Daily report 20-07-2020

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

Situation report 104 Contact: clara.prats@upc.edu
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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Disclaimer: These reports have been written by declared authors, who fully assume their content. They are submitted daily to the European Commission, but this body does not necessarily share their analyses, discussions and conclusions.
(0) Executive summary – Dashboard
Situation and highlights

Europe continues to show a situation where most countries have a $\rho_7$ above 1. In particular, Spain and Denmark show values around 2. Living with the presence of the virus requires adjusting control measures to maintain a sustainable situation. It would be desirable to reduce the number of daily new cases to be at least in the situation of countries such as the Netherlands or Switzerland, which corresponds to reducing social contacts to reach a Biocom-Cov degree of 2. The value of $A_{14}$ is quite high in a few countries, as well: Sweden (423 per $10^5$ inh.), Luxembourg (359), Romania (261), Belgium (241), Spain (228) and France (206). If these values decrease, these countries will make it possible to control each of the cases and their contacts (test and trace strategy).

The diagnostic effort in most European countries is currently higher than the one they had a few months ago. This means that the data on the number of daily new cases are not comparable with previous ones. We discuss this issue in the Analysis, and propose a simple method to allow comparison of new cases between different stages in the epidemic.
### Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. 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. Data from 2nd July.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10^5 inh.</th>
<th>Cumulative deaths</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>p_7 (1)</th>
<th>EPGREP (2)</th>
<th>EPGEST (3)</th>
<th>Biocom-Cov degree</th>
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**Scale**

![Scale Image](https://upcommons.upcommons.edu/handle/2117/189661, https://upcommons.upcommons.edu/handle/2117/189808)

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**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).
Analysis: Index for the comparison among number of cases with different diagnosis rates in the same country at different times.

From the beginning of the pandemic in March, the percentage of diagnosed cases has been, in general, continuously increasing in all the countries in the European Union. We have already studied such an increase in the reports #40 and #95. Next, we show a table where we show the evolution of the calculated diagnosis rate for different countries in the European Union. This table is the extension of the previous table shown in report #95, where we have also included Spain because it has finished with the checking of the number of deaths. Note that we estimate the total number from the number of deaths and therefore we need both quantities, number of cases and number of deaths.

Table 1. Percentage of diagnosed cases from March to June (diagnostic rate, DR), monthly variation of these values and overall variation for EU+EFTA+UK countries

<table>
<thead>
<tr>
<th>Country</th>
<th>March DR</th>
<th>April DR</th>
<th>March-April trend</th>
<th>May DR</th>
<th>April-May trend</th>
<th>June DR</th>
<th>May-June trend</th>
<th>Overall trend (March-June)</th>
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<td>11%</td>
<td>16%</td>
<td>-12%</td>
<td>21%</td>
<td>5%</td>
<td>4%</td>
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<td>9%</td>
<td>4%</td>
<td>13%</td>
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<td>13%</td>
<td>2%</td>
<td>18%</td>
<td>5%</td>
<td>15%</td>
<td>-4%</td>
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<td>28%</td>
<td>12%</td>
<td>36%</td>
<td>8%</td>
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<td>7%</td>
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<td>13%</td>
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<td>-7%</td>
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<tr>
<td>Greece</td>
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<td>18%</td>
<td>7%</td>
<td>15%</td>
<td>-3%</td>
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<td>18%</td>
<td>4%</td>
<td>6%</td>
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<td>3%</td>
<td>10%</td>
<td>6%</td>
<td>10%</td>
<td>0%</td>
<td>9%</td>
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<tr>
<td>EU+EFTA+UK</td>
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<td>8%</td>
<td>4%</td>
<td>11%</td>
<td>3%</td>
<td>14%</td>
<td>3%</td>
<td>10%</td>
</tr>
</tbody>
</table>

The main reason for this trend has been the generalized increase in the number of tests performed. In the following two figures we can observe this issue. In Figure 1 we see the cumulative number of tests and cases per 100,000 inhabitants, and the ratio between these two variables for Austria, Belgium, Italy, Spain, Switzerland and the UK. It should be noted that the y-axis of the graph is logarithmic, and the differences in the final values are not easily ascertained (cumulative cases per 10⁴ inhabitants: Austria 200, Belgium 540, Italy 400, Spain 530, UK 470). It is observed that, initially, the quotient between cases and test increases, and then, the rapid increase in the number of tests causes a progressive decrease in this ratio.

1 [https://upcommons.upc.edu/handle/2117/184991](https://upcommons.upc.edu/handle/2117/184991), [https://upcommons.upc.edu/handle/2117/191998](https://upcommons.upc.edu/handle/2117/191998)
These dynamics can be better visualized when we represent the daily testing level (DTL, tests performed daily per 100,000 inh.) and daily new cases per 100,000 hab. (Figure 2). Initially, the number of tests increased throughout the epidemic, but at a later stage we see how the DTL in some countries decreased or fluctuated. From the moment the tests were massively used (DTL of 100-150 between the different European countries), it is observed that the percentage of positive tests falls. In fact, at the beginning of the epidemic the number of cases detected depended largely on the tests performed and the percentage of positives was very high. The World Health Organization (WHO) has set a risk threshold based on the percentage of positives among performed tests, which WHO suggests that should be below 5% for two weeks before reopening.
Higher positive rates would indicate that testing effort is not enough and that a significant number of cases is being missed.

There is an important issue to keep in mind when assessing the percentage of positive tests: **not all the tests are used to test new patients.** In fact, a certain fraction of tests is used for checking the evolution of patients, in particular the negativization of the PCR. Therefore, the percentage of positive tests cannot be directly evaluated from the quotient between cases and tests. Italian government has published data that illustrates that between 50 and 60% of the tests are used to test new patient, while remaining tests are devoted to the follow-up of patients. This is shown in Figure 3.

---

2 https://apps.who.int/iris/rest/bitstreams/1277773/retrieve
Figure 3. Number of daily performed tests (blue) and number of new cases tested every day (red). Black line shows the quotient between both magnitudes.

The increase in number of tests is essential to improve the picture of the situation and the control of the epidemics. Nevertheless, an increase in the diagnosis rate prevents current number of cases to be compared with those of previous stages of this epidemic. For instance, the 1,361 new cases that were registered in Spain on July 17 are not comparable to the 1,266 that were detected on March 14 in the same country. Next, we propose a new magnitude that pursues the validity of comparing of new cases along the epidemic: it consists of re-scaling the number of new cases \( N_{\text{new}} \) with the percentage of positive tests divided by WHO recommendation (5 %). Ideally, we should directly use the percentage of positives among tests performed to new patients. Nevertheless, while these data are not specifically reported by countries, the quotient between new cases and performed tests can be used instead.

\[
N_{\text{new, re-scaled}}(t) = N_{\text{new}}(t) \cdot \left( \frac{\text{new cases}}{\text{performed tests}} \right)_{\text{country}, t} \cdot \left( \frac{\text{new cases}}{\text{performed tests}} \right)_{\text{reference}}
\]

Then, the re-scaled magnitude would permit the comparison of the situation at different stages of the epidemic. In other words, 10 new re-scaled cases now would be equivalent to 10 new re-scaled cases on March (Figure 4).
This new variable allows us the drawing of a risk diagram that provides a more reliable history of the epidemic in a country, since it facilitates the numerical comparison between different stages in the epidemic. Figure 5 presents the comparison of both risk diagrams for Italy. In the left, the standard risk diagram that is plotted using reported data. In the right, a risk diagram which is plotted using re-scaled new cases instead of reported. The colour code in the new risk diagram is still to be defined, since its meaning (possibility of tracing contacts with current DTL) is not directly exportable to the new one and requires further analysis.

In conclusion, the diagnosis rate has been continuously increasing during the last month. This is because the number of tests has increased during the pandemic while the number of cases has strongly decreased. These new tests actually refer not only to new cases but also because of the evolution of the patients as we have from the Italian case. We can finally define a rescaled number of cases, taking into account the number of tests. Such index permits to compare the situation corresponding to the new cases detected now in comparison with the cases detected some months ago.
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. EPG_{REP} and EPG_{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. Data from 2nd July.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10^5 inh.</th>
<th>Cumulative deaths</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>14-day attack rate /10^5 inh.</th>
<th>EPG_{REP}</th>
<th>EPG_{EST}</th>
<th>( \rho_7 )</th>
<th>Biocom-Cov degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States America</td>
<td>3,711,464</td>
<td>1,121.3</td>
<td>140,119</td>
<td>42.3</td>
<td>871,922</td>
<td>263.4</td>
<td>3,761,761</td>
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<td>293</td>
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<td>0</td>
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<td>2,054,862</td>
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<tr>
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<tr>
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<td>50,420</td>
<td>152.9</td>
<td>209,532</td>
<td>635.5</td>
<td>1.09</td>
<td>166</td>
<td>691</td>
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<td>102.9</td>
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<td>1.03</td>
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<td>Best</td>
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<td>0.0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</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).

\(^{(1)}\) \(\rho_7\) is the average of 7 consecutive \(\rho\), but can still fluctuate. \(^{(2,3)}\) EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by \(\rho_7\) (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and \(\rho_7\). 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).
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>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>147</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Germany</td>
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</tr>
<tr>
<td>France</td>
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<td>Spain</td>
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<td>12</td>
</tr>
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<td>Belgium</td>
<td>137</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>United Kingdom</td>
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</tr>
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</tr>
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<td>Norway</td>
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</tr>
<tr>
<td>Switzerland</td>
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<td>11</td>
</tr>
<tr>
<td>Austria</td>
<td>133</td>
<td>10</td>
<td>14</td>
</tr>
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<td>Denmark</td>
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<td>30</td>
</tr>
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<td>Czech Republic</td>
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<td>94</td>
</tr>
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<td>15</td>
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<td>NA</td>
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<td>30</td>
</tr>
<tr>
<td>Ireland</td>
<td>127</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Poland</td>
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<td>17</td>
<td>101</td>
</tr>
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<td>Romania</td>
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<td>15</td>
<td>66</td>
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<td>NA</td>
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<td>Bulgaria</td>
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</tr>
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<td>12</td>
<td>NA</td>
</tr>
<tr>
<td>Hungary</td>
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<td>20</td>
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<tr>
<td>Latvia</td>
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<td>12</td>
<td>NA</td>
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<tr>
<td>Lithuania</td>
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<td>NA</td>
</tr>
<tr>
<td>Malta</td>
<td>119</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>Cyprus</td>
<td>118</td>
<td>12</td>
<td>NA</td>
</tr>
</tbody>
</table>
## Other 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>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
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<td>11</td>
<td>42</td>
</tr>
<tr>
<td>United States of America</td>
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<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Canada</td>
<td>130</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Qatar</td>
<td>130</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>Brazil</td>
<td>127</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>126</td>
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<td>29</td>
</tr>
<tr>
<td>Chile</td>
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<td>Pakistan</td>
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<tr>
<td>India</td>
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<td>38</td>
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<td>Russia</td>
<td>124</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Peru</td>
<td>124</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>Ecuador</td>
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</tr>
<tr>
<td>Mexico</td>
<td>123</td>
<td>25</td>
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<tr>
<td>Argentina</td>
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<td>39</td>
<td>54</td>
</tr>
<tr>
<td>Belarus</td>
<td>111</td>
<td>10</td>
<td>18</td>
</tr>
</tbody>
</table>
**Long-term predictions**

Evaluated with the **whole historical series**. Up-left: Predictions of maximum incidences per country **at the end of the first wave** (total final expected attack rate per $10^5$ inh.). Up-right: Predictions of maximum absolute number of cases per country at the end of the first wave ($K$, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90% of $K$ was achieved / will be achieved. Blue dotted line indicates current date.

Final expected value for EU+EFTA+UK as a whole is not shown any more, since we are in the tail (see Analysis section in Report #87, [https://upcommons.upc.edu/handle/2117/190497](https://upcommons.upc.edu/handle/2117/190497)).
Situation and trends in Italian and Spanish regions

Italy
Data from 20th July

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /100k inh.</th>
<th>Cumulative deaths</th>
<th>Mortality /100k</th>
<th>Active cases (last 14 days)</th>
<th>14-day attack rate /100k</th>
<th>Estimated active cases (last 14 days)</th>
<th>Estimated 14-day attack rate /100k</th>
<th>EPGREP(1)</th>
<th>EPGREST(1)</th>
<th>Biocom-Cov degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lombardia</td>
<td>105,144</td>
<td>45.5</td>
<td>16,796</td>
<td>167.3</td>
<td>1,026</td>
<td>19.2</td>
<td>18,314</td>
<td>182.0</td>
<td>0.77</td>
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<td>145</td>
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<tr>
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<td>8,410</td>
<td>56.9</td>
<td>545</td>
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<td>4,032</td>
<td>380.1</td>
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<td>545</td>
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<tr>
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<td>41.8</td>
<td>322</td>
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<td>2.88</td>
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<td>683.3</td>
<td>815</td>
<td>72.1</td>
<td>545</td>
<td>12.2</td>
<td>3,170</td>
<td>68.7</td>
<td>2.54</td>
<td>17</td>
<td>174</td>
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<tr>
<td>Puglia</td>
<td>4,055</td>
<td>113.3</td>
<td>548</td>
<td>19.6</td>
<td>25</td>
<td>5.5</td>
<td>290</td>
<td>19.5</td>
<td>1.03</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Basilicata</td>
<td>4,055</td>
<td>845.1</td>
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<td>77.5</td>
<td>77</td>
<td>17.2</td>
<td>375</td>
<td>40.0</td>
<td>2.19</td>
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<tr>
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<td>446.5</td>
<td>987</td>
<td>64.7</td>
<td>25</td>
<td>5.5</td>
<td>290</td>
<td>19.5</td>
<td>1.03</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Trentino</td>
<td>5,555</td>
<td>835.3</td>
<td>815</td>
<td>72.1</td>
<td>545</td>
<td>12.2</td>
<td>3,170</td>
<td>68.7</td>
<td>2.54</td>
<td>17</td>
<td>174</td>
</tr>
</tbody>
</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) \( p_t \) is the average of 7 consecutive \( p_t \), but can still fluctuate. (2,3) EPG stands for Effective Growth Potential. EPGREP is the product of attack-rate of last 14 days per 105 inhabitants by \( p_7 \) (empiric reproduction number). EPGREST is the product of estimated real attack-rate of last 14 days per 105 inhabitants and \( p_7 \). 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).

Spain
Data from 10th July. Symptoms onset date.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /100k inh.</th>
<th>Cumulative deaths</th>
<th>Mortality /100k</th>
<th>Active cases (last 14 days)</th>
<th>14-day attack rate /100k</th>
<th>Estimated active cases (last 14 days)</th>
<th>Estimated 14-day attack rate /100k</th>
<th>p7(1)</th>
<th>EPGREP(1)</th>
<th>EPGREST(1)</th>
<th>Biocom-Cov degree</th>
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</thead>
<tbody>
<tr>
<td>Madrid</td>
<td>22,075</td>
<td>1,097.4</td>
<td>6,903</td>
<td>326.4</td>
<td>570</td>
<td>8.8</td>
<td>6,095</td>
<td>95.1</td>
<td>1.07</td>
<td>3</td>
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<td>Barcelona</td>
<td>3,098</td>
<td>277.2</td>
<td>545</td>
<td>28.4</td>
<td>30</td>
<td>2.5</td>
<td>304</td>
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<td>6</td>
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<tr>
<td>Valencia</td>
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<td>461</td>
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<td>32</td>
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<td>409</td>
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<td>2.0</td>
<td>170</td>
<td>94.6</td>
<td>2.45</td>
<td>1</td>
<td>142</td>
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<tr>
<td>Castilla y Leon</td>
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<td>2,090.2</td>
<td>292</td>
<td>237.8</td>
<td>32</td>
<td>34.8</td>
<td>401</td>
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<td>898.1</td>
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<td>160.5</td>
<td>24</td>
<td>3.3</td>
<td>177</td>
<td>95.1</td>
<td>3.89</td>
<td>1</td>
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<tr>
<td>Galicia</td>
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<td>879.3</td>
<td>147</td>
<td>128.3</td>
<td>19</td>
<td>2.4</td>
<td>185</td>
<td>95.1</td>
<td>3.89</td>
<td>1</td>
<td>142</td>
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<td>Asturias</td>
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<td>2,490.4</td>
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<td>25</td>
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<td>170</td>
<td>94.6</td>
<td>2.45</td>
<td>1</td>
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<tr>
<td>Cantabria</td>
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<td>125</td>
<td>21.0</td>
<td>2.54</td>
<td>10</td>
<td>39</td>
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<tr>
<td>Canarias</td>
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<td>727.9</td>
<td>150</td>
<td>82.5</td>
<td>13</td>
<td>2.0</td>
<td>125</td>
<td>21.0</td>
<td>2.54</td>
<td>10</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

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).
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 of last 15 days.**
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

Spain 17-07-2020. Pop: 47.0M. Cumulative incidence: 553/10^5

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)

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

Actual $\rho_f = 1.9$

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

Risk diagram

Risk diagram (last 15 days)
Italy 18-07-2020. Pop: 60.5M. Cumulative incidence: 404/10^5

[Graphs showing cumulative confirmed cases, number of cases, cumulative confirmed deaths, and incident observed cases per 10^5 inhabitants over time.]

Actual $r_0 = 1.0$

[BildO-M-CoV2 Degree = 2

[Graphs showing incident cases per 10^5 inhabitants, incident observed cases per 10^5 inhabitants, and case fatality rate (%) over time.]

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Cases per 10^4 inhabitants

Incident observed cases
- Confirmed
- Prediction

Incident cases per 10^5 inh.

Actual ρ = 1.2

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^7 inhabitants

Incident observed cases

Incident observed cases per 10^3 inh.

Incident observed cases per 10^2 inh.

Actual $p_f = 1.6$

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 10^7 inhabitants vs Time (day)

Incident observed cases vs Time (day)

Incident cases per 10^7 inh. vs Time (day)

BIOCOM-Cov2 Degree = 6

Actual $p_\gamma = 0.9$

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)
Poland 18-07-2020. Pop: 37.8M. Cumulative incidence: 105/10⁵

[Diagrams showing cumulative confirmed cases, cumulative confirmed deaths, number of cases, confirmed cases, estimated cases, incident observed cases, incident cases per 10⁵ inh., incident observed cases per 10⁵ inh., case fatality rate, and risk diagrams.

Actual $\rho_\gamma = 1.1$

[Graphs showing cumulative confirmed cases, cumulative confirmed deaths, number of cases, cases per 10^3 inhabitants, incident observed cases, incident cases per 10^3 inh., incident observed cases per 10^3 inh., and risk diagrams for July 18, March 31, July 18, and July 03.]

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 10^6 inh. vs Time (day)

BIOCOM-Cov2 Degree = 2

Incident observed cases per 10^6 inh. vs Time (day)

Actual $p_f = 1.6$

Case Fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)
Denmark 18-07-2020. Pop: 5.8M. Cumulative incidence: 227/10^5

- Cumulative confirmed cases
- Cumulative confirmed deaths

- Number of cases
- Cases per 10^5 inhabitants

- Incident observed cases
- Incident cases per 10^5 inh.

Actual \( \rho_2 = 2.0 \)

- Case fatality rate (%)

Risk diagram

- Risk diagram (last 15 days)
Norway 18-07-2020. Pop: 5.4M. Cumulative incidence: 166/10^5
Finland  18-07-2020. Pop: 5.5M. Cumulative incidence: 132/10^5
Luxembourg 18-07-2020. Pop: 0.6M. Cumulative incidence: 864/10^5

BIOCOM-Cov2 Degree = 8

Actual $\rho_f = 1.3$

Risk diagram

Risk diagram (last 15 days)
Slovakia 18-07-2020. Pop: 5.5M. Cumulative incidence: 36/10^5

[Graphs and diagrams showing cumulative confirmed cases, incident observed cases, and risk diagrams for different time periods.]

Actual $p_y = 1.0$

Risk diagram
Slovenia 18-07-2020. Pop: 2.1M. Cumulative incidence: 93/10^5

Actual $p_f = 0.8$

Risk diagram

Risk diagram (last 15 days)
Iceland 18-07-2020. Pop: 0.3M. Cumulative incidence: 563/10^5
Lithuania 18-07-2020. Pop: 2.7M. Cumulative incidence: 70/10^5

- Cumulative confirmed cases and deaths over time.
- Number of cases and cumulative deaths per 10^5 inhabitants.
- Incident observed cases and predicted cases over time.
- Incident cases per 10^5 inhabitants over time.
- Actual r_f = 1.6
- Case fatality rate (%) over time.
- Risk diagram with historical data points.
- Risk diagram (last 15 days) with recent data points.
Latvia 18-07-2020. Pop: 1.9M. Cumulative incidence: 63/10^5

Cumulative confirmed cases vs Time (days)

Number of cases vs Time (day)

Incident observed cases vs Time (day)

Incident cases per 10^5 inh.

Actual ρ_f = 0.6

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)
Cyprus 18-07-2020. Pop: 1.2M. Cumulative incidence: 86/10^5

Cumulative confirmed cases vs Time (Days)

Cumulative confirmed deaths vs Time (Days)

Number of cases vs Time (Days)

Cases per 10^5 inhabitants vs Time (Days)

Incident observed cases vs Time (Day)

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

Incident observed cases vs Time (Day)

Incident observed cases per 10^3 inh. vs Time (Day)

Actual ρ_H = 1.6

Case Fatality Rate (%) vs Time (Day)

Risk diagram

Risk diagram (last 15 days)
Malta 18-07-2020. Pop: 0.4M. Cumulative incidence: 153/10^5

[Graphs and charts related to the cumulative confirmed cases, incidence observed cases, and risk diagrams are shown.]
(2) Analysis and prediction of COVID-19 for other countries

USA 18-07-2020. Pop: 331.0M. Cumulative incidence: 1121/10^5
Brazil 18-07-2020. Pop: 212.6M. Cumulative incidence: 976/10^5
India 18-07-2020. Pop: 1380.0M. Cumulative incidence: 78/10^5

Cumulative confirmed cases and deaths over time.

Number of cases and estimated cases per 10^5 inhabitants.

Incident observed cases over time.

BIOCOM-Cov2 Degree = 5

Actual p_f = 1.2

Incident cases per 10^5 inh.

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
South Africa 18-07-2020. Pop: 59.3M. Cumulative incidence: 592/10⁵
Peru 18-07-2020. Pop: 33.0M. Cumulative incidence: 1060/10^5

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)

BIOCMM-Cov2 Degree = 8

Incident observed cases vs time (day)

Incident observed cases per 10^5 inhabitants vs time (day)

Actual \( R_0 = 1.1 \)

Case fatality rate (%) vs time (day)

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 10^7 inhabitants vs. time (day)

BIOCOM-Cov2 Degree = 6

Incident observed cases vs. time (day)

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

Incident observed cases per 10^3 inh. vs. time (day)

Actual \( R_0 = 1.0 \)

Case mortality rate (%) vs. time (day)

Risk diagram

Risk diagram (last 15 days)
Chile 18-07-2020. Pop: 19.1M. Cumulative incidence: 1708/10^5
Iran 18-07-2020. Pop: 84.0M. Cumulative incidence: 323/10^5
Turkey 18-07-2020. Pop: 84.3M. Cumulative incidence: 259/10^5

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Cases per 10^4 inhabitants
- Incidence observed cases
- Incident cases per 10^4 inh.
- Incident observed cases
- Incident observed cases per 10^4 inh.
- Actual $p_f = 0.9$
- Case fatality rate (%)
- Risk diagram
- Risk diagram (last 15 days)
Argentina 18-07-2020. Pop: 45.2M. Cumulative incidence: 264/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^5 inh.

Incident cases per 10^5 inh.

Actual Ω = 1.0

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

[Graphs and charts showing cumulative cases, confirmed cases, deaths, and incident cases per 10^3 inhabitants with time in days.]

Actual ρ̂ = 1.1

[Biocom-Cov2 Degree = 6]

[Risk diagram and risk diagram (last 15 days)]

[Graphs showing cumulative confirmed cases and deaths, confirmed and estimated cases, incident observed cases, and incident cases per 10^5 inh.]

Actual $p_\gamma = 0.9$

Risk diagram

Risk diagram (last 15 days)
Israel 18-07-2020. Pop: 8.7M. Cumulative incidence: 570/10^5

[Graphs showing cumulative confirmed cases, cumulative confirmed deaths, incident observed cases, incident cases per 10^5 inh., risk diagrams for active cases per 10^5 inh. (last 14 days).]
Japan 18-07-2020. Pop: 126.5M. Cumulative incidence: 19/10⁵

![Graphs showing cumulative confirmed cases and deaths, confirmed cases, estimated cases, incident observed cases, incident cases per 10⁵ inh., case fatality rate, and risk diagrams.](image)
South Korea  18-07-2020. Pop: 51.3M. Cumulative incidence: 27/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^7 inhabitants

Incident observed cases

Incident cases per 10^5 inh.

Incident observed cases per 10^5 inh.

Actual $\rho_1 = 1.0$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Australia 18-07-2020. Pop: 25.5M. Cumulative incidence: 45/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^5 inh.

Incident observed cases per 10^5 inh.

Actual $\rho_f = 1.4$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Malaysia 18-07-2020. Pop: 32.4M. Cumulative incidence: 27/10^5
(3) Analysis and prediction of COVID-19 for Italy and its regions

Italy 20-07-2020. Pop: 60.5M. Cumulative incidence: 405/10^5

---

**Cumulative confirmed cases**

- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

- Confirmed cases
- Estimated cases

---

**Incident observed cases**

- Confirmed
- Prediction

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

**Incident observed cases**

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

---

**Actual ρ_f = 0.7**

**Case fatality rate (%)**

**Time (day)**

**Risk diagram**

- July 20
- March 10

**Risk diagram (last 15 days)**

- July 20
- July 05
Toscana 20-07-2020. Pop: 3.7M. Cumulative incidence: 278/10^5

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

Actual $R_t = 2.0$

BIOCOM-Cov2 Degree = 2

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Cases per 10^7 inhabitants
- Incident observed cases
- Incident cases per 10^3 inh.
- Case fatality rate (%)
- Active cases per 10^5 inh. (last 14 days)

Actual $p_2 = 2.5$

Risk diagram

BIOCOM-Cov2 Degree = 3

Risk diagram (last 15 days)
Lazio 20-07-2020. Pop: 5.9M. Cumulative incidence: 144/10^5
Marche 20-07-2020. Pop: 1.5M. Cumulative incidence: 447/10^5
Trento 20-07-2020. Pop: 0.5M. Cumulative incidence: 909/10^5

BIOCOM-Cov2 Degree = 2
Puglia 20-07-2020. Pop: 4.0M. Cumulative incidence: 113/10^5

**Cumulative confirmed cases**

- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

- Confirmed cases
- Estimated cases

**Incident observed cases**

- Confirmed
- Prediction

**Actual \( \rho_f \) = NA**

**BIOCOM-Cov2 Degree = 1**

**Risk diagram**

- July 20
- March 19

**Risk diagram (last 15 days)**

- July 20
- July 05

Cumulative confirmed cases vs Time (days)

Cumulative confirmed deaths vs Time (days)

Cumulative confirmed cases vs Time (day)

Number of cases vs Time (day)

Cases per 10^7 inhabitants vs Time (day)

Confirmed cases vs Time (day)

Estimated cases vs Time (day)

BIOCOM-Cov2 Degree = 2

Incident observed cases vs Time (day)

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

Incident observed cases vs Time (day)

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

Actual ρ_y = 2.4

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)
Bolzano 20-07-2020. Pop: 0.5M. Cumulative incidence: 515/10^5
Umbria 20-07-2020. Pop: 0.9M. Cumulative incidence: 165/10^5

**Cumulative confirmed cases**

- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

- Confirmed cases
- Estimated cases

**Incident observed cases**

- Confirmed
- Predicted

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

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

**Actual ρ_f = NA**

**Case Fatality rate (%)**

**Risk diagram**

- July 20
- March 14

**Risk diagram (last 15 days)**

- July 20
- July 05
Sardegna 20-07-2020. Pop: 1.6M. Cumulative incidence: 84/10^5

---

Cumulative confirmed cases vs Time (days)

Cumulative confirmed deaths vs Time (days)

Number of cases vs Time (day)

Cases per 10^4 inhabitants vs Time (day)

Incident observed cases vs Time (day)

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

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

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

Actual \( \rho_f = NA \)

Case fatality rate (%) vs Time (day)

---

Risk diagram

Risk diagram (last 15 days)
Calabria 20-07-2020. Pop: 1.9M. Cumulative incidence: 64/10^5
Molise 20-07-2020. Pop: 0.3M. Cumulative incidence: 146/10^5

**Cumulative confirmed cases**

- **Cases**
- **Deaths**
- **Predictions**

**Number of cases**

- **Confirmed cases**
- **Estimated cases**

**Cases per 10^5 inhabitants**

**Incident observed cases**

- **Confirmed**
- **Predicted**

**Incident cases per 10^3 inh.**

**Incident observed cases per 10^3 inh.**

**Actual ρT = NA**

**Case fatality rate (%)**

**Risk diagram**

- July 20
- March 19

**Risk diagram (last 15 days)**

- July 20
- July 05
Basilicata 20-07-2020. Pop: 0.6M. Cumulative incidence: 73/10^5

- **Cumulative confirmed cases**
  - Time (Days)
  - Cases
  - Deaths
  - Predictions

- **Cumulative confirmed deaths**
  - Time (Days)
  - Confirmed cases
  - Estimated cases

- **Incident observed cases**
  - Time (Day)
  - Confirmed
  - Prediction

- **Incident observed cases per 10^3 inh.**
  - Time (Day)

- **Actual ρ_f = NA**
  - Time (Day)

- **Case Fatality rate (%)**
  - Time (Days)

- **Risk diagram**
  - Active cases per 10^3 inh. (last 14 days)

- **Risk diagram (last 15 days)**
  - July 20
  - March 21
  - July 05
Methods
Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports\(^3\), from European Centre for Disease Prevention and Control (ECDC)\(^4\) and from Ministerio de Sanidad\(^5\). These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

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

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

Then, two indicators are calculated and plotted, too:

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

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

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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\(^3\) [https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports](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 correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

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

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:

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

These plots illustrate the increase in fittings’ confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as “Not enough data” if \( a>0.2 \) 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:

\[ ^6 \text{Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.} \]
• Group A: prediction of expected cumulated cases for the following 3-5 days\(^7\);
• 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.

(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\(^8\) 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.

\(^7\) 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.