Daily report 29-07-2020

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

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Situation report 108
Foreword
The present report aims to provide a comprehensive picture of the pandemic situation of COVID-19 in the EU countries, and to be able to foresee the situation in the next coming days.

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

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

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

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

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

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(0) Executive summary – Dashboard
**Situation and highlights**

The risk diagram has proven to be a very useful tool for rapidly visualizing and assessing the epidemiological status of a state or region. In the risk diagram we see very easily if the epidemic is spreading ($\rho_7 > 1$) or if it is in the process of control ($\rho_7 < 1$). We also see the intensity of the epidemic through the value of $A_{14}$. Finally, using the color scale we can easily see if the epidemiological state is at high (red) or low risk (green). In addition, we also observe the evolution of recent days, through which it is clear whether the epidemic is getting worse or better.

Looking at the risk diagrams of the EU+EFTA+UK countries, we see that the majority of countries are in the green zone. Spain is close to the red, but showing the first signs of improvement, as $\rho_7$ has been declining for a few days. Romania is in a similar situation but has yet to show any clear signs of improvement. Luxembourg is completely inside the red zone, but has managed to reduce the $\rho_7$ to 1. Therefore, it is to be expected that the improvement will be rapid, since a small country may get worse very quickly but it can also resolve faster the situation. The situation is much more complex when we look at the diagrams of other countries like USA, South Africa, Chile and Qatar, which are in the red zone with high values of $A_{14}$, and those like Brazil, Perú, Argentina and Israel, which are getting worse quickly. We have added UK again, using the correction detailed in the last report.

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1. [https://upcommons.upc.edu/handle/2117/327785](https://upcommons.upc.edu/handle/2117/327785)
Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. Last column (EPGEST) is assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). EPGREP is calculated with data reported by countries. EPGREP and EPGEST cannot be compared between them because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

**Disclaimer:** estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1% (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher)**

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10^5 inh.</th>
<th>Mortality /10^5 inh.</th>
<th>Active cases (last 14 days)</th>
<th>14-day attack rate /10^5 inh.</th>
<th>Estimated active cases (last 14 days)</th>
<th>Estimated 14-day attack rate /10^5 inh.</th>
<th>ρ_7</th>
<th>EPGREP</th>
<th>EPGEST</th>
<th>Biocom-Cov degree</th>
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<tr>
<td>United Kingdom</td>
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</table>

**Disclaimer:** estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1% (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher)

(1) ρ_7 is the average of 7 consecutive p, but can still fluctuate. (2,3) EPG stands for Effective Growth Potential. EPGREP is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPGEST is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. 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 local containment of outbreaks (II). The false sense of security in exteriors and the focus on voice level.

We have been reporting on the evolution of the outbreak of covid19 that started last month in the city of Lleida, 200 km west of Barcelona (Figure 1). Since then, Barcelona and its surrounding area has also observed a large outbreak (Figure 1) which has been growing with empirical reproductive number higher than 2 for two weeks, with community transmission. In both cases, the transmission is slowing down this week as a result of the control measures taken by the regional government. Nevertheless, the new outbreak has stressed the ability of primary care to deal with all cases. **We use this assessment to address one of the drivers of the outbreak in Catalonia, the false sense of security that large gatherings outdoors are riskless.**

There has been a consistent message that the interiors were dangerous in terms of contagiousness, implicitly stating that exteriors had less risk, with no mention of voice levels. **This could have been read by the population that outdoors activities are basically safe.** The fact is that, as a consequence, Spain has had multiple activities allowed outdoors. Terraces in bars and restaurants opened very early, like in Spain, much earlier than cinemas or other indoors activities. The consequences have been dramatic in Catalonia. A very significant number of clusters has been generated outdoors. As it has been explained by WHO, but maybe not sufficiently emphasized, the key driver of the outbreaks is the number of drops with infected quanta. **The higher the level of voice, the higher the chances of infection.** Indoors can help this driver of contagion if there is bad ventilation or lack of proper AC filters, but close gatherings outdoors can be, in principle, as dangerous as indoors. Catalonia is a perfect proof of this concept.

The origin of the confusion comes from the analysis done in Japan regarding outdoor vs indoor activity [https://www.medrxiv.org/content/10.1101/2020.02.28.20029272v2](https://www.medrxiv.org/content/10.1101/2020.02.28.20029272v2). In the report, the probability of having infection indoors was reported to be roughly 20 times higher than outdoors. This kind of numbers seem to suggest that outdoors is save. There is, however, a danger in generalization of different contact networks and structures. If the main driver of infections is the level of voice and droplets, the use of voice in outdoor settings can have very important effects on these numbers. To guarantee that the results in Japan can be generalized to Catalonia, for example, we should guarantee that the average voice level in Japan outdoors is the same that in Catalonia or, more generally, in Southern Europe. We have looked for bibliography regarding the typical voice level (in dB) outdoors in Spain vs Japan. There are multiple anthropological reports regarding the use of voice and the value of silence across different cultures (see for example [https://web.uri.edu/iaics/files/08-Robert-N.-St.-Clair.pdf](https://web.uri.edu/iaics/files/08-Robert-N.-St.-Clair.pdf)). The different value of silence has been clearly documented. Regarding dB measurement, Japan presents very high levels of noise reaching 100 dB due to
warning signs, music and intrusive audio sound. In this sense, sales people scream systematically in the streets with megaphones. Actually, Spain and Japan cities are systematically on the top of noisiest cities, year after year.

The key problem is that general noise is not relevant, but the use of voice in public gatherings. If we go out of the core of the cities, into the suburbs, compulsory levels of 45 dB are common in Japan (lower than in a typical library). Even kids playing generate higher levels of noise. This is unheard of in Spain. It is thus clear that the relation between noise and voice in Catalonia and Japan is very different. It is then not surprising to observe that the number of clusters in Catalonia outdoors have been pretty significant. We provide here a list of the most dangerous outdoors environments detected in Catalonia (and also Spain), all of them related with heavy emissions of droplets.

- Huge clusters in temporary workers living and working outdoors but sharing those outdoor spaces with a large community in Lleida. All of these are associated with the fruit pick-up season. It is difficult to know the ratio of those infected that lived in community areas indoors vs those living in the streets. All of them, however, did work outdoors. Infections in outdoor activity can be very important. The physical exercise is large, and distances between workers are not necessarily large.

- Clusters in parties at the beach. According to the news report:

  “Doctors from the Vilassar de Dalt (Maresme) ambulatory yesterday carried out PCR tests on a dozen young people with symptoms of fever and diarrhea after having participated a few days ago in a massive party on the Palomares beach in Vilassar de Mar... Case zero is a young man from Vilassar de Dalt who went to the Primary Care Center yesterday with symptoms of Covid-19. After the tests, it was positive, so Salut started all the tracking protocols... Subsequently, a dozen young people also showed symptoms of fever and diarrhea after having participated a few days ago in the party.”

- Clusters in family gatherings and meeting in terraces and outdoor activity. According to health authorities in Spain, 40% of the chain infections involving 3 or more people are related with family gatherings. Detailed figures regarding where those gathering happened are not available. News report indicate that outdoor terraces have been present, and that barbecue-like gatherings are main drivers. In Spain, these gatherings are mainly outdoors (parks, terraces...). This is very reminiscent of large clusters in family barbecues gatherings in the US. Given that we do not have data from Spain, we can use data from other similar clusters. More specifically, the next image shows the structure of a cluster related with barbecue-gathering in North Carolina (Figure 2). We cannot be sure that the barbecue was all outdoor. It can be partially outdoor, and partially indoor. But more importantly, some of the members infected others in a beach gathering.
In other words, this type of cluster has been typical of Catalonia\textsuperscript{7}. The number of infections produced outdoors is large. The gatherings outdoors reverberate into indoors clusters with close contacts at work.

- Cluster in so-called botellón parties. Botellón parties are outdoor gatherings in the street where, generally, young people join economic resources to buy and share bottles of alcohol. Buying full bottles are, as a matter of fact, way cheaper than any drink in bar or disco when the content of the bottle is split. The image of young people sharing the drinks is common in Spanish streets\textsuperscript{8}. Clusters in these types of gatherings have been reported in all major news outlets.

A very final note is warranted. During the last month, cinemas and theaters have been open. They had to follow the guidelines regarding masks and distance. Obviously the level of voice in the cinemas is very low, basically around 30 dB compared with a normal conversation of 60 dB (Figure 3). We must remember here that the decibel scale is not linear but logarithmic. From 30 to 60 dB the intensity of the sound does not double but is multiplied by 1000. It is thus no surprising that not a single case of a cluster in cinemas has been reported in Spain. Actually, we have not been able to identify any cluster in an indoor cinema anywhere in the world. On the other hand, clusters of gatherings in the beach or street parties are very common. In other words, there is no doubt now that an outdoor family gathering, not to mention a party in the beach, is, at least, a hundred times more dangerous and riskier than a movie-watch gathering in silence. \textbf{For all we know, given the zero number of clusters in cinemas, risk in indoors silence gatherings could be thousand or ten-thousand times higher.}\textsuperscript{9}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Sound (dB)} & \textbf{Sound noise (with distance)} \\
\hline 0 dB & Hearing threshold \hline 10 dB & Distant rustling of leaves \hline 20 dB & Whisper close up \hline 30 dB & Quiet rural area \hline 40 dB & Quiet library \hline 50 dB & Conversation at home \hline 60 dB & Conversation in a bar \hline 70 dB & Vacuum cleaner at 3 ft. (1m) \hline 80 dB & Close alarm clock \hline 90 dB & Operating a lawn mower \hline 100 dB & Speaker in a club 3 ft. (1m) away \hline 110 dB & Vehicle horn 3 ft. (1m) away \hline 120 dB & Chain saw close up (discomfort) \hline 130 dB & Jack hammer (pain threshold) \hline 140 dB & Jet engine (pain threshold) \hline 150+ dB & Eardrum rupture \hline
\hline
\end{tabular}
\caption{Typical dB scale and sources of that noise’s level (source: \url{https://www.quora.com/How-loud-is-65-decibels})}
\end{table}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{catawbacountync.gov.png}
\caption{Structure of a cluster related with a barbecue and a beach gathering in North Carolina (source: catawbacountync.gov).}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{structure.png}
\caption{This graphic shows how the virus spread over a 16 day period.}
\end{figure}

\textsuperscript{7} \url{https://www.lavanguardia.com/vida/20200626/481959375408/brote-coronavirus-vall-aran-barbacoa-amigos.html}

times lower than most outdoors activities with normal 60 dB-talk interactions. The same can be said about gathering where people sing. Large clusters in chorus gatherings have become famous.\(^9\)

According to [https://www.engineeringtoolbox.com/voice-level-d_938.html](https://www.engineeringtoolbox.com/voice-level-d_938.html), in social settings people often talk with normal voice levels at distances ranging 1 to 4 meters. In outdoor play and recreational areas people often communicate with raised or very loud voices. Next table shows an estimation of the voice level at different distances and contexts.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Social settings</th>
<th>Outdoor play and recreational areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Raised</td>
</tr>
<tr>
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<td>70</td>
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<td>66</td>
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<tr>
<td>1.8</td>
<td>54</td>
<td>60</td>
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</tbody>
</table>

It should be clear that we are not saying that indoor activities are not problematic. Close contact at work has been the focus of major clusters. Similarly, large indoor parties in disco-bars have also been the source of very large clusters of cases in Spain. There is no doubt that bad ventilation indoors can help infections. But the same type of large infections is possible outdoors if the same type of party-like behavior is present. **What we are saying is that the focus of health authorities should move from indoor vs outdoor messages into low versus high voice use. The core problem is not indoor gathering. The core problem is high dB voice use because of loud conversation.**

\(^9\) [https://www.cdc.gov/mmwr/volumes/69/wr/mm6919e6.htm](https://www.cdc.gov/mmwr/volumes/69/wr/mm6919e6.htm)
### Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. $\text{EPG}_{\text{REP}}$ and $\text{EPG}_{\text{EST}}$ cannot be compared between them because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

<table>
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<tr>
<th>Country</th>
<th>Reported data</th>
<th>Indexes</th>
</tr>
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<td>Attack rate /10^5 inh.</td>
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</table>

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1% (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

---

1. $\rho_T$ is the average of 7 consecutive $\rho$, but can still fluctuate. 2. $\rho_T$ stands for Effective Growth Potential. $\text{EPG}_{\text{REP}}$ is the product of attack-rate of last 14 days per 10^5 inhabitants by $\rho_T$ (empiric reproduction number). $\text{EPG}_{\text{EST}}$ is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and $\rho_T$. 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/2117/189661), [https://upcommons.upc.edu/handle/2117/189808](https://upcommons.upc.edu/handle/2117/189808)).
Time indicators by country

These tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of 1/10^5 inhabitants and an attack rate of 10/10^5 inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold). **Data from 2nd July.**

**EU+EFTA+UK countries**

<table>
<thead>
<tr>
<th>Countries</th>
<th>Days since the first 100 cases</th>
<th>Time interval between 1 and 10 cases / 10^5 inh. (days)</th>
<th>Time interval between 10 and 100 cases / 10^5 inh. (days)</th>
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<td>Countries</td>
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<td>Time interval between 10 and 100 cases / $10^3$ inh. (days)</td>
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**Situation and trends in Italian and Spanish regions**

**Italy**

Data from **29th July**

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate (last 14 days)</th>
<th>Mortality (last 14 days)</th>
<th>Active cases (last 14 days)</th>
<th>24-day attack rate (last 14 days)</th>
<th>Estimated active cases (29th July)</th>
<th>Estimated 14-day attack rate (last 14 days)</th>
<th>Biocom-Cov degree</th>
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<td>Sicilia</td>
<td>3,319</td>
<td>465.0</td>
<td>855</td>
<td>8.2</td>
<td>2.0</td>
<td>372</td>
<td>10.3</td>
<td>2.10</td>
</tr>
<tr>
<td>Calabria</td>
<td>1,255</td>
<td>573.5</td>
<td>97</td>
<td>5.0</td>
<td>1.9</td>
<td>NA</td>
<td>NA</td>
<td>0.70</td>
</tr>
<tr>
<td>Valle d'Aosta</td>
<td>1,208</td>
<td>391.7</td>
<td>116</td>
<td>11.9</td>
<td>11.9</td>
<td>NA</td>
<td>NA</td>
<td>1.49</td>
</tr>
<tr>
<td>Molise</td>
<td>420</td>
<td>223.2</td>
<td>22</td>
<td>7.5</td>
<td>2.6</td>
<td>NA</td>
<td>NA</td>
<td>8.20</td>
</tr>
<tr>
<td>Basilicata</td>
<td>483</td>
<td>79.9</td>
<td>20</td>
<td>5.0</td>
<td>2.6</td>
<td>NA</td>
<td>NA</td>
<td>1.48</td>
</tr>
</tbody>
</table>

**Spain**

Data not updated

**Disclaimer:** estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1% (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

(1) $\rho_7$ is the average of 7 consecutive $\rho$, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG<sub>REP</sub> is the product of attack-rate of last 14 days per 10<sup>5</sup> inhabitants by $\rho_7$ (empiric reproduction number). EPG<sub>EST</sub> is the product of estimated real attack-rate of last 14 days per 10<sup>5</sup> inhabitants and $\rho$. 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/2117/189661), [https://upcommons.upc.edu/handle/2117/189808](https://upcommons.upc.edu/handle/2117/189808)).

**Long-term predictions** are not shown any more, since all Italian and Spanish regions are already in the tail (see Analysis section in Report #87, [https://upcommons.upc.edu/handle/2117/190497](https://upcommons.upc.edu/handle/2117/190497)).
Legend: Countries’ reports details

- Reported cumulative cases (blue) and deaths (brown), together with predictions (red)
- Estimated and reported cases.
- Incident observed cases and predictions.
- Evolution of empiric reproductive number $\rho$
- Case fatality rate
- Risk diagram
- Risk diagram of last 15 days
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

EU+EFTA+UK  25-07-2020. Pop: 2564.4M. Cumulative incidence: 52/10^5
Spain 27-07-2020. Pop: 47.0M. Cumulative incidence: 597/10^5

[Graphs showing cumulative cases and deaths, confirming cases, deaths, and predictions over time.]

Actual $\rho_2 = 1.7$

[Graph showing the actual $\rho_2$ over time.]

Risk diagram

[Risk diagram showing active cases per 10^5 inh. (last 14 days) with confidence intervals for July 27 and March 12.

Risk diagram (last 15 days)

[Risk diagram (last 15 days) with active cases per 10^5 inh. (last 14 days) showing confidence intervals for July 27 and July 12.]
Italy 28-07-2020. Pop: 60.5M. Cumulative incidence: 408/10^5

Cumulative confirmed cases vs Time (days)

Cumulative confirmed deaths vs Time (days)

Number of cases vs Time (day)

Cases per 10^6 inhabitants vs Time (day)

Incident observed cases vs Time (day)

Incident cases per 10^5 inh. vs Time (day)

Incident observed cases per 10^5 inh. vs Time (day)

Actual $p_β = 1.5$

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)

- Cases
- Deaths
- Predictions

- Confirmed cases
- Estimated cases

Actual $p_f = 0.8$

Risk diagram

Risk diagram (last 15 days)
Belgium 28-07-2020. Pop: 11.6M. Cumulative incidence: 574/10^5

**Cumulative confirmed cases vs Time (days)**

**Cumulative confirmed deaths vs Time (days)**

**Number of cases vs Time (day)**

**Cases per 10^5 inhabitants vs Time (day)**

**Incident observed cases vs Time (day)**

**Incident cases per 10^3 inh. vs Time (day)**

**Incident observed cases per 10^5 inh. vs Time (day)**

**Actual p_f = 1.4**

**Case rate (p_f rate) vs Time (day)**

**Risk diagram**

**Risk diagram (last 15 days)**

Cumulative confirmed cases vs Time (days)

Number of cases vs Time (day)

Cumulative confirmed deaths vs Time (days)

Cases per 10^5 inhabitants vs Time (day)

Incident observed cases vs Time (day)

Incident cases per 10^5 inh. vs Time (day)

BIOCOM-Cov2 Degree = 5

Actual $p_2 = 1.0$

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)

[Graphs showing cumulative confirmed cases, cumulative confirmed deaths, number of cases, incident observed cases, incident cases per 10^5 inh., and case fatality rate.]

- Cases
- Deaths
- Predictions

Cumulative confirmed cases

Time (days)

Cumulative confirmed deaths

Number of cases

Time (day)

Cases per 10^5 inhabitants

BIOCOM-Cov2 Degree = 4

Incident observed cases

Incident cases per 10^5 inh.

Incident observed cases per 10^5 inh.

Actual γ = 1.3

Time (day)

Case fatality rate (%)

Risk diagram

Active cases per 10^5 inh. (last 14 days)

Risk diagram (last 15 days)

Active cases per 10^5 inh. (last 14 days)

July 28

March 16

July 28

July 13
Finland 28-07-2020. Pop: 5.5M. Cumulative incidence: 134/10^5
Luxembourg 28-07-2020. Pop: 0.6M. Cumulative incidence: 1018/10^5

BIOCOM-Cov2 Degree = 9

Actual \( p_2 = 1.0 \)

Risk diagram

**Cumulative confirmed cases**

- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

- Confirmed cases
- Estimated cases

**Number of cases**

- Cases per 10^5 inhabitants

**Incident observed cases**

- Confirmed
- Predicted

**BIOCOM-Cov2 Degree = 3**

**Actual \(\rho_f = 1.1\)**

**Case Fatality rate (%)**

**Risk diagram**

- July 28
- March 15

**Risk diagram (last 15 days)**

- July 28
- July 13
Iceland 28-07-2020. Pop: 0.3M. Cumulative incidence: 544/10^5

Not enough data

BIOCOM-Cov2 Degree = 3

Actual ργ = 4.0

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Predictions

- Number of cases
- Confirmed cases
- Estimated cases

- Incidence observed cases
- Incident cases per 10^5

- Actual $\rho_2 = 1.7$

- Case fatality rate (%)

- Risk diagram
- Risk diagram (last 15 days)
Cyprus 28-07-2020. Pop: 1.2M. Cumulative incidence: 88/10^5
Malta 28-07-2020. Pop: 0.4M. Cumulative incidence: 160/10^5
(2) Analysis and prediction of COVID-19 for other countries

USA 28-07-2020. Pop: 331.0M. Cumulative incidence: 1315/10^5
Brazil 28-07-2020. Pop: 212.6M. Cumulative incidence: 1168/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^6 inh.

Actual $\gamma = 1.4$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
India 28-07-2020. Pop: 1380.0M. Cumulative incidence: 111/10^5

Incident observed cases.

BIOCOM-Cov2 Degree = 6

Risk diagram

Risk diagram (last 15 days)

Incident observed cases per 10^3 inh.

Incident observed cases per 10^3 inh.

Actual ργ = 1.0

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
South Africa 28-07-2020. Pop: 59.3M. Cumulative incidence: 775/10^5

Cumulative confirmed cases:
- Cases
- Deaths
- Predictions

Cumulative confirmed deaths:
- Cases
- Estimated cases

Number of cases:
- Confirmed cases
- Estimated cases

Cases per 10^5 inhabitants:

Incident observed cases:
- Confirmed
- Prediction

Incident cases per 10^5 inh.

Actual $p_\gamma = 1.0$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases vs. time (days)
- Cumulative confirmed deaths vs. time (days)
- Number of cases vs. time (day)
- Cases per 10^2 inhabitants per day
- Incident observed cases vs. time (day)
- Incident cases per 10^3 inh.
- Incident observed cases per 10^2 inh.

Actual ρ = 1.0

Risk diagram

Risk diagram (last 15 days)
Peru 28-07-2020. Pop: 33.0M. Cumulative incidence: 1198/10^5
Chile 28-07-2020. Pop: 19.1M. Cumulative incidence: 1830/10^5

**Cumulative confirmed cases**
- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

**Number of cases**
- Confirmed cases
- Estimated cases

**Cases per 10^7 inhabitants**

**BIOCOM-Cov2 Degree = 8**

**Incident observed cases**

**Incident cases per 10^5 inh.**

**Actual f_2 = 1.0**

**Case Fatality rate (%)**

**Risk diagram**

**Risk diagram (last 15 days)**
Iran 28-07-2020. Pop: 84.0M. Cumulative incidence: 353/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^3 inh.

Incident observed cases per 10^3 inh.

Actual $\rho_f = 1.0$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

Actual $\rho_f = 0.8$

Case fatality rate (%)
Saudi Arabia 28-07-2020. Pop: 34.8M. Cumulative incidence: 778/10^5

BIOCOM-Cov2 Degree = 7

Actual ρ₁ = 0.9

Case Fatality Rate (%)
Canada 28-07-2020. Pop: 37.7M. Cumulative incidence: 305/10^5

Incident observed cases

Actual $p_f = 1.1$

Risk diagram
Qatar 28-07-2020. Pop: 2.9M. Cumulative incidence: 3814/10^5

Actual $\rho_2 = 0.9$

BIOCOM-Cov2 Degree = 8

Risk diagram

Risk diagram (last 15 days)
Israel 28-07-2020. Pop: 8.7M. Cumulative incidence: 769/10^5

![Graphs showing cumulative confirmed cases, deaths, and predictions.]

**BIOCOP-Cov2 Degree = 9**

![Graphs showing incident observed cases and incident cases per 10^5 inh.]

**Actual $R_T = 1.1$**

![Graphs showing time series of actual $R_T$ values and case fatality rate.]

**Risk diagram**

![Risk diagram showing active cases per 10^5 inh. for different dates.]

**Risk diagram (last 15 days)**

![Risk diagram showing active cases per 10^5 inh. for the last 15 days.]

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Australia 28-07-2020. Pop: 25.5M. Cumulative incidence: 60/10^5

- Cumulative confirmed cases vs. Time (days)
- Cumulative confirmed deaths vs. Time (days)
- Incident observed cases vs. Time (day)
- Incident cases per 10^5 inh. vs. Time (day)
- Confirmed vs. Predicted cases vs. Time (day)
- BIOCGM-Cov2 Degree = 4
- Actual ρ₂ = 1.2
- Case fatality rate (%) vs. Time (day)
- Risk diagram
- Risk diagram (last 15 days)
(3) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale
Italy  29-07-2020. Pop: 60.5M. Cumulative incidence: 408/10^5

[Series of graphs and charts showing data over time, including cumulative cases, confirmed cases, incident observed cases, and risk diagrams for specific dates.]

Actual $R_t = 1.1$

BIOCOM-Cov2 Degree = 2

Risk diagram

Risk diagram (last 15 days)

Actual $p_f = 1.1$

Risk diagram

Risk diagram (last 15 days)

[Graphs showing cumulative confirmed cases and deaths, number of cases, and case fatality rate over time.]

Actual $p_1 = 1.1$

Risk diagram

BIOCOM-Cov2 Degree = 3

Incident observed cases per 10^6 inh.

Incident observed cases per 10^7 inh.
Toscana 29-07-2020. Pop: 3.7M. Cumulative incidence: 280/10^5

- Cumulative confirmed cases and deaths over time.
- Cumulative confirmed deaths.
- Number of cases over time.
- Cases per 10^5 inhabitants.

Incident observed cases over time.

BIOM-Cov2 Degree = 2

Actual $p_7 = 1.3$

Case fatality rate (%) over time.

Risk diagram

Risk diagram (last 15 days)
Marche 29-07-2020. Pop: 1.5M. Cumulative incidence: 450/10^5
Campania 29-07-2020. Pop: 5.8M. Cumulative incidence: 86/10^5
Trento 29-07-2020. Pop: 0.5M. Cumulative incidence: 924/10^5

Cumulative confirmed cases vs time (days)

Cumulative confirmed deaths vs time (days)

Number of cases vs time (day)

Cases per 10^5 inhabitants vs time (day)

Incident observed cases vs time (day)

Incident cases per 10^5 inh. vs time (day)

BIOCOM-Cov2 Degree = 4

Actual \( \rho_2 = 6.3 \)

Case fatality rate (%) vs time (day)

Risk diagram

Risk diagram (last 15 days)
Puglia 29-07-2020. Pop: 4.0M. Cumulative incidence: 114/10^5

**Cumulative confirmed cases vs Time (days)**

**Cumulative confirmed deaths vs Time (days)**

**Number of cases vs Time (day)**

**Cumulative confirmed deaths vs Cases per 10^7 inhabitants**

**Incident observed cases vs Incident cases per 10^5 inh.**

**Actual \( \rho_g = 0.9 \)**

**Incident observed cases vs Time (day)**

**Incident observed cases vs Incidents cases per 10^5 inh.**

**Risk diagram**

**Risk diagram (last 15 days)**
Abruzzo 29-07-2020. Pop: 1.3M. Cumulative incidence: 257/10^5

[Graphs showing cumulative confirmed cases, cumulative confirmed deaths, incident observed cases, incident cases per 10^5 inh., case fatality rate, and risk diagrams for different dates.]
Sicilia 29-07-2020. Pop: 5.0M. Cumulative incidence: 65/10^5

**Incident observed cases**

Actual $p_2 = 2.7$

**Risk diagram**

July 29
March 22

**Risk diagram (last 15 days)**

July 29
July 14
Bolzano 29-07-2020. Pop: 0.5M. Cumulative incidence: 517/10^5

Actual $p_2 = 3.2$

Risk diagram

Risk diagram (last 15 days)
Umbria 29-07-2020. Pop: 0.9M. Cumulative incidence: 166/10^5

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Number of deaths
- Cases per 10^5 inhabitants

BIOCOC-Cov2 Degree = 1

Actual $\rho_7 = 0.8$

Risk diagram

Risk diagram (last 15 days)
Calabria 29-07-2020. Pop: 1.9M. Cumulative incidence: 64/10^5
Valle d’Aosta  29-07-2020. Pop: 0.1M. Cumulative incidence: 959/10^5

Cumulative confirmed cases vs. Time (days)

Cumulative confirmed deaths vs. Time (days)

Number of cases vs. Time (day)

Cases per 10^5 inhabitants vs. Time (day)

Incident observed cases vs. Time (day)

Confirmed vs. Predicted vs. Incident observed cases vs. Time (day)

Actual ρ_Y = NA

Case fatality rate (%) vs. Time (day)

Risk diagram

Risk diagram (last 15 days)
Basilicata 29-07-2020. Pop: 0.6M. Cumulative incidence: 80/10^5

[Charts and graphs showing cumulative cases and incidence observed cases over time, with risk diagrams indicating active cases per 10^3 inh. (last 14 days).]
Methods
Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports\(^{10}\), from European Centre for Disease Prevention and Control (ECDC)\(^{11}\) and from Ministerio de Sanidad\(^{12}\). These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

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

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

Then, two indicators are calculated and plotted, too:

- Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- \( \rho(t - 1) = \frac{N_{\text{new}}(t) + N_{\text{new}}(t - 1) + N_{\text{new}}(t - 2)}{N_{\text{new}}(t - 5) + N_{\text{new}}(t - 6) + N_{\text{new}}(t - 7)} \)

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

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

The evolution of confirmed cases shows a biphasic behaviour:

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

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

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

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\(^{10}\) https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports


(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model\textsuperscript{13} correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

\[ N(t) = K e^{-\ln\left(\frac{K}{K_0}\right) e^{-a(t-t_0)}} \]

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

\( a \) is the velocity at which specific spreading rate is slowing down;

\( K \) is the expected final number of cumulated cases at the end of the epidemic.

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

\( a \) Evolution of fitted \( a \) with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;

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

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

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

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

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

\textsuperscript{13} Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.
- Group A: prediction of expected cumulated cases for the following 3-5 days\textsuperscript{14};
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

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

\textbf{(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\textsuperscript{15} 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.

\textsuperscript{14} At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.