UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
Computational Biology and Complex Systems Research Group
CMCiB Comparative Medicine & Bioimage Centre of Catalonia
IGTP Germans Trias i Pujol Research Institute

Daily report 02-10-2020

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

Situation report 136

Contact: clara.prats@upc.edu

With the financial support of European Commission *and* Ministerio de Ciencia e Innovación "la Caixa"

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 8 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.

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

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

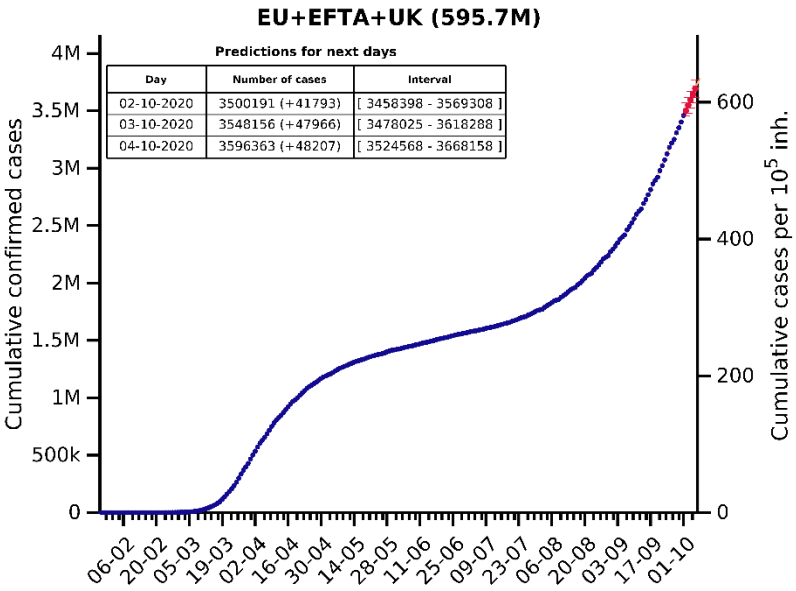
With the collaboration of: Daniel Molinuevo, Pablo Palacios, Tomás Urdiales, Aida Perramon, Inmaculada Villanueva

These reports are funded by the European Commission (DG CONNECT, LC-01485746)

PJC and MC received funding from "la Caixa" Foundation (ID 100010434), under agreement LCF/PR/GN17/50300003; CP, DL, SA, MC, received funding from Ministerio de Ciencia, Innovación y Universidades and FEDER, with the project PGC2018-095456-B-I00;

Situation and highlights

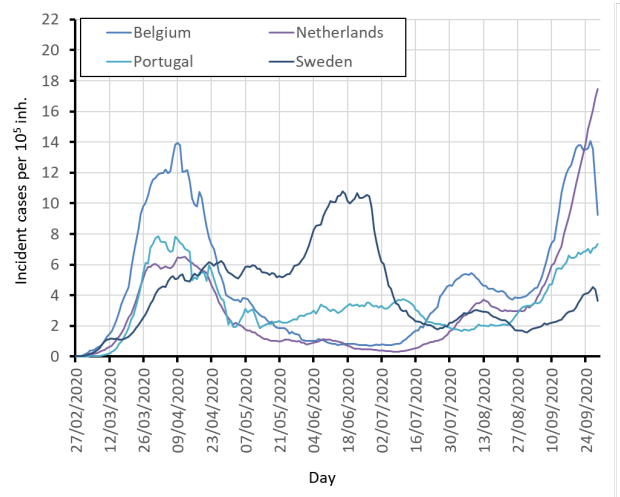
Global situation

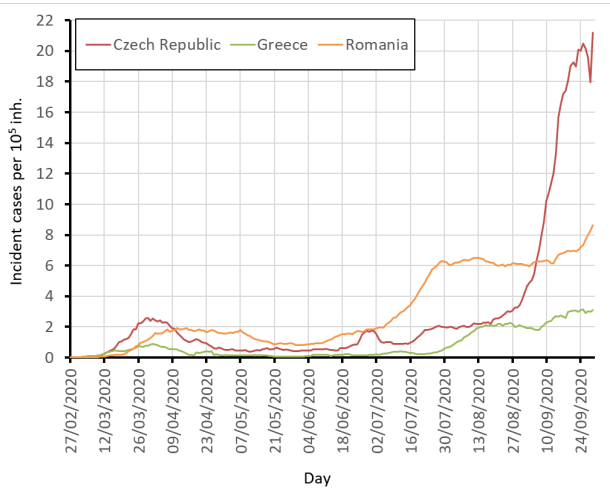


Within the EU+EFTA+UK countries, there are 7 with a population between 10 and 20 million. In the figures below we have represented the number of daily new cases per 100,000 inhabitants. We observe an important variety of dynamics. To facilitate visualization, we have divided the countries into two groups: a first group (Belgium, Portugal, Netherlands, Sweden) which had a significant incidence during the months of March and April, and a second group (Czech Republic, Greece, Romania) that controlled the epidemic very well during those months. Within the first group, the dynamics of Sweden and Portugal stand out.

As shown, Sweden suffered a first growth that managed to stabilize for a few weeks with an incidence of approximately 6 cases per day per 100,000 inhabitants. Later, they had a second growth which they stopped at about 10 cases per day per 100,000 hab. After, they managed to reduce the intensity of the pandemic for a while, but could be currently entering a third growth. In Portugal it was very difficult to lower the incidence, and they are currently also showing a second significant growth. The Netherlands controlled the growth in August, but the dynamics in September is out of control. A similar behavior shows Belgium, although in recent days it seems that they have begun to control the situation.

The second group of countries controlled the pandemic very well for months. Romania suffered its first growth since mid-June which it managed to control with an incidence of 6, but since about September 13 it is suffering a new growth. The Czech Republic has been experiencing very strong growth since mid-August, although it does not look like they are getting close to control. Finally, Greece is the country that has suffered the lowest incidence. Although it is currently reaching highest incidence it has had throughout the process, it seems to be controlling it. In this group of countries it is clear that it does not make sense to talk about a second wave. In fact, in some countries, like Sweden, we can talk about a third wave. In others, like the Czech Republic, we are still in the same initial stage, with growth and degrowth being associated with epidemiological control efforts.



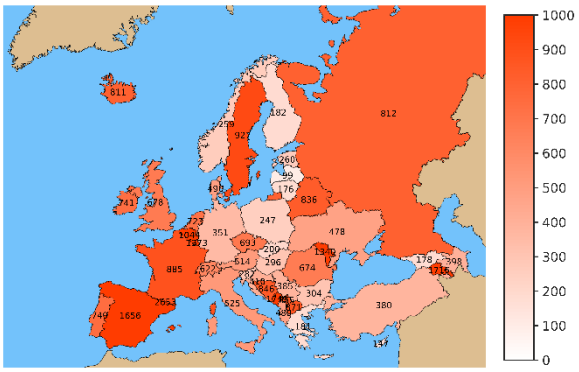


Situation and trends per country

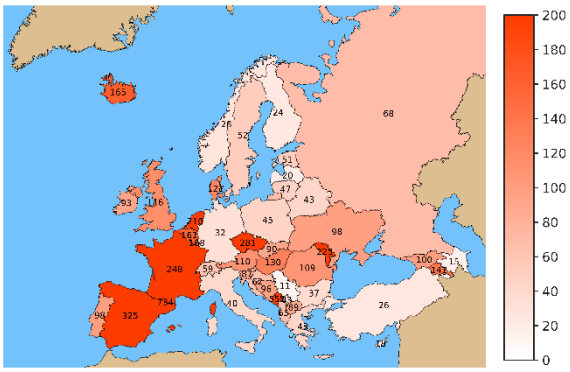
Maps of current situation in EU countries. Colour scale is indicated in each legend.

- 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 ($EPG = A_{14} \cdot \rho_7$)

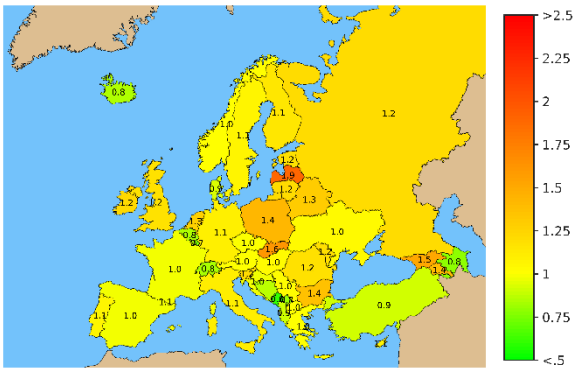
Cumulative incidence



A_{14}



ρ_7



EPG

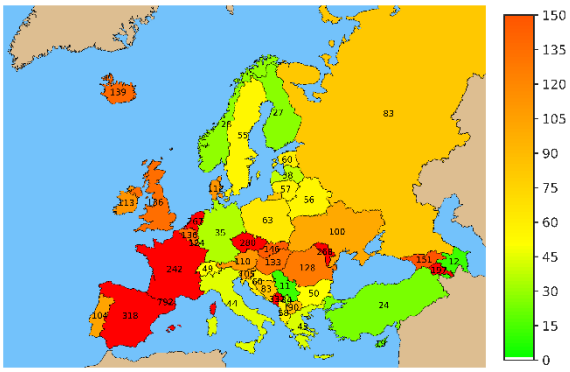


Table of current situation in EU countries. Colour scale is indicated in each legend.

	Reported data						Indexes		
Country	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality /10^5 inh.	Cumulative deaths	ρ_7 [(1)]	EPG [(2)]	Biocom-Cov degree
Spain	325.3	152,956	1,655.7	778,607	68.0	31,973	0.98	318	9
Czech Republic	281.1	30,100	693.4	74,255	6.3	678	0.99	280	9
France	248.2	162,024	884.7	577,505	49.1	32,019	0.98	242	9
Netherlands	210.0	35,979	723.5	123,966	37.4	6,410	1.27	267	9
Luxembourg	168.4	1,054	1,373.1	8,595	20.0	125	0.74	124	8
Iceland	165.0	563	811.4	2,769	2.9	10	0.84	139	8
Belgium	161.4	18,708	1,043.7	120,965	86.5	10,023	0.84	136	8
Hungary	129.6	12,520	296.4	28,631	8.3	798	1.02	133	8
Denmark	120.9	7,003	490.2	28,396	11.2	651	0.93	112	8
United Kingdom	115.7	78,564	677.9	460,178	62.2	42,202	1.17	136	8
Malta	113.0	499	701.0	3,095	7.9	35	0.75	84	7
Austria	110.4	9,947	514.3	46,317	8.9	802	1.00	110	8
Romania	109.0	20,968	674.0	129,658	25.3	4,862	1.18	128	8
Portugal	98.1	10,000	749.2	76,396	19.4	1,977	1.06	104	7
Ireland	92.6	4,574	741.2	36,597	36.6	1,806	1.22	113	7
Slovakia	90.1	4,917	200.3	10,938	0.9	48	1.62	146	8
Slovenia	86.9	1,807	282.1	5,865	6.6	138	1.21	105	7
Croatia	62.1	2,548	409.9	16,827	6.9	284	0.97	60	6
Switzerland	59.5	5,148	622.0	53,832	20.6	1,784	0.83	49	6
Sweden	51.7	5,221	926.9	93,615	58.4	5,893	1.06	55	6
Estonia	50.7	672	260.1	3,450	4.9	65	1.18	60	6
Lithuania	47.0	1,280	175.7	4,784	3.4	92	1.21	57	6
Poland	44.7	16,910	247.0	93,481	6.7	2,543	1.42	63	6
Greece	43.0	4,486	181.2	18,886	3.8	393	1.00	43	6
Italy	40.3	24,384	525.0	317,409	59.4	35,918	1.10	44	6
Bulgaria	36.7	2,552	303.6	21,096	12.0	832	1.36	50	6
Germany	31.8	26,622	351.4	294,395	11.3	9,508	1.09	35	5
Norway	28.2	1,528	258.7	14,027	5.1	274	1.00	28	4
Liechtenstein	23.6	9	314.7	120	2.6	1	0.63	15	3
Finland	23.5	1,304	182.3	10,103	6.2	344	1.14	27	4
Latvia	19.8	374	99.0	1,868	2.0	37	1.90	38	5
Cyprus	17.7	214	146.8	1,772	1.8	22	1.06	19	4

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>2.0	>150
0.0	Best	Best	Best	Best	Best	0.0	0

[(1)] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [(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 (%)
Austria	10.4	935	2.0	100.0	17.9	1.7	150	50.2	13.7
France	10.2	6652	3.3	20.6	10.7	1.9	1265	17.9	22.5
Hungary	7.7	740	1.8	95.7	34.1	0.5	47	87.0	36.4
Portugal	6.7	682	2.0	96.2	18.3	1.0	107	46.9	32.8
Belgium	6.4	737	1.3	12.8	38.1	1.4	157	12.2	49.9
Italy	5.6	3388	2.2	10.3	14.1	0.5	291	7.2	12.7
Slovakia	4.6	251	1.0	98.8	54.7	0.3	15	88.2	34.7
Slovenia	4.1	86	1.0	72.3	22.5	0.7	15	40.5	18.9
Switzerland	1.8	156	0.5	6.9	3.2	0.3	22	5.7	-5.1

Colour scale
>20%
-20%

Colour scale
>20%
-20%

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

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

Situation and trends in some European regions[3]

Table of current situation in Spain regions. 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 /10^5 inh.	Cumulative deaths	ρ_7 (1)	EPG (2)	Biocom-Cov degree
Madrid	785.1	52,135	3,417.8	226,969	138.7	9,210	0.92	722	9
Navarra	662.3	4,305	3,036.2	19,734	86.5	562	0.97	646	9
La Rioja	457.6	1,435	2,638.2	8,273	130.1	408	0.74	340	9
Castilla-La Mancha	450.6	9,173	2,268.0	46,166	148.8	3,029	0.89	399	9
Murcia	414.5	6,166	1,310.2	19,492	10.6	158	0.91	378	9
Castilla y Leon	413.6	9,959	2,217.7	53,404	124.7	3,002	0.99	408	9
Aragon	367.1	4,849	2,720.9	35,937	102.7	1,356	0.87	319	9
Melilla	330.5	280	1,126.1	954	4.7	4	1.42	468	9
Extremadura	306.9	3,270	1,200.7	12,792	52.7	561	0.92	284	9
Euskadi	276.0	6,012	2,047.3	44,591	85.3	1,857	0.87	241	9
Ceuta	200.4	170	748.4	635	11.8	10	1.38	276	9
Andalucia	172.6	14,540	756.8	63,774	20.6	1,735	1.04	179	8
Catalunya	169.1	12,790	1,753.1	132,621	77.1	5,835	0.96	163	8
Baleares	161.5	1,918	1,160.9	13,789	24.6	292	0.77	124	8
Cantabria	157.8	918	1,152.9	6,706	38.5	224	0.74	117	8
Asturias	121.7	1,244	515.3	5,268	33.5	342	1.33	162	8
Comunitat Valenciana	116.6	5,800	874.9	43,520	31.9	1,586	0.84	98	7
Galicia	115.1	3,108	830.6	22,430	26.8	724	1.01	116	8
Canarias	108.4	2,393	595.7	13,149	9.9	219	0.98	106	7

Colour scale							
>150.0	Worst	Worst	Worst	Worst	Worst	>2.0	>150
0.0	Best	Best	Best	Best	Best	0.0	0

Table of current situation in the Sweden regions. 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	ρ_7 (1)	EPG (2)	Biocom-Cov degree
Jönköping	404.3	380	5,772.3	5,426	0.76	308	9
Uppsala	191.3	329	2,413.4	4,151	1.34	256	9
Örebro	169.9	265	1,939.1	3,025	0.92	156	8
Kronoberg	148.0	296	873.0	1,746	1.20	178	8
Västmanland	136.9	375	1,156.2	3,168	2.43	333	9
Dalarna	126.5	363	899.0	2,580	0.73	92	7
Halland	116.7	384	801.2	2,636	1.43	166	8
Stockholm	103.5	2,427	1,095.1	25,668	1.76	182	8
Kalmar	100.0	36	2,588.9	932	1.13	113	7
Blekinge	82.5	132	466.9	747	2.97	245	8
Västra Götaland	76.9	1,315	1,193.3	20,406	1.31	100	7
Skåne	75.1	1,023	443.0	6,034	1.11	84	7
Jämtland	68.5	89	1,000.0	1,300	2.53	173	7
Västerbotten	66.1	181	384.3	1,053	1.90	125	7
Gävleborg	62.0	178	1,189.9	3,415	1.53	95	7
Östergötland	56.5	261	894.8	4,134	1.46	83	6
Södermanland	38.7	99	989.5	2,533	1.24	48	6
Norrbotten	38.4	96	706.0	1,765	2.59	100	6
Värmland	31.7	89	462.3	1,299	1.16	37	5
Gotland	30.5	18	571.2	337	1.05	32	5
Västernorrland	27.3	67	786.9	1,928	1.30	35	5

Colour scale					
>150.0	Worst	Worst	Worst	>2.0	>150
0.0	Best	Best	Best	0.0	0

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

Table of current situation in Belgium regions. 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 /10^5 inh.	Cumulative deaths	ρ_7 [1]	EPG [2]	Biocom-Cov degree
Brussels	500.8	6,050	1,517.4	18,330	128.9	1,557	1.35	677	9
Wallonia	268.6	9,786	1,003.2	36,558	95.8	3,490	1.36	366	9
Flanders	183.0	12,060	958.8	63,178	75.5	4,973	1.27	232	9
Colour scale									
>150.0	Worst	Worst	Worst	Worst	Worst	Worst	>2.0	>150	
0.0	Best	Best	Best	Best	Best	Best	0.0	0	

Situation and trends in other countries

	Reported data						Indexes		
Country	14-day attack rate /10^5 inh.	Active cases (last 14 days)	Attack rate /10^5 inh.	Cumulative cases	Mortality /10^5 inh.	Cumulative deaths	ρ_7 [1]	EPG [2]	Biocom-Cov degree
Israel	910.8	78,838	2,955.0	255,771	18.7	1,622	1.09	997	9
Argentina	389.4	175,990	1,692.6	764,989	44.9	20,288	0.96	374	9
Peru	206.8	68,199	2,481.8	818,297	98.7	32,535	0.85	175	8
Brazil	184.3	391,706	2,280.3	4,847,092	68.1	144,680	0.96	176	8
United States of America	182.3	603,356	2,198.7	7,277,814	62.8	207,808	0.96	176	8
Colombia	179.6	91,394	1,641.7	835,339	51.5	26,196	0.96	172	8
Iraq	149.4	60,089	913.6	367,474	22.9	9,231	1.01	152	8
Chile	123.5	23,600	2,431.2	464,750	67.1	12,822	1.19	147	8
Qatar	113.4	3,266	4,372.0	125,959	7.4	214	0.92	104	7
Ukraine	97.7	42,715	477.8	208,959	9.6	4,193	1.03	100	7
Ecuador	92.5	16,327	785.5	138,584	64.8	11,433	0.89	82	7
India	87.2	1,179,391	472.6	6,394,068	7.4	99,773	0.97	84	7
Russia	68.5	99,950	812.2	1,185,231	14.3	20,891	1.21	83	7
Iran	57.0	47,895	548.9	461,044	31.4	26,380	1.04	59	6
Canada	52.1	19,668	425.3	160,535	24.7	9,319	1.28	66	6
Mexico	49.8	64,202	580.4	748,315	60.6	78,078	1.04	52	6
Belarus	42.7	4,032	836.2	79,019	8.9	839	1.30	56	6
Philippines	34.5	37,790	286.6	314,079	5.1	5,562	0.85	29	5
Indonesia	21.4	58,554	106.5	291,182	4.0	10,856	0.98	21	4
Saudi Arabia	20.0	6,953	962.5	335,097	13.8	4,794	0.91	18	4
Pakistan	4.1	9,045	141.9	313,431	2.9	6,499	1.00	4	2
Colour scale									
>150.0	Worst	Worst	Worst	Worst	Worst	Worst	>2.0	>150	
0.0	Best	Best	Best	Best	Best	Best	0.0	0	

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [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: Re-opening schools in times of pandemics (III). A first evaluation, three weeks later.

In Spain, primary and secondary schools re-opened between 7th and 14th of September, depending on the Autonomous Community (region). Therefore, children and teenagers have gone to school for three to four weeks. Given the characteristic time of 10-14 days to observe the effects of control measures in this epidemic, it is time to carry out a first evaluation of the impact of such re-opening.

In previous reports[4], we discussed that the most important risk factor in schools is the surrounding incidence. In this sense, we showed that most of expected positive cases in the schools would come from the exterior, and that transmission inside the schools was not expected to be relevant. Now, we want to check: (1) if the incidence trends of late September have been affected by the re-opening of the schools, and (2) if the pattern of incidence by age has displaced towards pediatric age. Given that Spain does not publish retrospective data series of cases disaggregated by age, we will focus on those communities that do so: Andalucía, Castilla y León, Catalunya and Comunitat Valenciana (see map). We will also add Comunidad de Madrid in the global analysis, given its current importance in terms of epidemiological situation.

Incidence level at the re-opening time

Primary and secondary schools re-opened between 7th and 14th September. At that time, 14-day cumulative incidence (A_{14}) in Spain was between 230 (7th) and 248 (14th) per 100,000 inhabitants, according to data from the Health Ministry[5]. Nevertheless, incidence levels were quite heterogeneous (Figure 1).

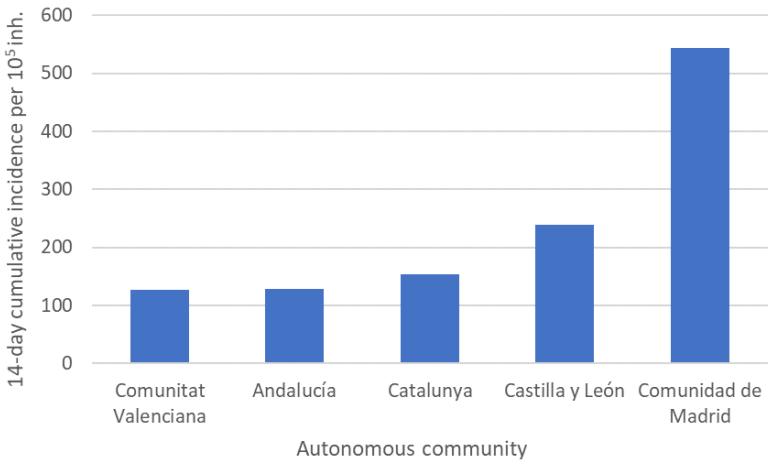


Figure 1: *14-day cumulative incidence the day at which each Autonomous Community re-opened schools.*

[4] https://upcommons.upc.edu/handle/2117/328694, https://upcommons.upc.edu/handle/2117/328695
[5] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov/situacionActual.htm

Among these regions, the day at which schools opened doors, A_{14} ranged from the 127 per 10^5 inhabitants of Comunitat Valenciana until the 544 cases per 10^5 inh. of Comunidad de Madrid. In all cases, high incidences that forced communities to establish serious hygiene and prevention protocols. In most of the regions, in addition to the compulsory use of masks for children above 6 years and the distancing, hygiene and ventilation measures, the control is based on the organization of children in closed groups (bubble groups) that are quarantined whenever a positive case is detected. Moreover, in communities like Catalunya there is a specific program of scholar mass screenings in high burden counties.

Effect of the re-opening in the global incidence

If schools had acted as amplifiers of the contagions, we should already observe an effect on the global incidence. Let us focus on the value of A_{14}. Figure 2 shows its value at five different weeks since 31st August[6]. We also indicate in the plot the day at which schools were opened in each case.

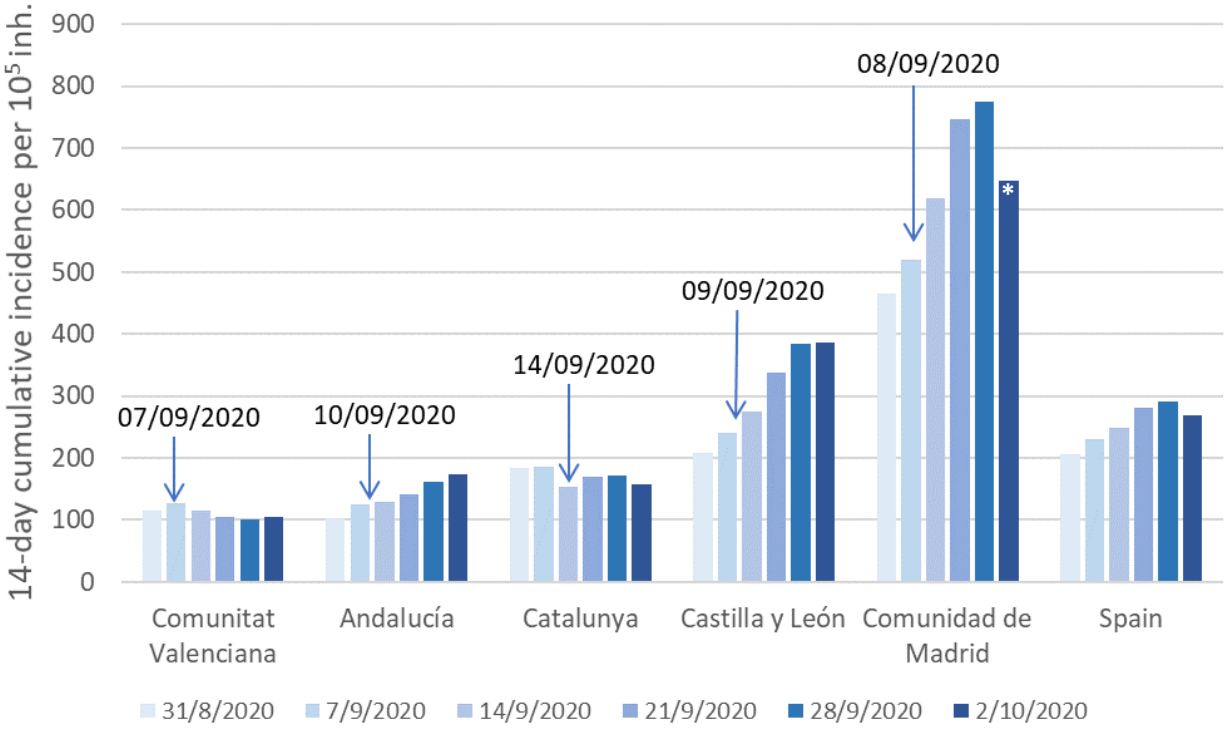


Figure 2: *Evolution of 14-day cumulative incidence in some Autonomous Communities, showing the period immediately before and after reopening the schools. The dates and arrows indicate the day at which schools were opened in each case. *Madrid's last point should be validated in further updates.*

At first view, re-opening the schools has not significantly modified the trend in any Autonomous Community. Global decreasing trend in Comunitat Valenciana has been maintained for the first three weeks after re-opening, while this week the incidence shows a slight increase. Andalucía maintains a similar increasing trend from the beginning of the month. Catalunya is still oscillating around an incidence of 150 cases per 100,000 inh. Before re-opening, Castilla y León and Madrid were immersed in an increasing trend that was maintained afterwards but that could have stopped last week (to be confirmed next week).

Figure 3 shows the ratio of A_{14} between two consecutive weeks. If either the growth had been accelerated or the decrease had been slowed down by reopening the schools, we should observe an increase in this ratio the last two weeks, when the effects could be perceived. The constant incidence level is indicated as a horizontal dotted line.

[6] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov/situacionActual.htm

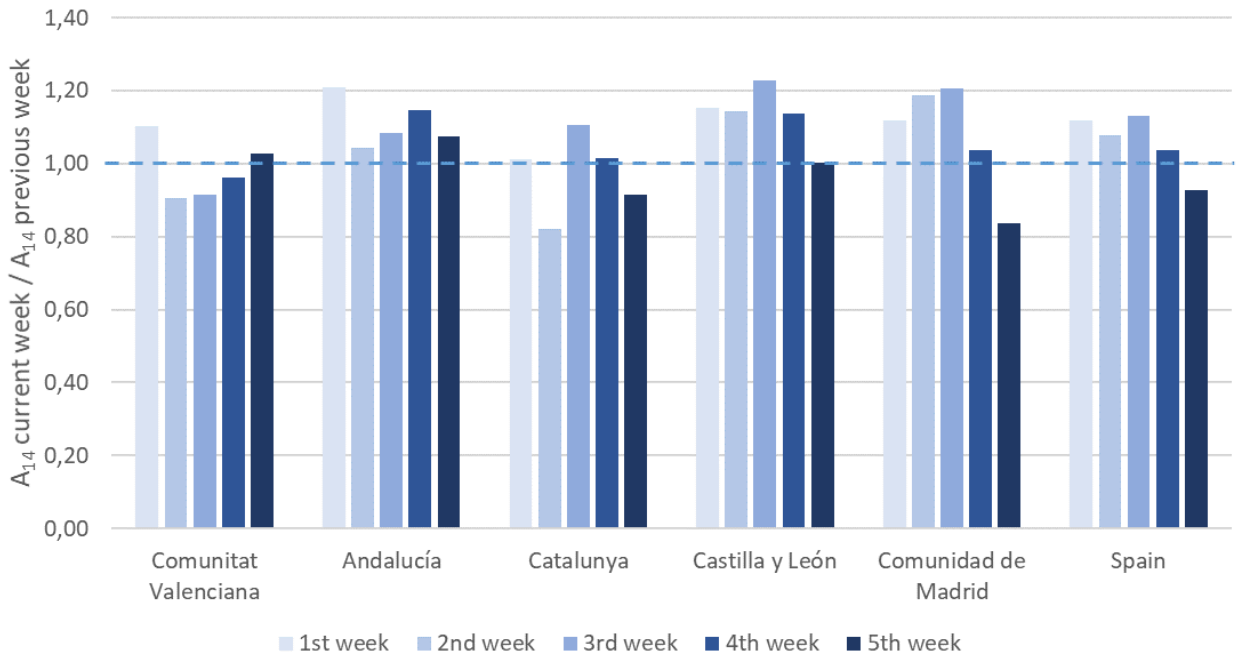


Figure 3: *Ration between A_{14} of a certain week and A_{14} the previous one, showing the increasing or decreasing trend in the incidence and the magnitude of this trend.*

1st week: A_{14}(7th Sept)/ A_{14}(31st Aug); 2nd week: A_{14}(14th Sept)/ A_{14}(7th Sept); 3rd week: A_{14}(21st Sept)/ A_{14}(14th Sept); 4th week: A_{14}(28th Sept)/ A_{14}(21st Sept); 5th week: A_{14}(2nd Oct)/A_{14}(28th Sept)

As shown in Figure 3, last two weeks we observe a decrease in the A_{14} ratios in most cases, **suggesting no effect of re-opening the schools in terms of global incidence**. There are two exceptions. First, Comunitat Valenciana, where this ratio increases the last two weeks. Nevertheless, as shown in Figure 2, this is the region with lowest incidence and, in fact, it seems to be stuck at the level of 100 cases per 100,000 inh. Andalucía slightly accelerated the growth on the penultimate week, but this growth slowed down last one.

Effect of re-opening in the pattern of incidence by age

Now, we are to see the dynamics of incidence disaggregated by age. The goal is to detect if the re-opening of the schools has caused a displacement of incidence pattern towards pediatric ages. Next tables show, month by month, the distribution of incidence among age groups. We have calculated the cumulative incidence in each age group as the number of cases per population in that age group. Then, we have evaluated which percentage of total incidence correspond to each age group.

Table 1: *Percentage of monthly incidence that corresponds to each age group. September is divided in two fortnights, so that the possible effect of re-opening schools can be evaluated. Data from Catalunya[7]. Color scale is arbitrary (highest-red, lowest-green).*

CATALUNYA									
Month	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80+**
March	0,2%	0,4%	5,2%	6,8%	8,4%	12,2%	14,8%	20,2%	31,7%
April	0,1%	0,5%	5,5%	5,4%	6,4%	8,6%	7,5%	10,8%	55,0%
May	2,1%	2,7%	9,7%	8,8%	9,5%	11,1%	7,9%	9,3%	38,9%
June	3,7%	7,3%	14,6%	13,2%	12,9%	11,5%	8,6%	8,3%	19,8%
July	8,1%	9,2%	21,5%	16,4%	12,6%	10,3%	7,0%	5,5%	9,3%
August	9,0%	10,8%	20,6%	14,8%	11,5%	10,1%	7,7%	6,2%	9,2%
September (1-13)	8,8%	11,8%	18,1%	14,1%	12,1%	10,7%	8,2%	6,9%	9,3%
September (14-30)	12,0%	13,7%	15,0%	12,7%	11,3%	10,0%	7,9%	7,1%	10,3%

[7] https://dadescovid.cat/descarregues?lang=eng

Catalunya shows the typical pattern of the epidemic in Spain: the first months, most affected population was the older one, when almost only serious cases were diagnosed in hospitals. The early and long confinement of children is seen as a lack of cases in pediatric ages before Summer. During Summer months, the median was displaced to the range 20-29 years old. Focusing on September, we see a 2-3 points increase of relative incidence in youngest age groups. This increase is compatible with both the contact studies in bubble groups and the mass screening campaigns in schools. It is also worth to mention here that Catalan Government announced last Wednesday that, during first 2 weeks, 87 % of primary cases in schools did not produce a secondary case in their class, 7 % of index cases infected 1 contact in their class, 4 % infected 2 of them, 1 % infected 3 of them and 0.6 % infected more than 3.

Table 2: *Percentage of monthly incidence that corresponds to each age group. September is divided in two fortnights, so that the possible effect of re-opening schools can be evaluated. Data from Andalucía[8]. Color scale is arbitrary (highest-red, lowest-green).*

ANDALUCÍA						
Month	**0-14**	**15-29**	**30-44**	**45-64**	**65-84**	**85+**
March	0,2%	4,5%	10,3%	18,4%	23,0%	43,6%
April	0,1%	3,2%	6,1%	9,8%	14,2%	66,6%
May	2,3%	10,5%	10,8%	13,4%	14,2%	48,8%
June	7,7%	30,6%	19,7%	13,2%	8,3%	20,5%
July	11,4%	34,0%	24,7%	14,3%	6,7%	8,9%
August	9,2%	30,5%	22,2%	14,9%	9,5%	13,6%
September (1-13)	10,6%	19,6%	17,9%	15,5%	13,8%	22,6%
September (14-30)	12,2%	19,1%	16,2%	15,1%	13,3%	24,1%

Andalucía shows the same pattern as Catalunya. In this case, the increase in the 0-14 age group is around 1.5 points.

Table 3: *Percentage of monthly incidence that corresponds to each age group. September is divided in two fortnights, so that the possible effect of re-opening schools can be evaluated. Data from Castilla y León[9]. Color scale is arbitrary (highest-red, lowest-green).*

CASTILLA Y LEÓN									
Month	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80+**
April	5,1%	4,1%	8,0%	9,4%	10,7%	10,8%	9,1%	10,1%	32,8%
May	6,6%	5,9%	10,2%	11,9%	14,3%	15,8%	12,5%	8,9%	13,9%
June	8,0%	9,3%	12,2%	10,8%	11,7%	12,8%	12,7%	11,3%	11,2%
July	14,2%	12,5%	16,4%	11,1%	9,0%	9,2%	8,7%	9,8%	9,2%
August	12,1%	13,1%	17,7%	12,1%	10,2%	8,6%	7,6%	7,3%	11,3%
September (1-13)	12,7%	12,2%	15,6%	10,9%	11,1%	10,2%	8,7%	9,0%	9,7%
September (14-30)	22,8%	14,6%	12,4%	10,2%	9,3%	7,8%	7,7%	6,7%	8,5%

Castilla y León starts with a similar pattern, but last fortnight shows a significant increase in the 0-9 age group. This would reflect either a certain level of contagions inside the school, or an underdiagnosis of general population of other age groups. In fact, media inform that there have been detected several cases among children and staff of groups with a primary case (137 positive cases among 249 groups with a primary case). The question that remains open is if these positive cases are originated inside the schools or in the exterior.

8 https://www.juntadeandalucia.es/institutodeestadisticaycartografia/badea/operaciones/consulta/anual/41135?CodOper=b3_2314&codConsulta=41135

9 https://analisis.datosabiertos.jcyl.es/explore/dataset/situacion-enfermos-por-coronavirus-detectados-en-atencion-primaria-por-tramos-d0/table/?sort=fecha

Table 4: *Percentage of monthly incidence that corresponds to each age group. September is divided in two fortnights, so that the possible effect of re-opening schools can be evaluated. Data from Comunitat Valenciana[10]. Color scale is arbitrary (highest-red, lowest-green).*

COMUNITAT VALENCIANA									
Month	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80+**
April	0,5%	0,7%	5,4%	7,7%	8,7%	11,7%	13,7%	17,1%	34,5%
May	2,1%	3,3%	11,2%	13,6%	13,8%	15,3%	15,3%	12,8%	12,5%
June	2,8%	4,5%	9,0%	10,2%	11,6%	12,1%	11,7%	13,3%	24,9%
July	5,3%	9,7%	22,7%	12,2%	10,8%	10,6%	9,0%	9,4%	10,4%
August	7,9%	10,5%	24,6%	16,2%	10,6%	9,3%	7,2%	5,8%	7,9%
September (1-13)	9,0%	11,9%	19,5%	14,0%	10,5%	10,6%	8,2%	6,5%	9,8%
September (14-30)	8,5%	10,3%	15,2%	11,8%	10,0%	9,7%	20,5%	6,0%	7,8%

On the contrary, Comunitat Valenciana reports a decrease in relative incidence in 0-9 and 10-19 age groups after the re-opening of the schools. Nevertheless, this can be biased by a significant increase in the range 60-69 years old, that could be associated to a particular outbreak.

We can also see the deviation among expected mean incidence, assuming the incidence to be the same in all age groups. Next set of tables shows, for each age group, time period and Autonomous Community, the ratio between the incidence in each age group and the mean incidence of that time period in the region.

Table 5: *Ratio between the incidence in each age group and the mean incidence of that time period in the region, for each period. September is divided in two fortnights. Color scale is arbitrary (highest-red, lowest-green).*

CATALUNYA									
Month	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80+**
March	0,02	0,03	0,47	0,61	0,76	1,10	1,33	1,82	2,86
April	0,01	0,05	0,50	0,49	0,58	0,77	0,68	0,98	4,95
May	0,19	0,24	0,87	0,79	0,86	0,99	0,71	0,84	3,50
June	0,34	0,66	1,32	1,19	1,16	1,04	0,77	0,74	1,78
July	0,73	0,83	1,94	1,47	1,13	0,93	0,63	0,50	0,84
August	0,81	0,98	1,86	1,34	1,03	0,91	0,70	0,56	0,83
September (1-13)	0,79	1,06	1,63	1,27	1,09	0,96	0,74	0,62	0,84
September (14-30)	1,08	1,23	1,35	1,14	1,02	0,90	0,72	0,64	0,93

ANDALUSIA						
Month	**0-14**	**15-29**	**30-44**	**45-64**	**65-84**	**85+**
March	0,01	0,27	0,62	1,10	1,38	2,61
April	0,00	0,19	0,37	0,59	0,85	4,00
May	0,14	0,63	0,65	0,80	0,85	2,93
June	0,46	1,83	1,18	0,79	0,50	1,23
July	0,68	2,04	1,48	0,86	0,40	0,53
August	0,55	1,83	1,33	0,90	0,57	0,82
September (1-13)	0,63	1,18	1,07	0,93	0,83	1,36
September (14-30)	0,73	1,14	0,97	0,90	0,80	1,45

CyL									
Month	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80+**
April	0,46	0,37	0,72	0,84	0,97	0,97	0,82	0,91	2,95
May	0,60	0,53	0,92	1,07	1,28	1,43	1,12	0,80	1,26
June	0,72	0,84	1,10	0,97	1,05	1,15	1,15	1,02	1,01
July	1,27	1,12	1,47	1,00	0,81	0,82	0,78	0,89	0,83
August	1,09	1,18	1,59	1,09	0,92	0,78	0,68	0,66	1,02
September (1-13)	1,15	1,10	1,40	0,98	1,00	0,92	0,78	0,81	0,87
September (14-30)	2,05	1,32	1,12	0,91	0,84	0,70	0,69	0,60	0,77

Valencia									
Month	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80+**
April	0,05	0,06	0,48	0,69	0,78	1,06	1,23	1,54	3,10
May	0,19	0,30	1,01	1,23	1,25	1,38	1,38	1,15	1,13
June	0,25	0,41	0,81	0,91	1,04	1,08	1,06	1,20	2,24
July	0,48	0,87	2,05	1,09	0,97	0,95	0,81	0,84	0,93
August	0,71	0,94	2,21	1,46	0,96	0,83	0,65	0,52	0,71
September (1-13)	0,81	1,07	1,76	1,26	0,94	0,95	0,74	0,59	0,88
September (14-30)	0,76	0,93	1,37	1,07	0,90	0,88	1,85	0,54	0,70

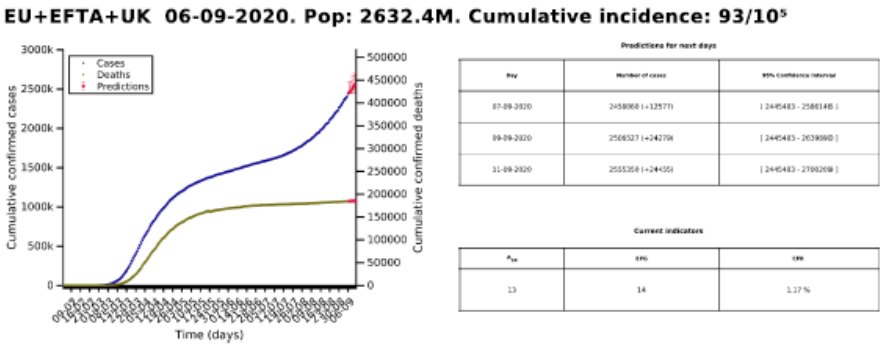
[10] https://dadesobertes.gva.es/va/dataset/dades-covid-19-percentatge-i-nombre-de-casos-per-rang-edat-i-sexe

These ratios show which age groups are above and below the mean incidence in each time period. In all cases, this ratio is high for the old people at the beginning of the epidemic, and moves towards range 20-29 range in Summer months. **School re-opening is followed by a slight increase in some of the youngest bins**, with a ratio of 1.2 in Catalunya (10-19) and 1.14 in Andalucía (15-29), as well as a significant increase in Castilla y León (ratio of 2 in 0-9 and 1.3 in 10-19).

To conclude, we must recall that the global incidence evolution suggests no significant effects of the re-opening of schools, and that, in most cases, there is either absence of increase in cases of pediatric ages or a slight increase that is compatible with current diagnostic effort in the schools. The particular case of Castilla y León remains open for future research.

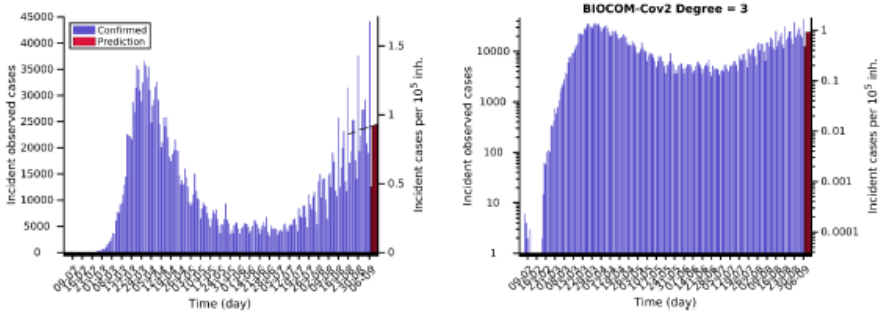
Legend: Countries' reports details

Reported cumulative cases (blue) and deaths (brown), together with predictions (red)



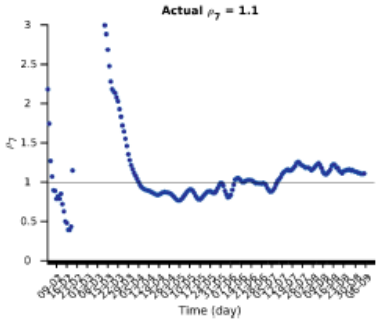
Predictions and indicators

Incident observed cases and predictions.

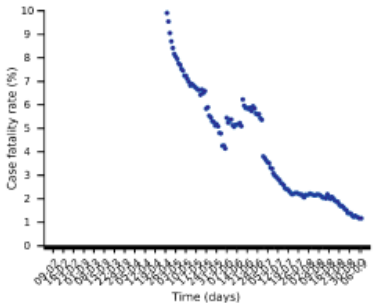


Incident observed cases in a logarithmic scale, with Biocom-Cov degree.

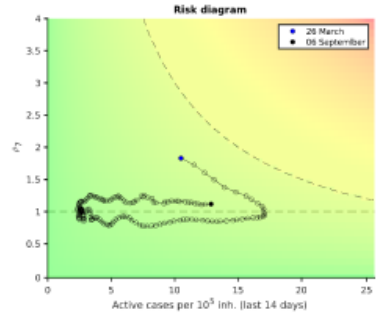
Evolution of empiric reproduction number ρ_7



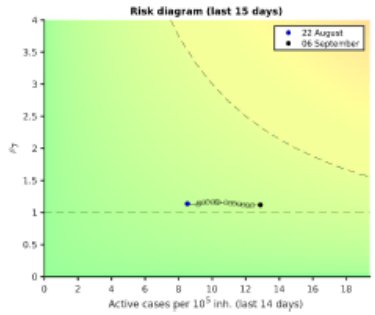
Case fatality rate



Risk diagram



Risk diagram of last 15 days



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

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

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

Methods

Methods

(1) Data source

Data are daily obtained from European Centre for Disease Prevention and Control (ECDC)[11] 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 cumulative deaths divided by the number of cumulative confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

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

where $N_{new}(t)$ is the number of new confirmed cases at day t. Then, we calculate a 7-day moving average (ρ_7) so that noise is reduced and trends become clearer.

(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
8	8-14
9	>14

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

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[12] 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.

(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.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors[13] 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

[12] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.
[13] 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

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.