Daily report 24-04-2020

Analysis and prediction of COVID-19 for different regions and countries

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

We 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.
Global EU+EFTA+UK trends and needs

EU+EFTA+UK countries are following the trend of previous days, arriving at the top of a new peak in the decrease. As expected, this peak seems lower than previous ones, which is good news. Predictions also indicate this decreasing dynamic, situating daily new cases just beneath the level of 20,000 daily new cases.

Long term prediction of total number of cases (K) is at the level of 1.6 million. If this is confirmed for the next days, we would be at 65% of this value. Nevertheless, it must be kept in mind that final tail is long, as the slope of the curve is expected to decrease slower than a few weeks ago.

Spanish government has changed the criteria on data reporting and the historical series has break. The whole series will be corrected the next days. Meanwhile, detailed reports of Spain will not be included, and all the analysis and predictions for this country should be interpreted with caution. Greek series of reported series also shows a gap, and thus masks any evaluation based on last data about new cases (e.g., evaluation of $\rho$ is not reliable).

In the Analysis section we present last instalment of this week’s assessment of real cases and diagnostic rate. Today, we focus on the comparison between countries whose dynamics is apparently similar or different but that, when looking at estimated real data, the resulting picture show the contrary situation.

Trends for specific countries

Most worrying situation is found in the four countries with highest EPG: Ireland (140), Belgium (123), Spain (115) and United Kingdom (102). There are other ways of evaluating the gravity of the situation, one of them being the number of deaths. Looking at last data on number of deaths in a single day, highest value corresponds to United Kingdom (638) followed by France (516), Italy (464), Spain (440) and Germany (227).
Situation and trends per country

Table of current situation in EU countries, according to data published by ECDC on April 15th. 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.

(1) Disclaimer: parameter $\rho$ is very sensitive and experiments daily variations. Mean $\rho$ is averaged per 3 consecutive days, but it can still vary the following days. (2) EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10^5 inhabitants of last 14 days (i.e. density of cases) by $\rho$ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 14 days is multiplied by $\rho^2$.

Highlights for countries with highest number of reported cases

- Spanish data are under quarantine again, since historical series has broken. This is partially reflected on the analysis by countries, since they are based on ECDC data that have a 1-day delay with respect to local ones. We should wait for the new data that will be reported tomorrow to see if it has been corrected or not.
- Expected new cases for next days are similar to yesterday’s predictions: at the level of 4,000 (UK), 2,700 (Italy), 2,100 (Germany) and 1,400 (France).
- Spreading rate dynamics also follow expected trends, oscillating around 1 with a period of 1 week.
### Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per $10^5$ inhabitants (only for countries that have overtaken this threshold).

<table>
<thead>
<tr>
<th>Countries</th>
<th>Days since the first 50 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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</thead>
<tbody>
<tr>
<td>Italy</td>
<td>62</td>
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<tr>
<td>Liechtenstein</td>
<td>30</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>
Analysis: Estimating real incidence in European countries (IV) – Comparing reported and estimated situations in different countries.

This week we have been discussing how to provide reliable estimations of real situations of countries, in the context of COVID19 epidemic. In particular, we have developed a robust method for estimating Diagnosis Delay and Diagnostic Rate in different countries. These values allow for an assessment of an incidence that, although not perfect, is closer to reality than the reported one.

The risk situation of countries is given by a combination of their current 3-day average growth rate \( \rho_3 \), i.e., mean value of last 3 days, which provides a potential velocity for infection’s spreading, and the 14-day attack rate \( A_{14} \), i.e., number of new cases per 10^5 inhabitants last 14 days), which is an indicator of potential spreaders. Risk diagrams show the evolution of these variables for each country, and they are an appropriate way of visualizing the risk in terms of history and current situation. In this Analysis, we want to compare reported and estimated situations in three pairs of countries, using the risk diagram. For each pair of countries, we show two risk diagrams: first, risk diagram with reported \( A_{14} \) in the x-axis; second, risk diagram with estimated \( A_{14} \) in the x-axis.

**Portugal vs Italy**

Portugal and Italy are two countries with a similar reported EPG. Last week, Italy’s EPG has been in the range [66.3-78.7] while Portugal’s EPG has been in the range [51.8-95.3]. Then, it could be deduced that both countries are in a similar risk situation. Risk diagram in the left show similar trajectories for both countries. Nevertheless, the figure in the right, which corresponds to the risk diagram with estimated cases, shows a totally different picture. According to estimations, **Italy’s curve has reached much higher risk values than Portugal.**

**Spain vs France**

This pair of countries is an example of the opposite situation. Last week, Spain’s EPG has moved in the range [114-164], while France’s EPG was in the range [28.1-66.6]. Left plot shows to countries with different risk levels. Nevertheless, if we plot the risk diagram assessed with estimated cases, **both countries converge to a similar pattern.**
Belgium vs Luxembourg

These countries have been in EPG’s top five several times the last weeks, with an EPG>100. Let us look at the risk diagrams to see if real situation behind data can be better understood.

Risk diagram with reported data (left) show that incidence’s values have been high, at the level of most affected countries. In fact, according to reported data, Luxembourg would have been in a worse situation than Belgium. However, risk diagram with estimated data provide, again, a totally different situation. Real situation in Luxembourg would have been similar to that in Portugal, with an intermediate affectation. Contrarily, Belgium shows a situation even worse to the one reported. We must say, as a limitation, that deaths’ reporting protocols in this country could be different from other countries, but these data are the basis for the estimation of diagnostic rate. Belgium is reporting deaths in nursery homes at roughly the same level as in hospitals, including cases which are highly dubious. Other heavy-hit regions in Spain report deaths in nursery homes that increase around 40% the total death toll including only suspicious cases. Average values of underreporting of deaths using the comparison of mortality rates during previous years in Spain indicate underreporting of around 20%. This fits the data from Catalonia and Madrid since not all areas are as affected as these two regions. Belgium numbers present similarities with Catalonia and Madrid. It makes sense that it is probably including some deaths correctly, maybe half of them, but not all of them. Therefore, the estimated situation for Belgium would be an upper level, the real one being between reported and estimated situations.
Long-term predictions

Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per $10^5$ inh.). Up-right: Predictions of maximum absolute number of cases per country ($K$, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of $K$ was achieved / will be achieved. Blue dotted line indicates current date. See details in Report from 11th April 2020.

**UE-EFTA-UK countries**

**Final expected $K$ for UE+EFTA+UK.** Evolution of predicted $K$ with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.
Italian regions

MAXIMUM AND CURRENT INCIDENCES

MAXIMUM NUMBER OF NEW CASES

90% OF MAXIMUM NUMBER OF CASES

Predicted incidence
Predicted K (log scale)

Time (days)

02-21 02-24 02-27 03-03 03-06 04-02 04-08

04-09 04-14 04-19 04-24 04-29 05-04 05-14

Valle d’Aosta
Lombardia
Trento
Piemonte
Emilia Romagna
Bolzano
Umbria
Veneto
Marche
Toscana
Friuli Venezia Giulia
Abruzzo
Umbria
Puglia
Campania
Sicilia
Basilicata
Calabria

Prediction
Current Situation
Situation and tendencies in Italian regions

Italy

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate / 10^5 inh.</th>
<th>Cumulative deaths / 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>Mean ρ (^{(1)})</th>
<th>EPG (^{(2)})</th>
<th>EPG (^{(2)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lombardia</td>
<td>70,160</td>
<td>698.7</td>
<td>12,940</td>
<td>128.9</td>
<td>15,363</td>
<td>153.0</td>
<td>0.97</td>
<td>149.1</td>
<td>145.3</td>
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<td>Emilia Romagna</td>
<td>23,723</td>
<td>532.0</td>
<td>3,269</td>
<td>73.3</td>
<td>5,046</td>
<td>113.2</td>
<td>0.81</td>
<td>91.2</td>
<td>73.4</td>
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<td>Piemonte</td>
<td>23,140</td>
<td>531.2</td>
<td>2,630</td>
<td>60.4</td>
<td>8,618</td>
<td>197.8</td>
<td>0.78</td>
<td>155.1</td>
<td>121.7</td>
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<td>344.1</td>
<td>1,206</td>
<td>24.6</td>
<td>3,948</td>
<td>80.5</td>
<td>0.64</td>
<td>67.7</td>
<td>56.9</td>
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<td>Toscana</td>
<td>8,780</td>
<td>235.4</td>
<td>723</td>
<td>19.4</td>
<td>2,228</td>
<td>59.7</td>
<td>0.57</td>
<td>33.6</td>
<td>18.2</td>
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<td>454.6</td>
<td>1,047</td>
<td>67.5</td>
<td>2,029</td>
<td>130.8</td>
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<td>375</td>
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<td>1,625</td>
<td>27.6</td>
<td>0.54</td>
<td>15.0</td>
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<td>Marche</td>
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<td>390.2</td>
<td>857</td>
<td>56.2</td>
<td>997</td>
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<td>0.66</td>
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<td>0.81</td>
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<td>1,123</td>
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<td>1.09</td>
<td>30.4</td>
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<tr>
<td>Trento</td>
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<td>382</td>
<td>35.6</td>
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<td>0.74</td>
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<tr>
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<td>213</td>
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<td>13.9</td>
<td>1.10</td>
<td>18.1</td>
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<td>1.08</td>
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<td>9.4</td>
<td>0.68</td>
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<td>4.4</td>
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<td>50</td>
<td>16.4</td>
<td>1.03</td>
<td>16.8</td>
<td>17.3</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Disclaimer: parameter ρ is very sensitive and experiments daily variations. Mean ρ is averaged per 3 consecutive days, but it can still vary the following days. \(^{(2)}\) EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10^5 inhabitants of last 14 days (i.e. density of cases) by ρ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 14 days is multiplied by ρ^2.

Maps of Italian regions

Cumulative incidence and spreading rate (ρ) in Europe, Italian regions and Spanish autonomous communities.

Legend: Countries’ reports details
Confirmed cases: data (blue), model fitted (dashed line), predictions (red points and table)

Fitted $a$ value using points prior to each date

Fitted $K$ value using points prior to each date

Reported and predicted new cases

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

Deaths / cumulated reported cases

Estimated cases using death rate (see Methods)
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale (Italy)
Italy 23-04-2020. Population: 60.5M. Current cumulated incidence: 314/10^5

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-04-2020</td>
<td>172,111 (x211)</td>
<td>156,935-187,286</td>
</tr>
<tr>
<td>22-04-2020</td>
<td>177,111 (x211)</td>
<td>156,935-187,286</td>
</tr>
<tr>
<td>23-04-2020</td>
<td>182,111 (x211)</td>
<td>156,935-187,286</td>
</tr>
</tbody>
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- Number of cases
- Prediction

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Actual \( \rho = 0.7 \)

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-04-2020</td>
<td>142,759 (± 4,129)</td>
<td>118,094 - 18,824</td>
</tr>
<tr>
<td>22-04-2020</td>
<td>161,007 (± 4,321)</td>
<td>126,003 - 19,511</td>
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<tr>
<td>23-04-2020</td>
<td>180,400 (± 3,245)</td>
<td>146,255 - 21,545</td>
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- Number of cases
- Prediction

Actual ρ = 0.8

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<th>Actual</th>
<th>Predicted</th>
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</thead>
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<td>16751</td>
<td>1535</td>
</tr>
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<td>25-04-2020</td>
<td>10091 (\pm 6061)</td>
<td>15801</td>
<td>1961</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>10722 (\pm 7031)</td>
<td>17673</td>
<td>2243</td>
</tr>
</tbody>
</table>

- **Number of cases**
- **Prediction**

![Graph showing cumulative confirmed cases over time](image1)

![Graph showing cumulative cases per 10^5 over time](image2)

![Graph showing confirmed cases over time](image3)

![Graph showing estimated cases over time](image4)

![Graph showing k (final number of cases) over time](image5)

![Graph showing k (final number of cases) over time](image6)

![Graph showing incident observed cases over time](image7)

![Graph showing predicted vs. actual cases per 10^5 inhabitants over time](image8)

![Graph showing cumulative observed deaths over time](image9)

![Graph showing case fatality rate (%) over time](image10)
Predictions for next days:

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-02-2020</td>
<td>15028 (±42)</td>
<td>±4980</td>
</tr>
<tr>
<td>25-02-2020</td>
<td>18711 (±42)</td>
<td>±5467</td>
</tr>
<tr>
<td>26-02-2020</td>
<td>19117 (±42)</td>
<td>±5421</td>
</tr>
</tbody>
</table>

Number of cases:  
Prediction:

Cumulative confirmed cases:

Cumulative cases per 10^5:

Cumulative cases per 10^6:

Cumulative cases per 10^7:

Incident observed cases:

Incident cases per 10^5:

Incident cases per 10^6:

Incident cases per 10^7:

Cumulative deaths:

Cumulative deaths per 10^5:

Cumulative deaths per 10^6:

Cumulative deaths per 10^7:

Cases per 10^5:

Cases per 10^6:

Cases per 10^7:

Actual $\rho = 0.7$

Growth factor $\rho$:

Cases fatality rate (%):
Finland  23-04-2020. Population: 5.5M. Current cumulated incidence: 77/10^5

Predictions for next days

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04-2020</td>
<td>2495 x 2458</td>
<td>2463 - 2722</td>
</tr>
<tr>
<td>25-04-2020</td>
<td>2522 x 330</td>
<td>2465 - 2717</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>2553 x 321</td>
<td>2465 - 2748</td>
</tr>
</tbody>
</table>

- Number of cases
- Prediction

Actual $\rho = 4.7$

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04-2020</td>
<td>1372 ± 100</td>
<td>1366 - 1378</td>
</tr>
<tr>
<td>25-04-2020</td>
<td>1396 ± 100</td>
<td>1386 - 1388</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>1196 ± 100</td>
<td>1186 - 1198</td>
</tr>
</tbody>
</table>

- Number of cases
- Prediction

Actual ρ = 0.4

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04-2020</td>
<td>1332 ± 15</td>
<td>10/04 - 14/04</td>
</tr>
<tr>
<td>25-04-2020</td>
<td>1353 ± 44</td>
<td>10/04 - 14/04</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>1195 ± 42</td>
<td>10/04 - 14/04</td>
</tr>
</tbody>
</table>

- Number of cases
- Prediction

- Cumulative confirmed cases
- Cumulative cases per 10^5

- Number of cases
- Estimation cases

- Confirmed cases
- Estimated cases

- Actual ρ = 1.3

- Incident observed cases
- Incident cases per 10^5

- Cumulative observed deaths
- Cumulative deaths per 10^5

- Case fatality rate (%)

**Predictions for next days**

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04-2020</td>
<td>450+/-31</td>
<td>445+/-70</td>
</tr>
<tr>
<td>25-04-2020</td>
<td>450+/-21</td>
<td>445+/-67</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>452+/-11</td>
<td>445+/-72</td>
</tr>
</tbody>
</table>

- **Number of cases**
- **Prediction**

**Not enough data**

**Actual ρ = 0.5**

- **Cumulative confirmed cases**
- **Cumulative cases per 10^5**

- **Incident observed cases**
- **Incident cases per 10^5 inhabitants**

- **Cumulative observed deaths**
- **Cumulative deaths per 10^5 inhabitants**

- **Case fatality rate (%)**
- **Time (days)**
(2) Analysis and prediction of COVID-19 for other countries


<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04-2020</td>
<td>69376 (±5550)</td>
<td>63514 - 75256</td>
</tr>
<tr>
<td>25-04-2020</td>
<td>71090 (±5430)</td>
<td>65120 - 77060</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>73227 (±5457)</td>
<td>67352 - 79514</td>
</tr>
</tbody>
</table>

- Number of cases
- Prediction

Cumulative confirmed cases

Cumulative cases per 10^5

Number of cases

Cases per 10^5 inhabitants

Actual \( \rho = 1.3 \)

Incident observed cases

Incident cases per 10^5 inhabitants

Confirmed

Prediction

Cumulative observed deaths

Cumulative deaths per 10^5 inhabitants

Case fatality rate (\%)

![Graph of cumulative confirmed cases over time](image1)

![Graph of cumulative cases per 10^5 over time](image2)

![Graph of number of cases per day over time](image3)

![Graph of confirmed cases and estimated cases over time](image4)

![Graph of incident cases over time](image5)

![Graph of incident cases per 10^5 inhabitants over time](image6)

![Graph of cumulative deaths over time](image7)

![Graph of cumulative deaths per 10^5 inhabitants over time](image8)

![Graph of case fatality rate over time](image9)

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of cases</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04-2020</td>
<td>11366 (±6731)</td>
<td>11183 - 11539</td>
</tr>
<tr>
<td>25-04-2020</td>
<td>11461 (±7777)</td>
<td>11183 - 11833</td>
</tr>
<tr>
<td>26-04-2020</td>
<td>12127 (±1001)</td>
<td>11183 - 11721</td>
</tr>
</tbody>
</table>

Actual $\rho = 0.9$

Predictions for next days

<table>
<thead>
<tr>
<th>Day</th>
<th>Number of cases</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-04</td>
<td>5638 + 35</td>
<td>5603 - 5673</td>
</tr>
<tr>
<td>25-04</td>
<td>5690 + 45</td>
<td>5655 - 5725</td>
</tr>
<tr>
<td>26-04</td>
<td>5718 + 30</td>
<td>5683 - 5753</td>
</tr>
</tbody>
</table>

- Number of cases
- Prediction

Cumulative cases per 10^5

Cumulative cases per 10^5

Time (day)

Time (day)

Actual $\rho = 0.8$

Cumulative observed cases

Incident cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^5 inhabitants

Cumulative observed deaths

Cumulative deaths per 10^5 inhabitants

Cumulative deaths per 10^5 inhabitants

Cases fatality rate (%)
Methods
Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports\(^1\), from European Centre for Disease Prevention and Control (ECDC)\(^2\) and from Ministerio de Sanidad\(^3\). 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.
- \( \rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)} \)

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

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

The evolution of confirmed cases shows a biphasic behaviour:

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

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

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

\(^1\) [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\(^4\) 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 \(a>0.2\) \(\text{day}^{-1}\), 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:

• Group A: prediction of expected cumulated cases for the following 3-5 days\(^5\);
• 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\(^6\) 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.

---

\(^5\) 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.