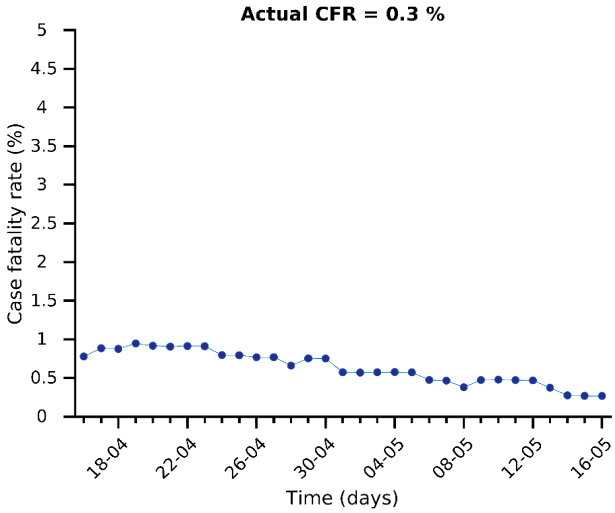
Current indicators

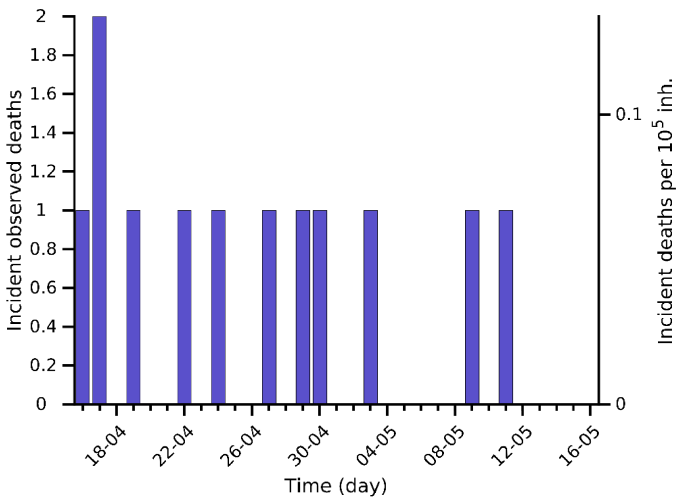
	A14	EPG	CFR	N7	D7
Today	67	66	0.27 %	71	0
A Week ago	68	70	0.47 %	72	0
Maximum	1601	2104	4.76 %	1851	27

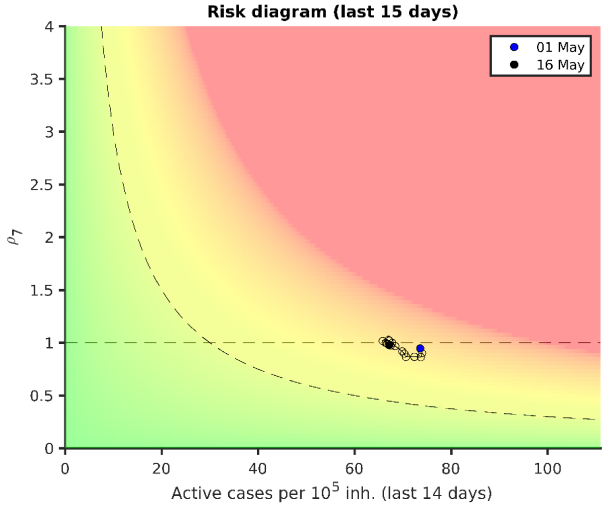




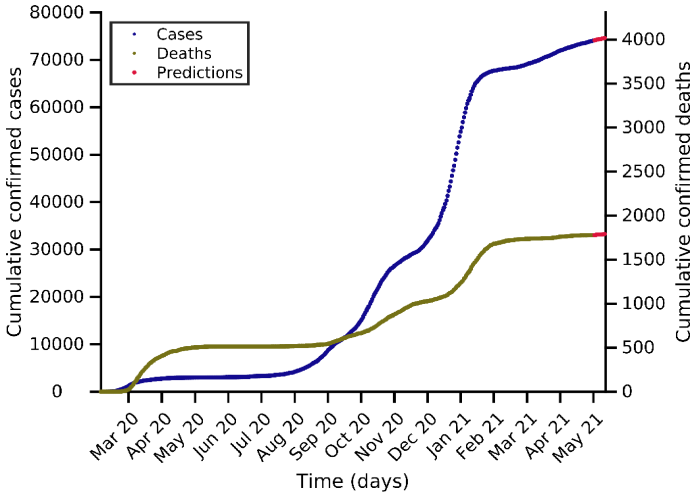








Extremadura 16-05-2021. Pop: 1.1M. Cumulative incidence: 6938/10^5

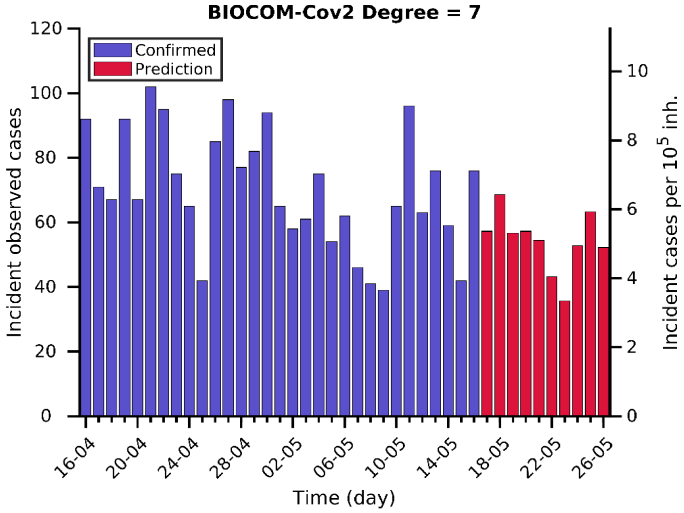


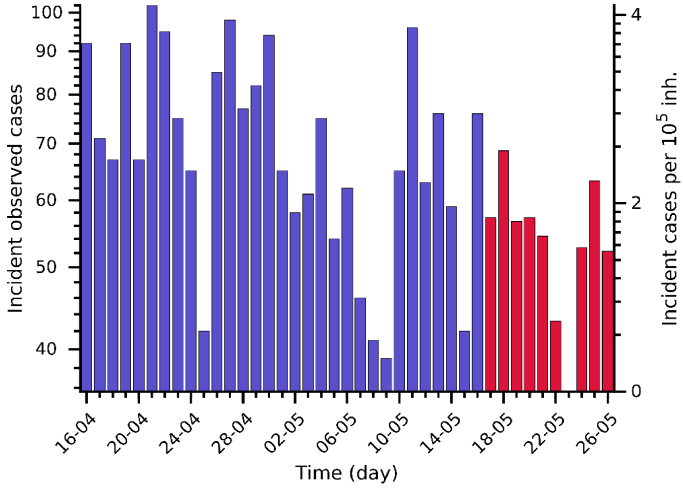
Predictions for next days

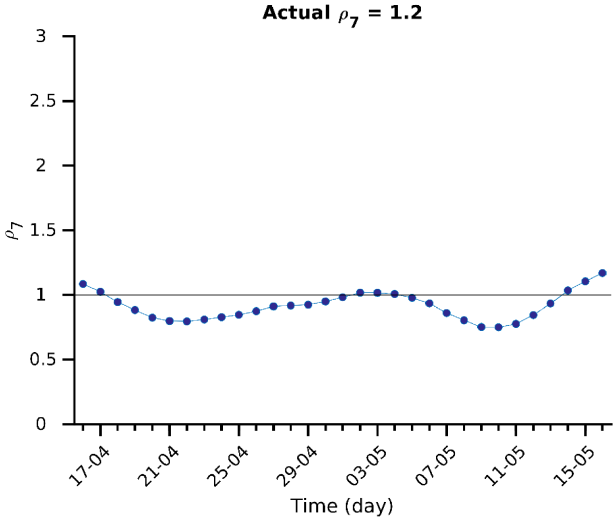
Day	Number of cases
19-05-2021	74259 (+183)
23-05-2021	74449 (+373)
26-05-2021	74617 (+541)

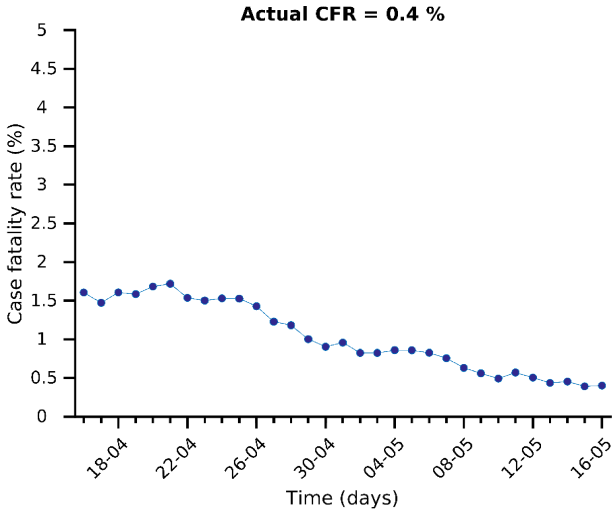
Current indicators

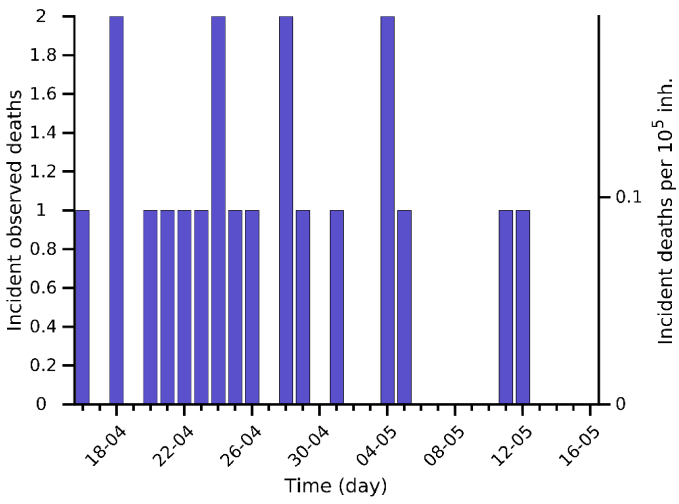
	A14	EPG	CFR	N7	D7
Today	80	94	0.40 %	68	0
A Week ago	88	66	0.56 %	54	0
Maximum	1464	1676	3.62 %	1186	21

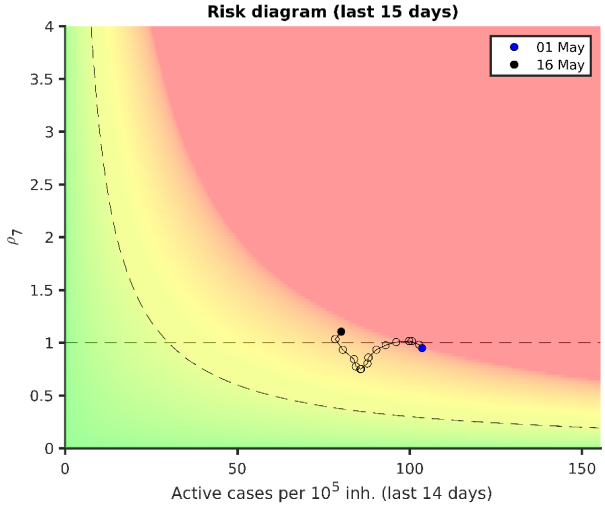




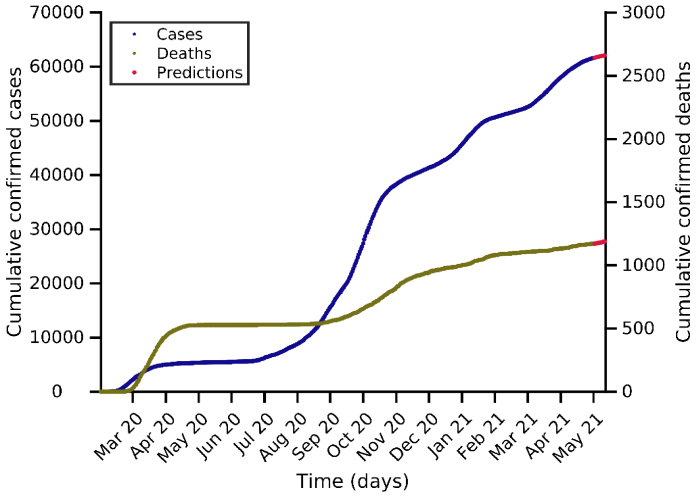








Navarra 16-05-2021. Pop: 0.7M. Cumulative incidence: 9413/10^5

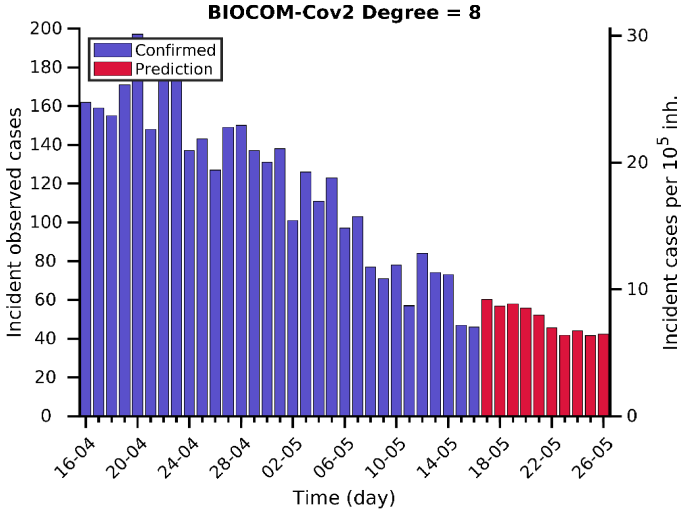


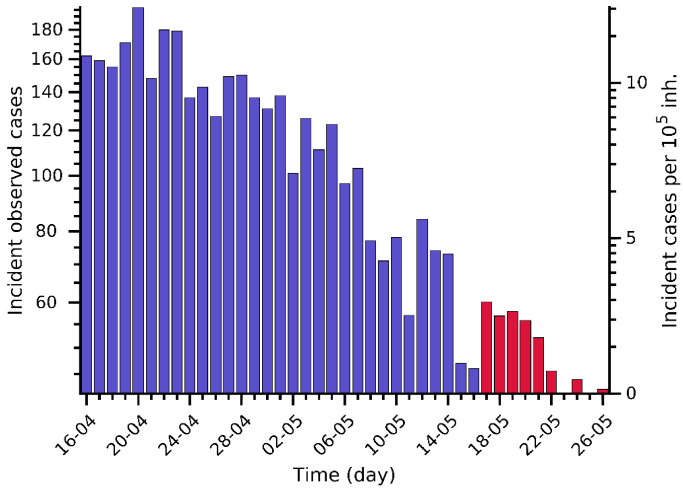
Predictions for next days

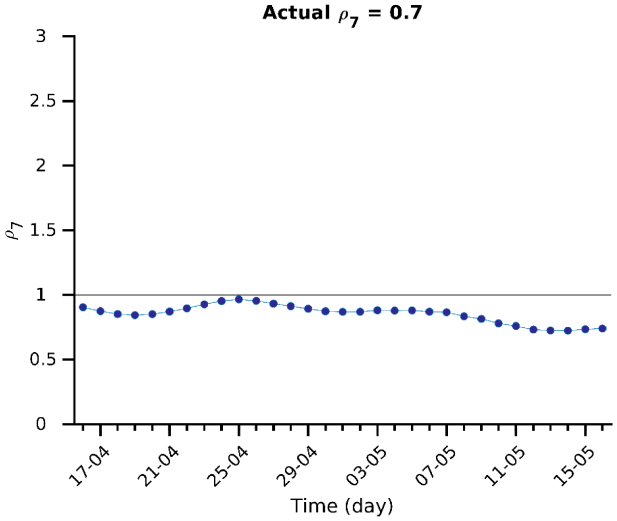
Day	Number of cases
19-05-2021	61756 (+175)
23-05-2021	61951 (+370)
26-05-2021	62079 (+498)

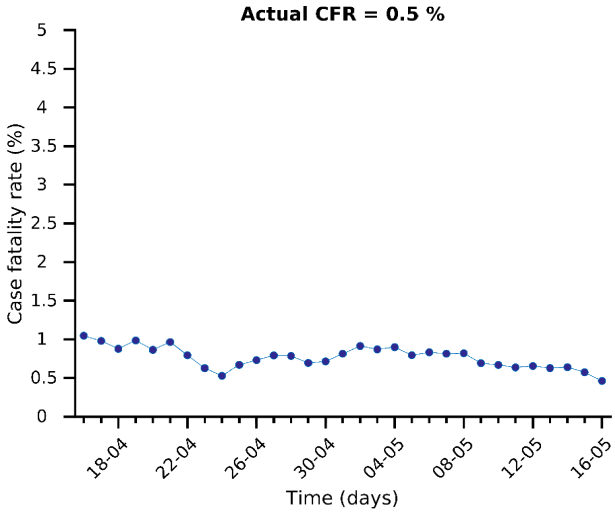
Current indicators

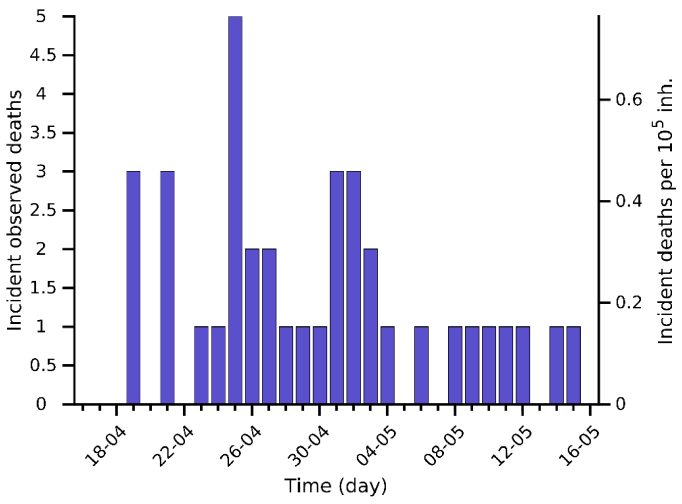
	A14	EPG	CFR	N7	D7
Today	178	132	0.46 %	66	1
A Week ago	251	204	0.69 %	101	1
Maximum	1179	1260	4.10 %	582	17

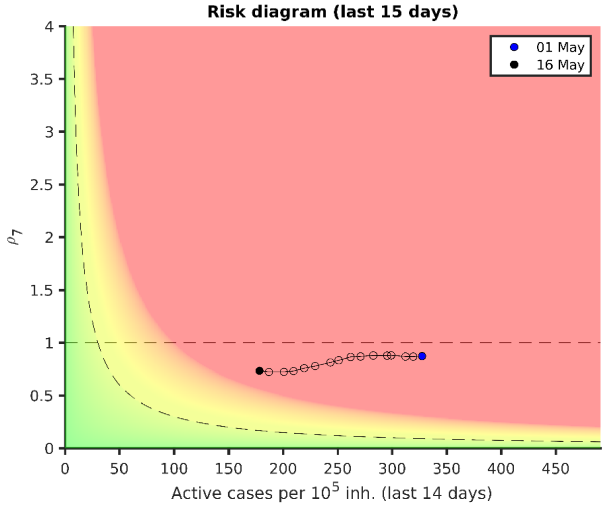




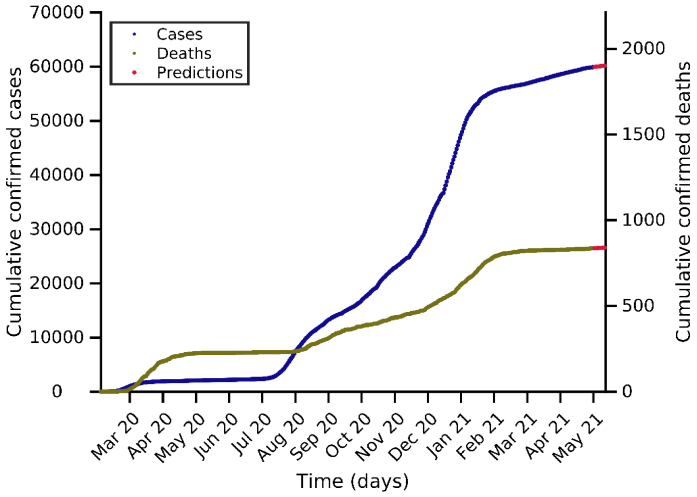








Baleares 16-05-2021. Pop: 1.1M. Cumulative incidence: 5213/10⁵

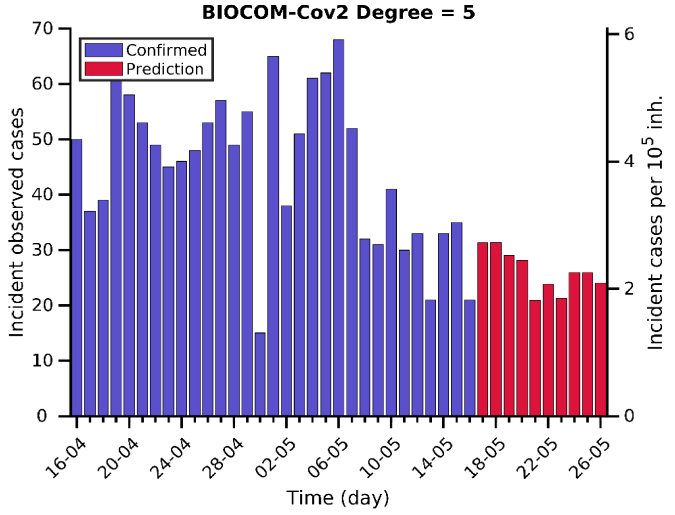


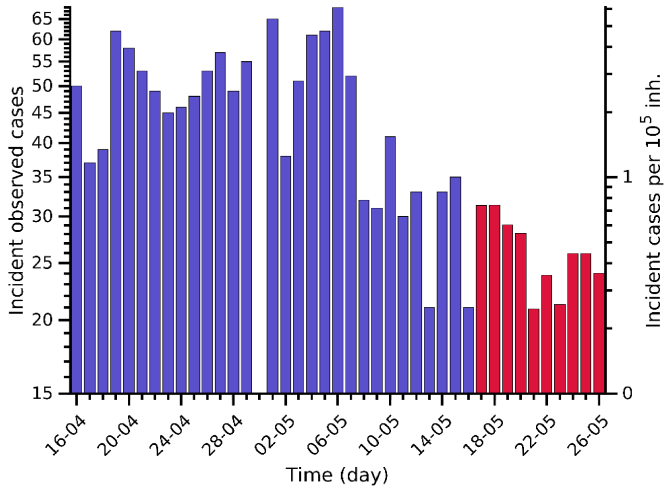
Predictions for next days

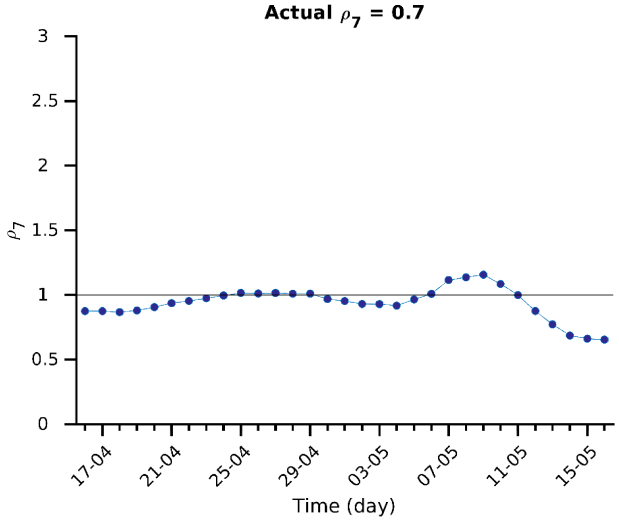
Day	Number of cases
19-05-2021	60019 (+92)
23-05-2021	60113 (+186)
26-05-2021	60189 (+262)

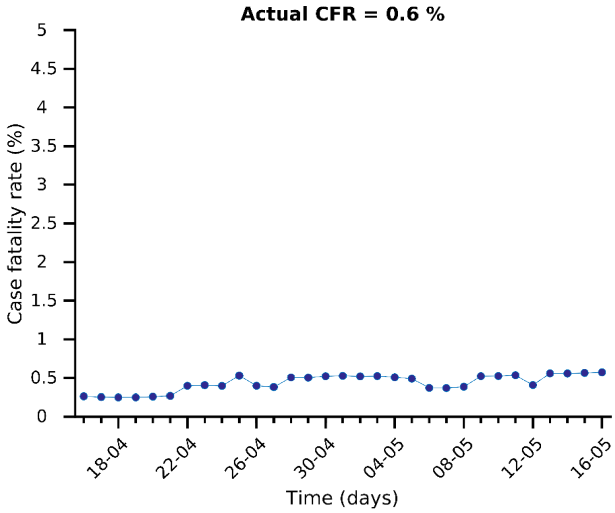
Current indicators

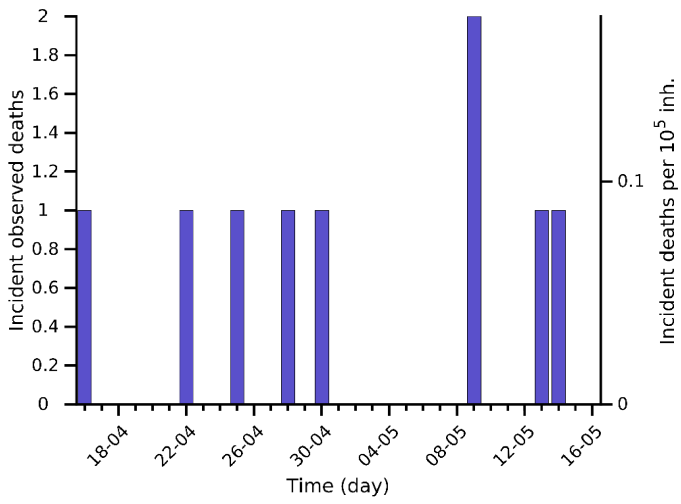
	A14	EPG	CFR	N7	D7
Today	50	32	0.57 %	31	0
A Week ago	60	69	0.52 %	51	0
Maximum	826	982	3.92 %	683	7

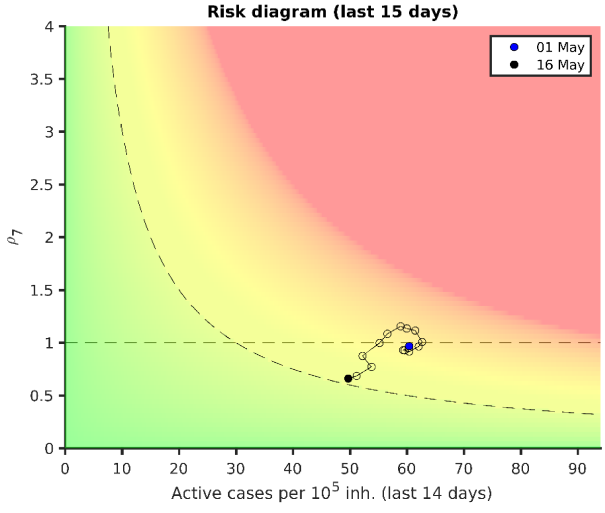




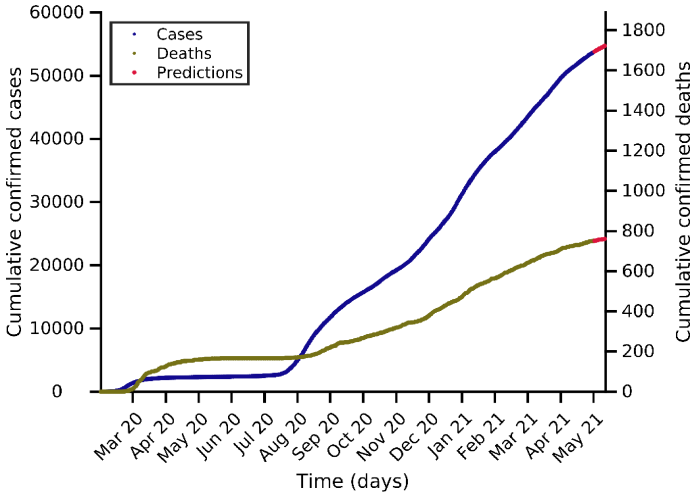








Canarias 16-05-2021. Pop: 2.2M. Cumulative incidence: 2495/10^5



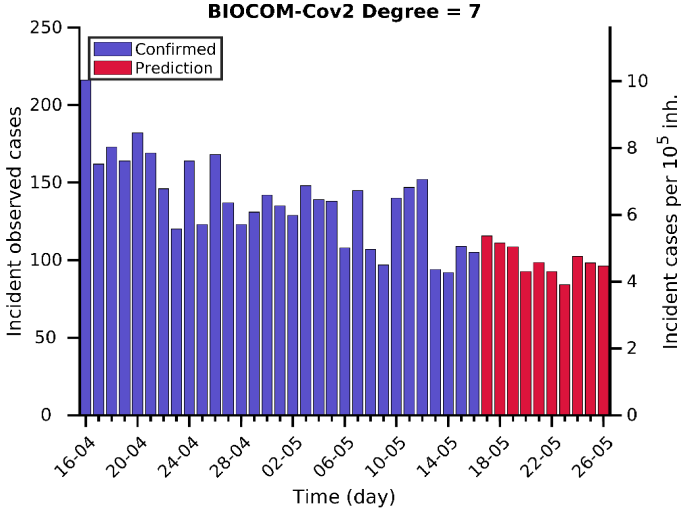
Predictions for next days

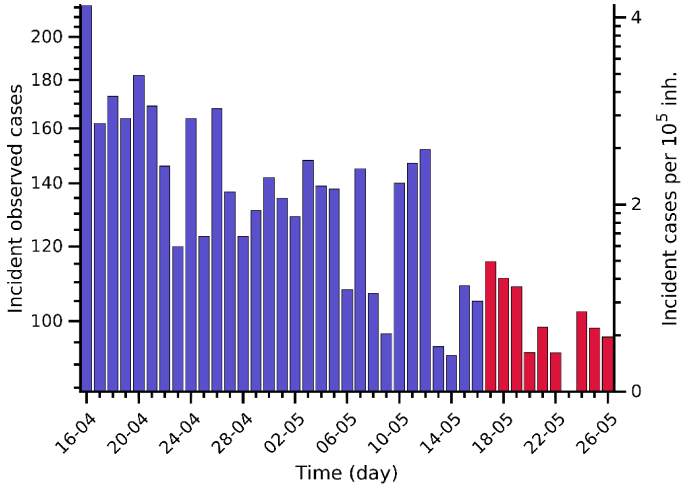
Day	Number of cases
19-05-2021	54054 (+335)
23-05-2021	54422 (+703)
26-05-2021	54719 (+1000)

Current indicators

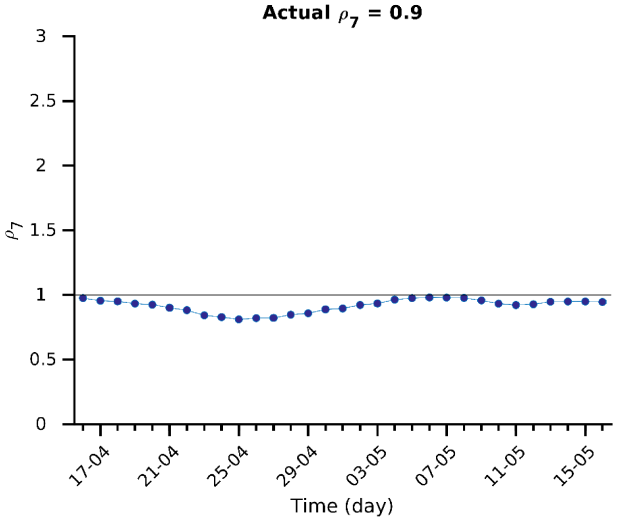
	A14	EPG	CFR	N7	D7
Today	80	76	0.81 %	120	1
A Week ago	86	82	0.65 %	126	2
Maximum	192	218	4.94 %	310	7

BIOCOM-Cov2 Degree = 7

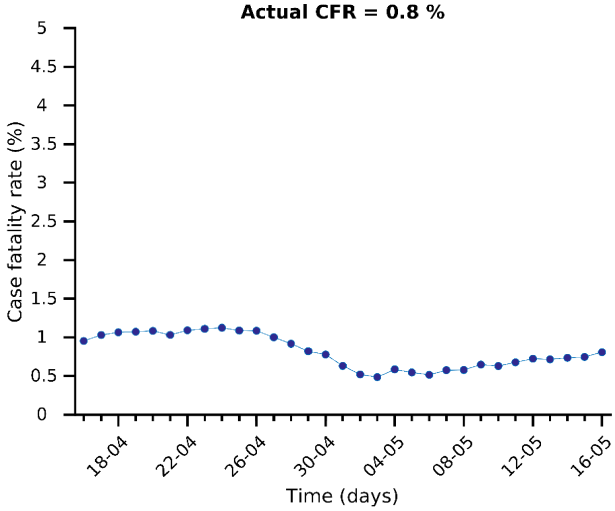


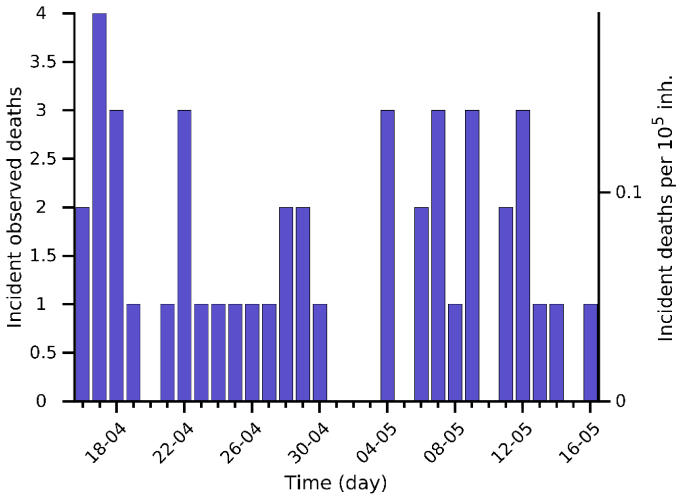


Actual ρ_7 = 0.9

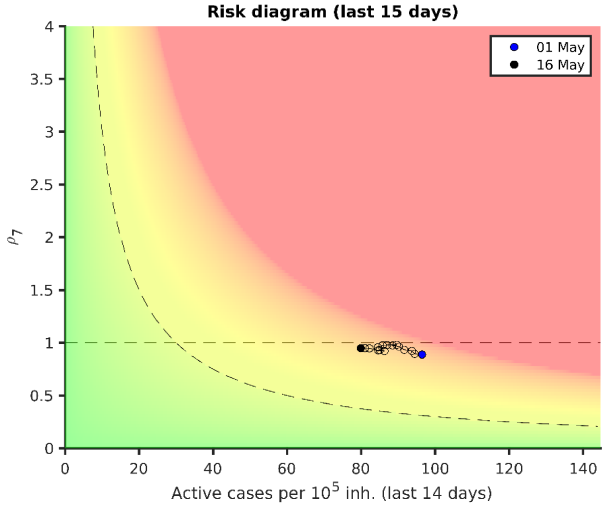


Actual CFR = 0.8 %

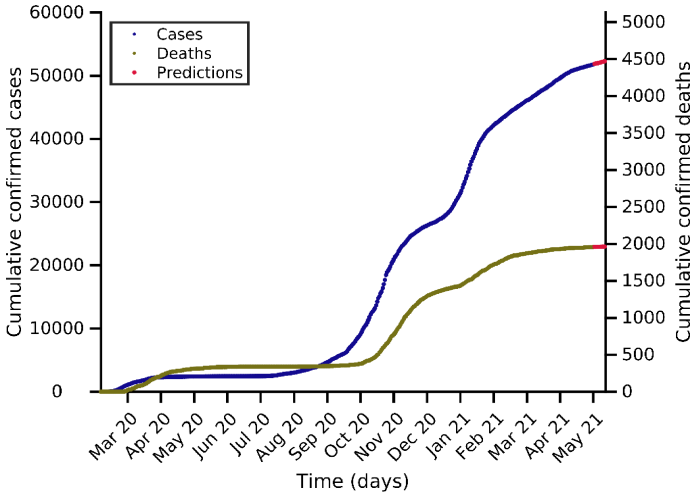




Risk diagram (last 15 days)



Asturias 16-05-2021. Pop: 1.0M. Cumulative incidence: 5066/10⁵



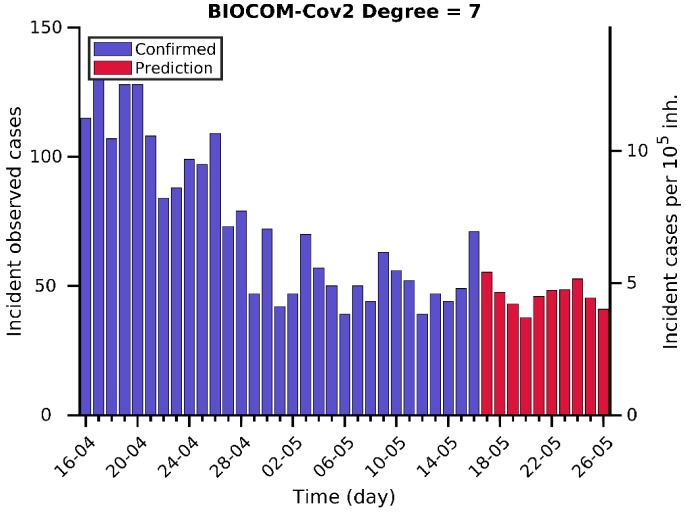
Predictions for next days

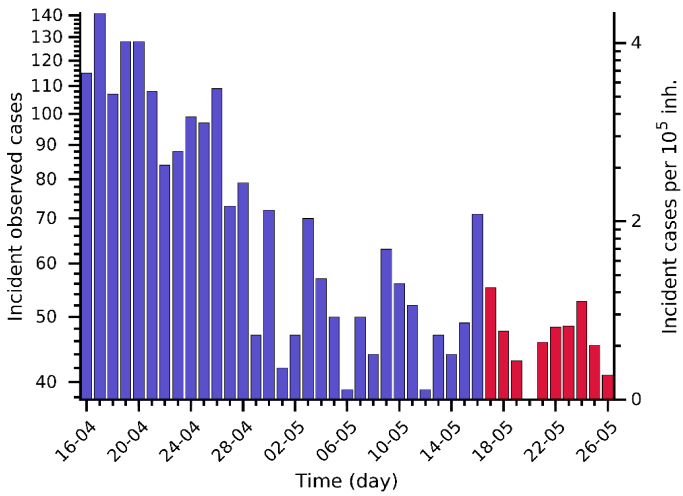
Day	Number of cases
19-05-2021	51956 (+146)
23-05-2021	52136 (+326)
26-05-2021	52275 (+465)

Current indicators

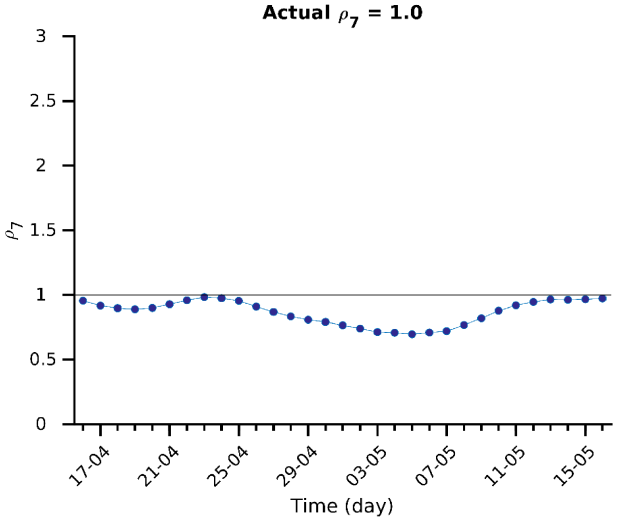
	A14	EPG	CFR	N7	D7
Today	71	70	0.79 %	51	1
A Week ago	82	67	0.52 %	53	1
Maximum	658	818	4.98 %	545	24

BIOCOM-Cov2 Degree = 7

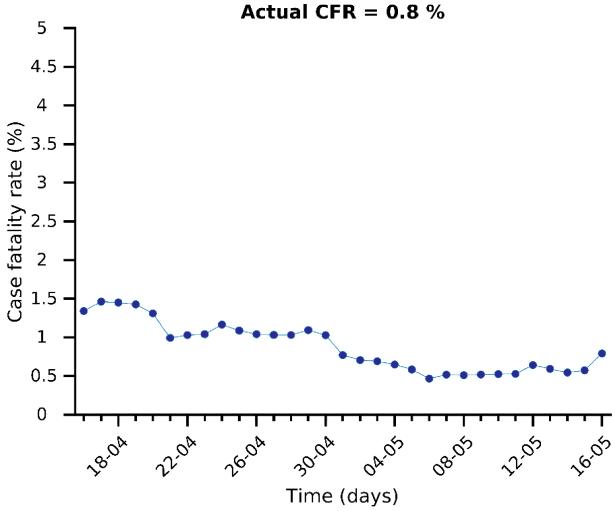


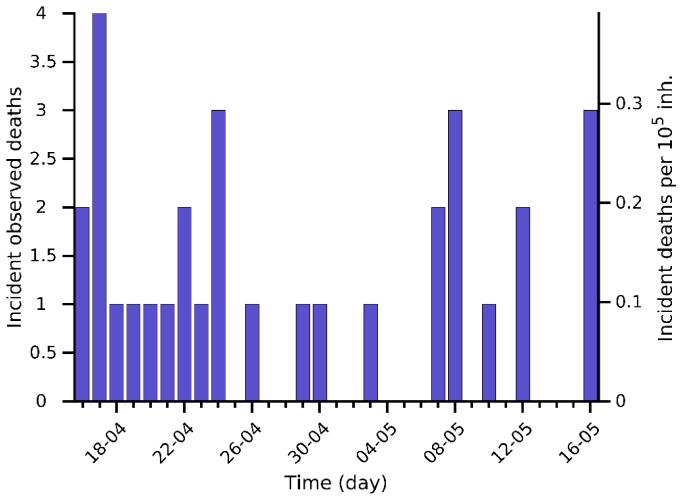


Actual ρ_7 = 1.0

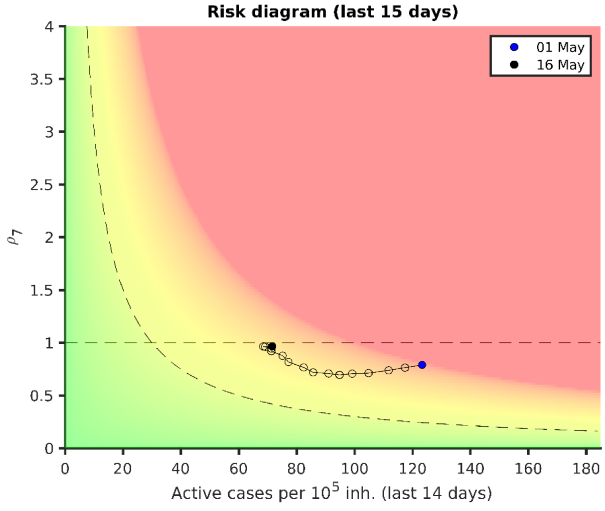


Actual CFR = 0.8 %

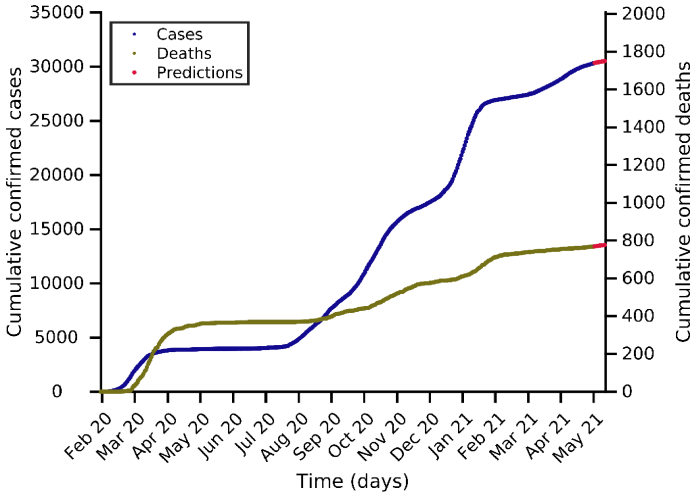




Risk diagram (last 15 days)



La Rioja 16-05-2021. Pop: 0.3M. Cumulative incidence: 9568/10^5

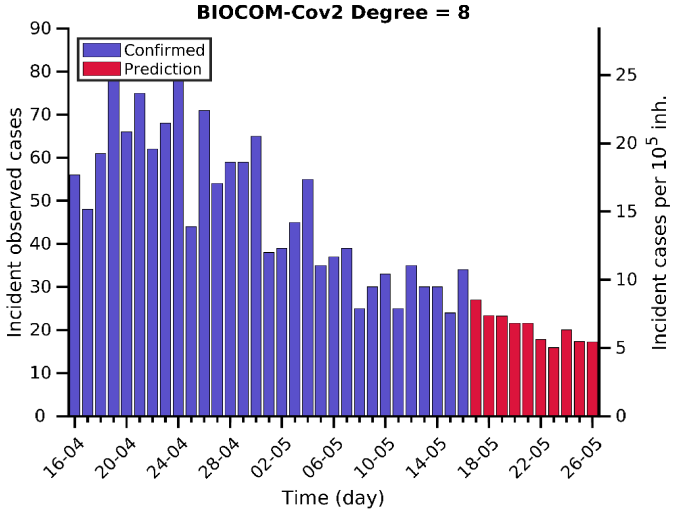


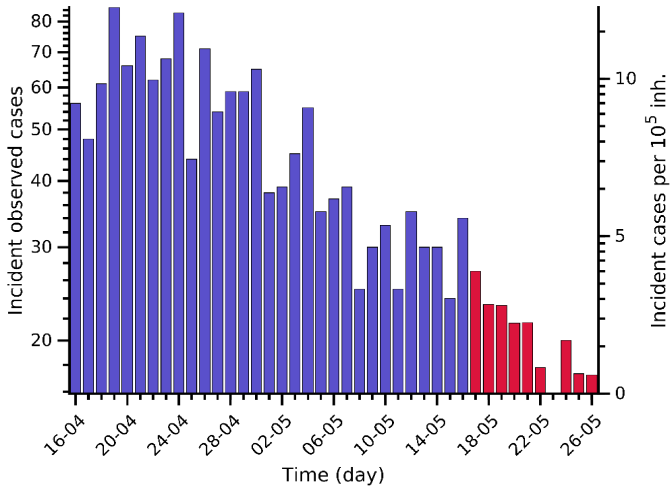
Predictions for next days

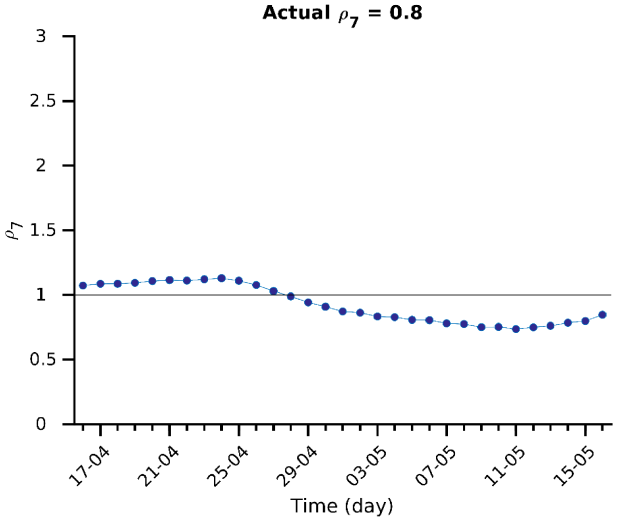
Day	Number of cases
19-05-2021	30386 (+74)
23-05-2021	30463 (+151)
26-05-2021	30517 (+205)

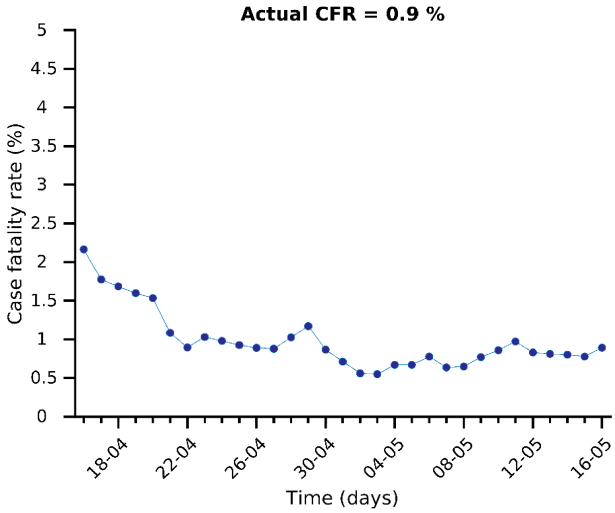
Current indicators

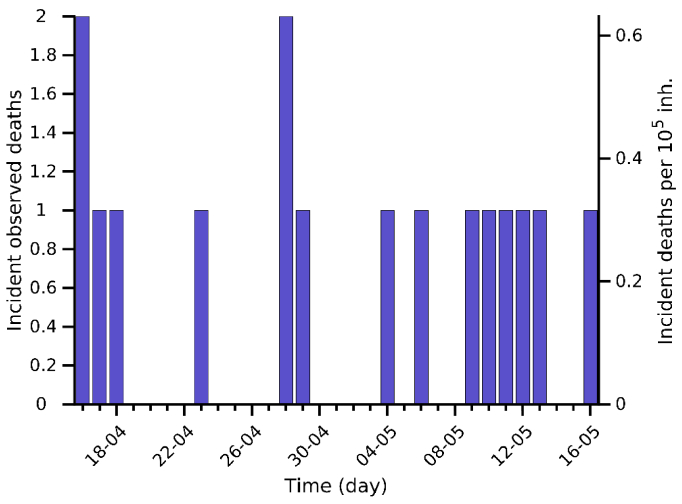
	A14	EPG	CFR	N7	D7
Today	151	127	0.89 %	30	1
A Week ago	205	154	0.77 %	38	0
Maximum	1311	1446	4.94 %	318	14

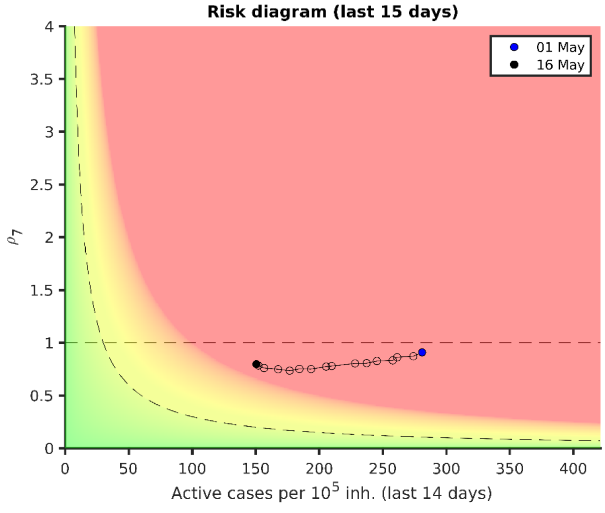




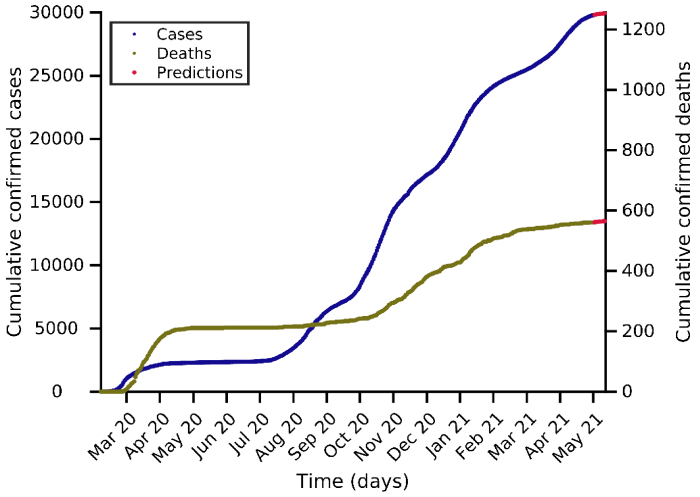








Cantabria 16-05-2021. Pop: 0.6M. Cumulative incidence: 5127/10^5

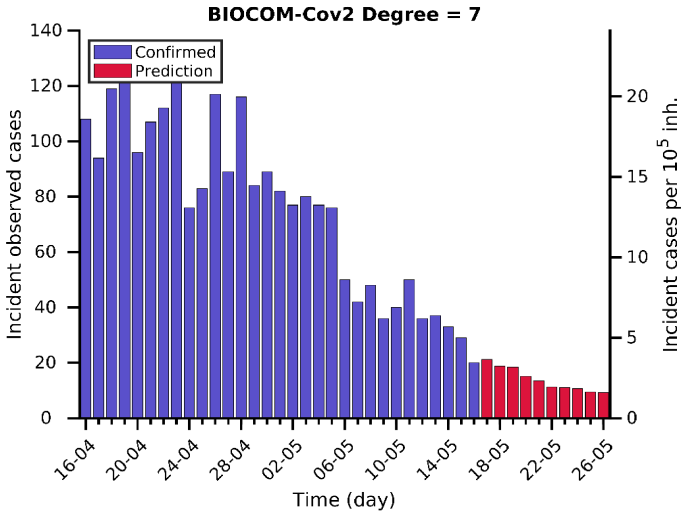


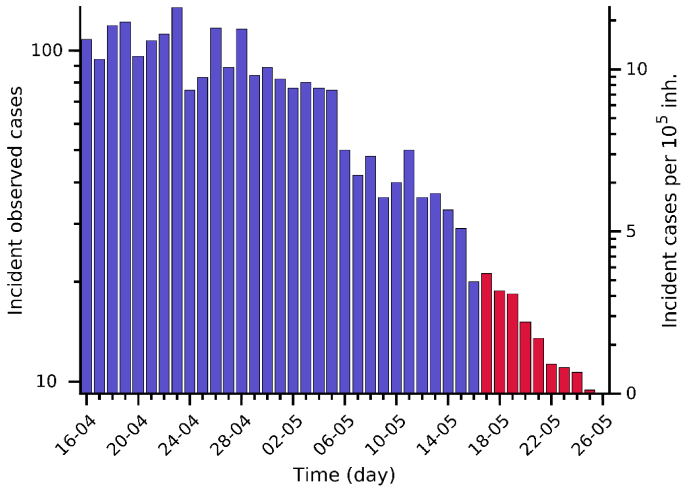
Predictions for next days

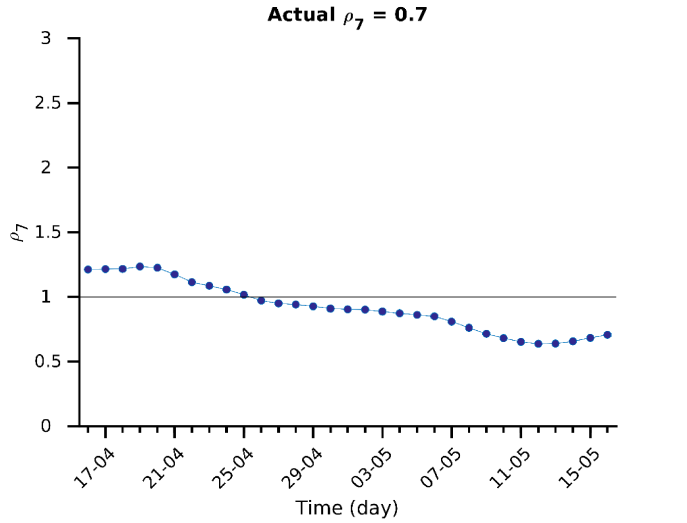
Day	Number of cases
19-05-2021	29850 (+58)
23-05-2021	29901 (+109)
26-05-2021	29931 (+139)

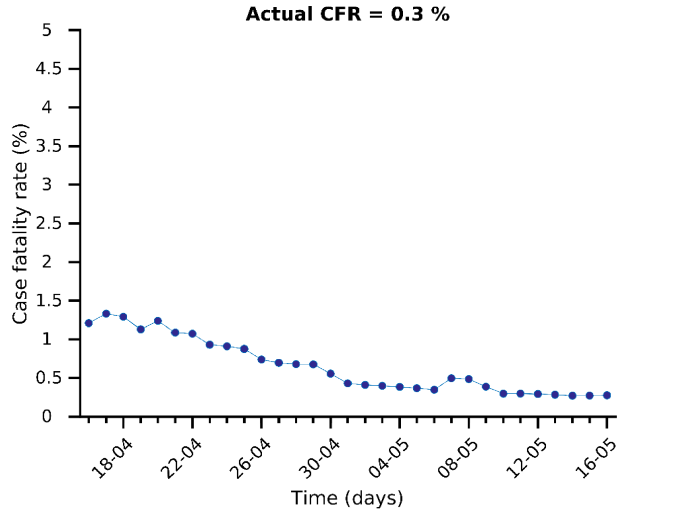
Current indicators

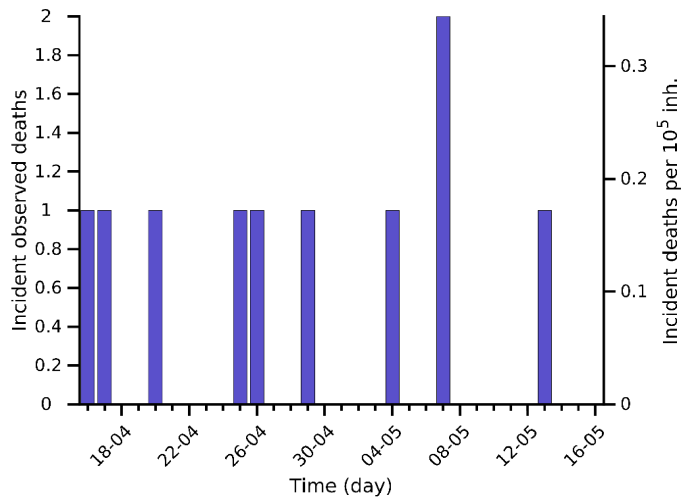
	A14	EPG	CFR	N7	D7
Today	113	80	0.28 %	35	0
A Week ago	183	131	0.39 %	58	0
Maximum	536	572	4.76 %	228	8

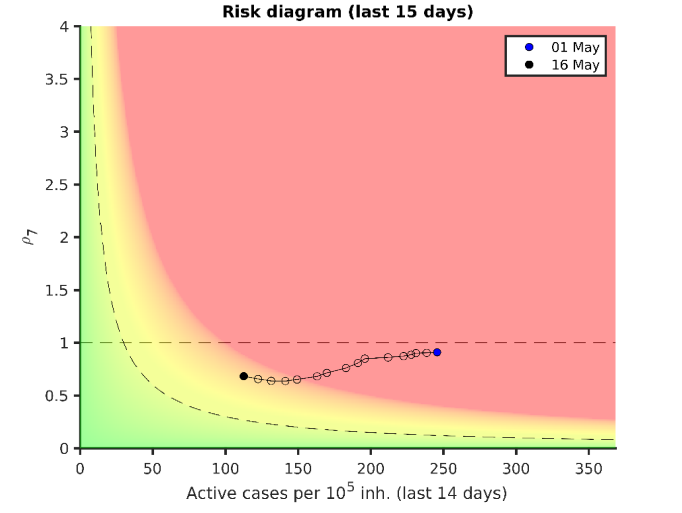




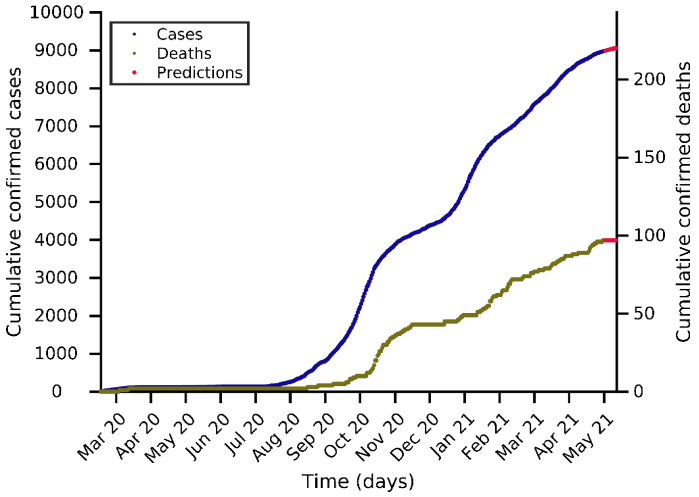








Melilla 16-05-2021. Pop: 0.1M. Cumulative incidence: 10388/10^5

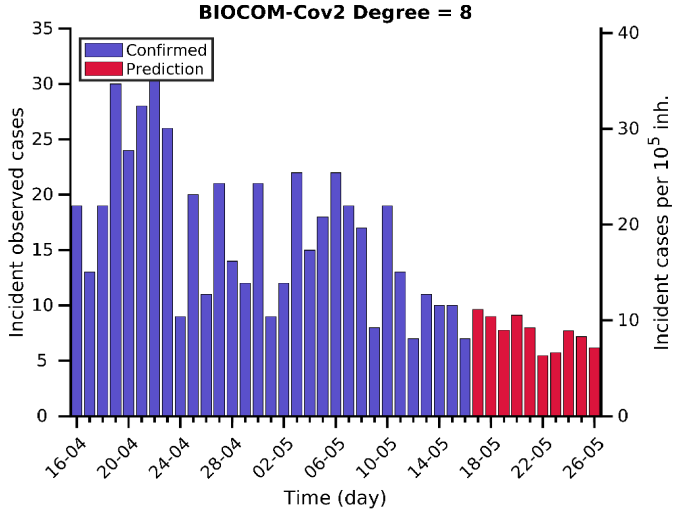


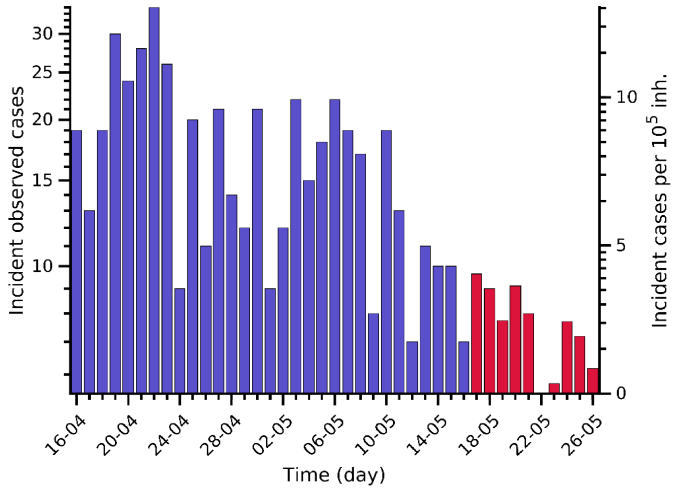
Predictions for next days

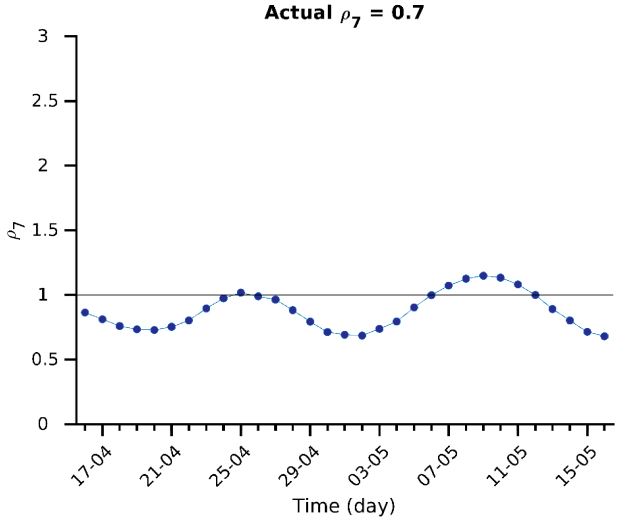
Day	Number of cases
19-05-2021	9010 (+26)
23-05-2021	9039 (+55)
26-05-2021	9060 (+76)

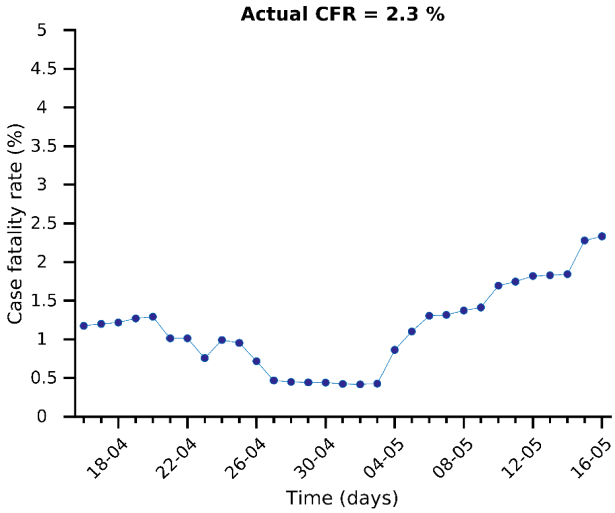
Current indicators

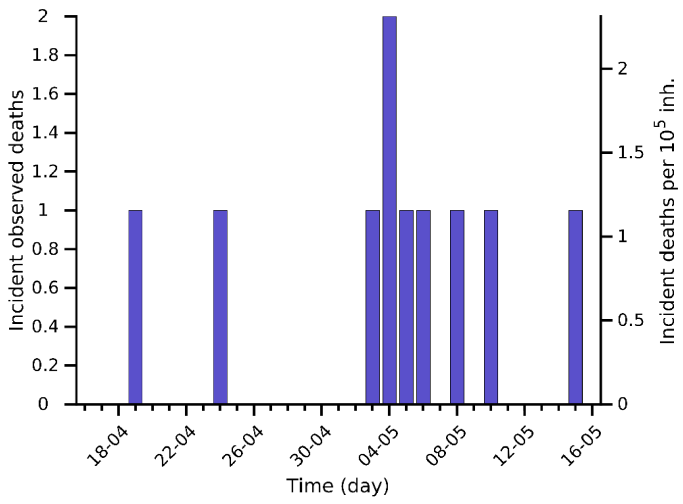
	A14	EPG	CFR	N7	D7
Today	229	156	2.33 %	11	0
A Week ago	256	293	1.41 %	17	1
Maximum	1339	1488	4.88 %	86	2

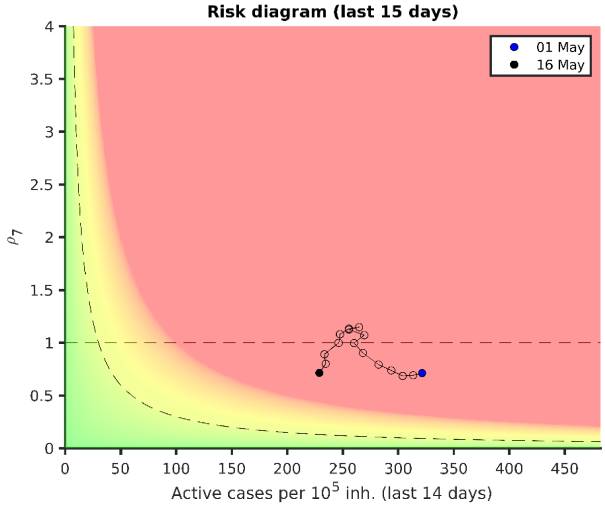




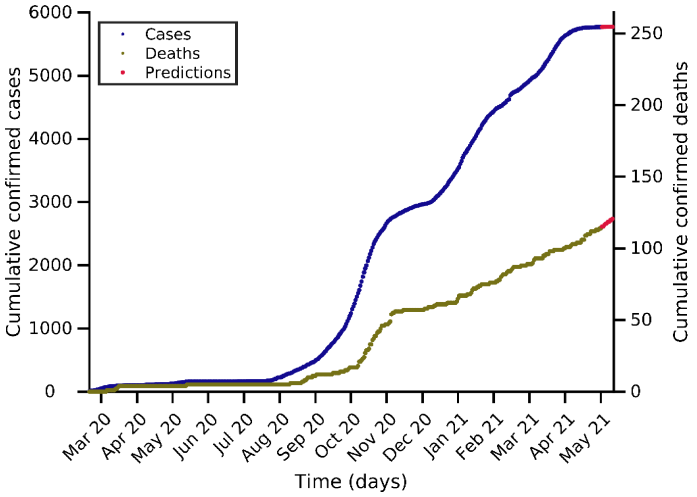








Ceuta 16-05-2021. Pop: 0.1M. Cumulative incidence: 6805/10^5

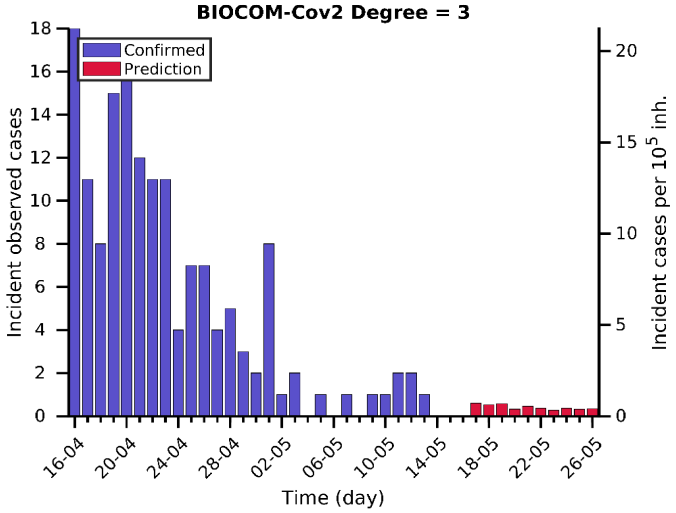


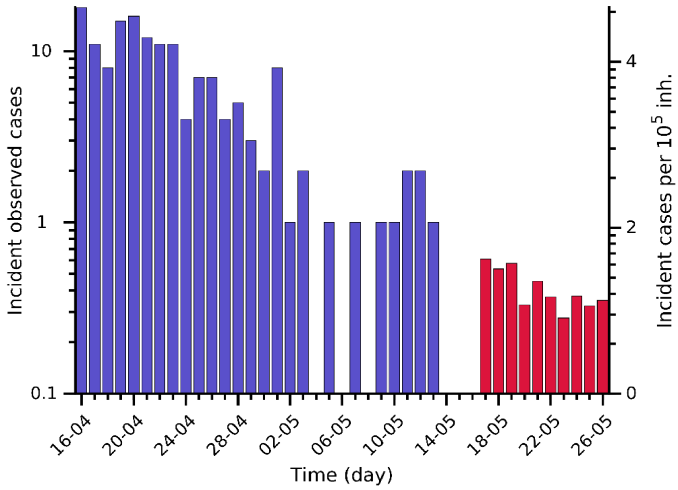
Predictions for next days

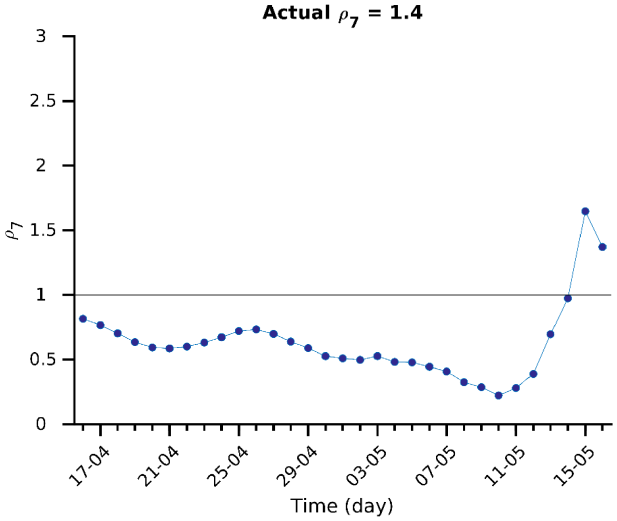
Day	Number of cases
19-05-2021	5771 (+2)
23-05-2021	5772 (+3)
26-05-2021	5773 (+4)

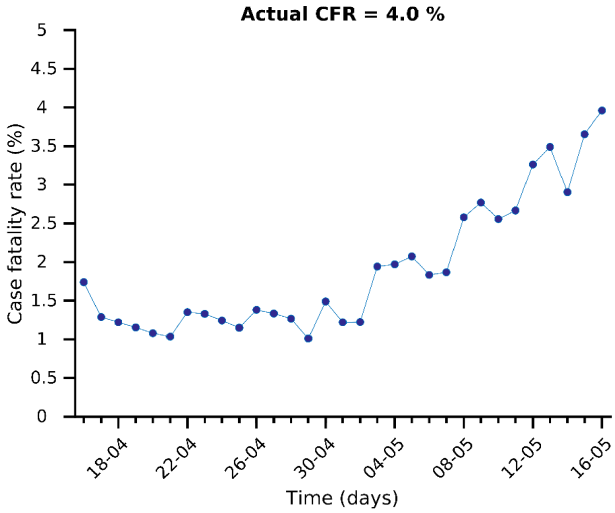
Current indicators

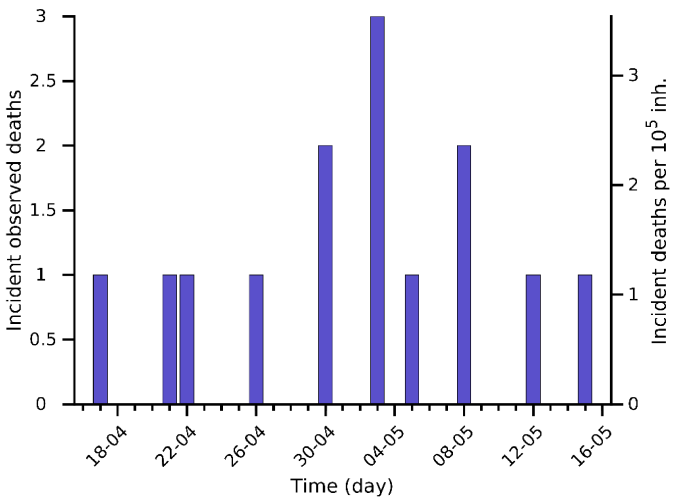
	A14	EPG	CFR	N7	D7
Today	13	18	3.96 %	1	0
A Week ago	41	12	2.77 %	1	1
Maximum	986	1159	4.96 %	65	2

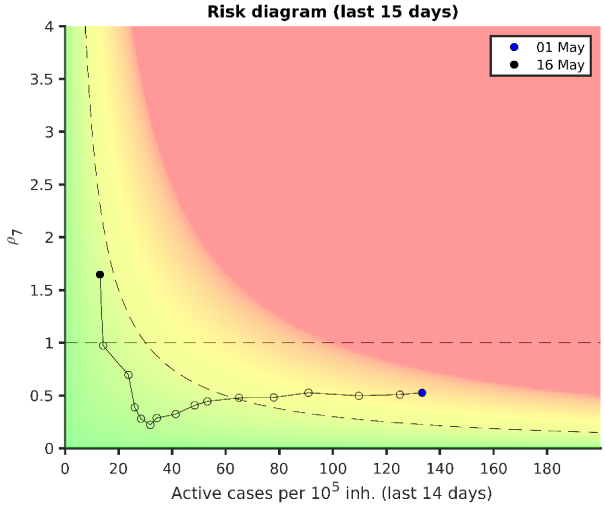












Methods

Methods

(1) Data source

Data are daily obtained from European Centre for Disease Prevention and Control (ECDC)[5] and country official sources (when indicated). 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 individual countries and for the UE+EFTA+UK as a whole:

- ✓ Number of cumulative confirmed cases
- ✓ Number of reported new cases
- ✓ Number of cumulative deaths

Then, two indicators are calculated and plotted, too:

- ✓ Case fatality rate: number of 14-day cumulative deaths divided by the number of 14-day cumulative confirmed cases of 21 days before, to account for the average 21-day delay between diagnosis and death.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

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

where $N_{new}(t)$ is the number of new confirmed cases at day *t* after applying a 7-day moving average to the new cases dataset, so that fluctuations (e.g., weekend effect) are smoothed. **Updated methodology to account for weekend effect is discussed and explained in reports #152[6] and #154[7].**

(3) Classification of countries according to their epidemic level: the scale Biocom-Cov

Countries are assigned a degree in the discrete Biocom-Cov scale, which aims to facilitate a simple way of assessing the situation of the country. It is based on the level of daily new cases per 100,000 inhabitants as follows:

Pandemic degree	Daily new incident cases per 10^5 inh.
0	0
1	0-0.1
2	0.1-0.5
3	0.5-1.25
4	1.25-2
5	2-3
6	3-5
7	5-8

[5] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases
[6] https://upcommons.upc.edu/handle/2117/331959
[7] https://upcommons.upc.edu/handle/2117/332347

8	8-14
9	>14

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[8] 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 wave that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied. Once in the tail, predictions work but the meaning of parameters is lost.

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 cumulative cases of the UE and of countries 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*.

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.

The model and its results on predictions in European countries during the first wave has been published in Plos Computational Biology[9].

(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 (3-5 days). 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 bar. 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. **Updated methodology to account for weekend effect is explained in report #155[10].**

(6) Estimating non-diagnosed cases

[8] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.
[9] Català et al, 2020, Plos Comput Biol 16(12): e1008431, https://doi.org/10.1371/journal.pcbi.1008431
[10] https://upcommons.upc.edu/handle/2117/332350

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[11] 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.

Full methodology and results have been published in Plos One[12].

[11] 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

[12] Català et al, PLoS ONE 16(1): e0243701, 2021. https://doi.org/10.1371/journal.pone.0243701