Daily report 08-07-2020

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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Computational Biology and Complex Systems;
Universitat Politècnica de Catalunya - BarcelonaTech

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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

The UK continues with the ongoing revision of historical data that has lead to a decreased number of cases. Therefore, as in the previous reports, the cumulative figure for today does not include the UK and it shows only EU+EFTA. The number of daily new cases in the EU+EFTA stays around the 4,000-5,000 cases keeping a basal value of new cases. The UK is on the revision of the data and Sweden is reporting a reduced amount of data which does not seem complete.

The cases reported by France show large oscillations from zero to 1000 new cases with a clear mean around the 500 new cases daily. Germany seems to keep values below the 400 cases. While some countries oscillate around a basal value after the decrease, for example Germany, with 400 new cases, or Portugal and Spain, with 300 new cases, other countries like Italy, Belgium and The Netherlands show a continuous decrease, now with less than 200, 100 and 50 new cases respectively. Note also that, although they are small countries, Croatia and Bulgaria are growing again following a worrying second wave.

The USA and Brazil with smaller populations than EU+EFTA are reporting 10 times large values of new cases, both around 50,000 daily. Worrying countries like Mexico, India and South Africa continue still in the growing phase and no maximum value seems to be achieved. On the other hand, Canada, a neighboring country of the USA, has already arrived at a basal value of only around 300 daily new cases.

![Map of EU+EFTA with cumulative confirmed cases](image1)

![Cumulative incidence map of EU+EFTA](image2)
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 of current situation in EU countries

<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>Estimated attack-rate (last 14 days)</th>
<th>Estimated 14-day attack rate /10^5 inh.</th>
<th>Biocom-Cov degree</th>
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</thead>
<tbody>
<tr>
<td>Spain</td>
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<td>28,302</td>
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<td>2</td>
<td>5.2</td>
<td>NA</td>
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</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) $\rho_T$ is the average of 7 consecutive $\rho$, 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 $\rho_T$ (empirc reproduction number). EPGEST is the product of estimated real 14-day attack-rate of last 14 days per 10^5 inhabitants by $\rho_T$. 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/2117/189808).
Analysis: Final hurdle to tracing with APPS. Herd protection due to the use of a perfect APP even with full smartphone penetration is not possible.

In previous assessments\(^1\), we have discussed the different hurdles that tracing APPS present, indicating that we estimated 20% as the maximum limit of contacts that the app could detect. The total amount of contacts would be around 10% if it is a very successful APP and people use it actively as much as large brands, but will drop to 1% if the penetration is not large. We now address another limit that APP present: with present smartphone penetration around 70% is not possible to obtain herd protection. We discuss here that this is the case even if there was no chance of getting infected by people further away than 2 meters and the APP would be able to detect all of them. We will call this type of APP a perfect APP and proceed to discuss why even this type of APP even with universal smartphone penetration is not enough. This confirms completely that a realistic APP will only be a small help, if at all, at the margins. The real effort must be done by epidemiological teams doing proper evaluation and tracing of contacts.

Herd immunity

Let us recall first what herd immunity means. Number \( R \) is defined as the average of the number of people infected by a single individual. For example, an epidemic with \( R=3 \) means that each individual with the disease will infect, in average, 3 other individuals. If this number \( R<1 \), then each generation infect less individuals than the previous generation, and the epidemic extinguishes. However, if \( R>1 \) there is an exponential growth and the epidemics goes out of control. See panel A of the next figure with the chains of infections for the particular case of \( R=3 \) and the corresponding exponential growth \( 1 \rightarrow 3 \rightarrow 9 \rightarrow 27 \ldots \)

When certain individuals of the population are immune towards the epidemics, the propagation of the epidemics delays when they were going to be infected. Under such conditions, a large number of immune individuals can even stop the epidemics. If \( H \) is the fraction of the immune population we can define the probability of propagation as \((1-H)\) and therefore under certain value of the immunity we obtain a new reproductive number \( R \):

\[
R = R_0 \cdot (1 - H)
\]

If \( H \) is large enough we can arrive to \( R=1 \) and the epidemics does not propagate any more. For an initial value of \( R_0 \), we obtain a critical value of \( H \) which theoretically stops the epidemics:

\[
H_c = 1 - \frac{1}{R_0}
\]

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\(^1\) https://upcommons.upc.edu/handle/2117/192198, https://upcommons.upc.edu/handle/2117/191755
For the particular case of $R_0=3$, we obtain a critical value for the fraction of immune of 0.66, see panel B of the figure above. In this case the number of infected individuals for each generation changes as $1 \rightarrow 1 \rightarrow 1 \rightarrow 1 \ldots$

The necessary fraction of immune individuals to obtain herd immunity depends on the value of $R_0$ of the particular epidemics, see next figure to observe the dependence of the value of $H_c$ as function of $R_0$.

**Herd protection due to APPs**

Let us consider now an APP which detects all dangerous contacts among people. We consider that the APP is perfectly designed and it detects all the cases where a contagious is happening, which is actually a big assumption (see previous reports\(^2\)). In such case, the detection of an individual with the APP installed, will be alerted all their contacts and it will stop the infection chain because all the alerted individuals will stay in strict quarantine. We are, therefore, employing a perfect APP approach. Therefore, if everybody had the APP installed, the epidemics will drastically stop. **We will assume now that only a fraction of the individuals $\Phi$ has such perfect APP installed.**

There is a probability of the evolution of the infection because the APP does not detect the contagion. This can happen because the two infected individuals do not have the APP ($1-\Phi$) or because one of the infected has installed the APP ($\Phi$) but it infects an individual without the APP ($1-\Phi$). Therefore, the epidemic continues (no detection) in both cases and the probability of success of the epidemics for each infection is:

$$P(\phi) = (1 - \phi) + (1 - \phi)\phi = (1 - \phi)(1 + \phi) = 1 - \phi^2$$

The probability to stop the infection depends on the condition that the first and second infected have the APP and therefore, both go into quarantine before the second propagates further the epidemics. Therefore, the probability of success to stop the epidemics for a single infection is:

$$P_{stop}(\phi) = \phi^2$$

Note that there are only two possibilities, therefore, both probabilities added have to keep the condition:

$$P_{stop}(\phi) + P(\phi) = 1$$

The total number of infections for each person is then the probability to continue the epidemic multiply by the people infected (epidemiological number $R_0$), and in this case it depends on the fraction of people with the APP, $\Phi$:

$$R(\phi) = R_0 \cdot P(\phi) = R_0 \cdot (1 - \phi^2)$$

\(^2\) [https://upcommons.upc.edu/handle/2117/192198, https://upcommons.upc.edu/handle/2117/191755]
See the explanatory figure for a fraction of 66% individuals with the APP. In such case, the epidemic is not stopped (1→ 3→ 5 → 9...), but grows slower than without APP.

For a particular combination of values of $R_0$ and $\Phi$ we can stop the epidemics if the final reproductive number due to the effect of the APP is reduced to 1:

$$R(\phi) = 1$$

For a particular infection the stop of the propagation is obtained if $P(\phi) < \frac{1}{R_0}$

Therefore, we obtain the critical value for the fraction of users of the APP as a limit condition:

$$P(\phi_c) = 1 - \phi_c^2 = \frac{1}{R_0}$$

and the critical value of such fraction as function of the actual value of $R$ is:

$$\phi_c = \sqrt{1 - \frac{1}{R_0}}$$

See the accompanying figure, where the value of the fraction of users needed to stop the epidemic is plotted as function of the reproductive number. Note that the dynamics of $H_c$ is shown for comparison.

Variation of $R$ due to the use of apps

During an epidemic without any kind of APP installed, the number of new cases for each case is $R_0$. However, if there is a fraction $\Phi$ of individuals with the APP installed, then:

$$R(\phi) = R_0 \cdot P(\phi) = R_0 \cdot (1 - \phi^2)$$
Therefore, we evaluate the **reduction on R due to the increase on the fraction of users of the APP (Φ)**. See in the figure the decrease of the reproductive number due to the users of the APP. The intersection with the line $R=1$ marks the critical values of $\Phi$.

![Graph showing the decrease of R with increasing Φ](image)

**Conclusions**

- An unrealistic number of users is needed to obtain Herd protection due to the use of the APP.
- Depending on the reproductive number, the fraction of users of the APP needed to stop the epidemics (condition $R=1$) changes, the bigger the reproductive number, the larger the critical fraction $\Phi_c$ is.
- The increase in users of the APP reduces the reproductive number of the epidemics. Although this reduction is probably small, a decrease is always positive in the control of the epidemic.
- We are employing an approach of a perfect APP, which is not realistic. A large fraction of cases is actually not detected by the APP and the effect of the use of the APP is even smaller.
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) from worst (red) situations according to each of the variables. 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>Reported data</th>
<th>Indexes</th>
<th>Biocom-Cov degree</th>
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<td></td>
<td>Cumulative cases</td>
<td>Attack rate /10^5 inh.</td>
<td>Cumulative deaths</td>
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<th>Worst</th>
<th>Worst</th>
<th>Worst</th>
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</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) $P_I$ 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 $P_I$ (empiric reproduction number). EPGEST is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and $P_I$. 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>
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</thead>
<tbody>
<tr>
<td>Italy</td>
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<tr>
<td>Countries</td>
<td>Days since the first 100 cases</td>
<td>Time interval between 1 and 10 cases / 10^5 inh. (days)</td>
<td>Time interval between 10 and 100 cases / 10^5 inh. (days)</td>
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<td>--------------------------------------------------------</td>
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<td>Iran</td>
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<tr>
<td>Belarus</td>
<td>100</td>
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</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 10^6 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 08th July

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10^5 inh.</th>
<th>Cumulative deaths</th>
<th>Mortality /10^3 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 estimated attack rate /10^5 inh.</th>
<th>ρ(7)</th>
<th>EPGREP(1)</th>
<th>EPGEST(2)</th>
<th>Biocom-Cov degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lombardia</td>
<td>83,671</td>
<td>196.8</td>
<td>20,726</td>
<td>886.6</td>
<td>1,292</td>
<td>13.9</td>
<td>28,590</td>
<td>329.3</td>
<td>1.01</td>
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<td>Piemonte</td>
<td>81,417</td>
<td>206.1</td>
<td>29,307</td>
<td>961.3</td>
<td>1,863</td>
<td>18.6</td>
<td>33,590</td>
<td>350.2</td>
<td>1.17</td>
<td>9</td>
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<td>2</td>
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<tr>
<td>Lazio</td>
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<td>19,420</td>
<td>166.3</td>
<td>461</td>
<td>15.2</td>
<td>4,093</td>
<td>330.1</td>
<td>1.31</td>
<td>14</td>
<td>296</td>
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<td>250.3</td>
<td>14,104</td>
<td>91.5</td>
<td>620</td>
<td>15.6</td>
<td>3,791</td>
<td>330.1</td>
<td>1.31</td>
<td>14</td>
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<tr>
<td>Toscana</td>
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<td>240.4</td>
<td>13,041</td>
<td>45.5</td>
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<td>15</td>
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<td>Sardinia</td>
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<td>14.7</td>
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<td>44.3</td>
<td>1.05</td>
<td>8</td>
<td>87</td>
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<td>Valle d'Alta</td>
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<td>997</td>
<td>65.7</td>
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<td>1.05</td>
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<td>44.3</td>
<td>1.05</td>
<td>8</td>
<td>87</td>
<td>1</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) ρ7 is the average of 7 consecutive ρ, 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 ρ7 (empiric reproduction number). EPGEST is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ7. 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 1st July, series built with the day of symptoms’ onset

<table>
<thead>
<tr>
<th>Autonomous regions</th>
<th>Cumulative cases</th>
<th>Attack rate /10^5 inh.</th>
<th>Active cases (last 14 days)</th>
<th>14-day attack rate /10^5 inh.</th>
<th>ρ(7)</th>
<th>EPGREP(1)</th>
<th>EPGEST(2)</th>
<th>Biocom-Cov degree</th>
</tr>
</thead>
</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).
- Incident observed cases and predictions.
- Evolution of empiric reproductive number $\rho_T$.
- Risk diagram
- Estimated and reported cases.
- Incident observed cases in a logarithmic scale, with Biocom-Cov degree.
- Case fatality rate
- Risk diagram of last 15 days.
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

EU+EFTA 07-07-2020. Pop: 460.0M. Cumulative incidence: 284/10^5
Spain  06-07-2020. Pop: 47.0M. Cumulative incidence: 536/10^5

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 (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_7 = 1.0

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)
Germany 07-07-2020. Pop: 83.8M. Cumulative incidence: 236/10^5

- Cumulative confirmed cases vs. Time (days)
- Cumulative confirmed deaths vs. Time (days)
- Number of cases vs. Time (days)
- Cases per 10^7 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)

Actual \( r_f \) = 0.9

Risk diagram

Risk diagram (last 15 days)

Actual $\rho_g = 0.9$

BIOCOM-Cov2 Degree = 7

Risk diagram

Risk diagram (last 15 days)
Belgium  07-07-2020. Pop: 11.6M. Cumulative incidence: 536/10^5

[Graphs showing cumulative confirmed cases and deaths, incidence observed cases, and risk diagrams with dates and labels such as July 07, March 13, June 22.]
Poland 07-07-2020. Pop: 37.8M. Cumulative incidence: 96/10^5
Switzerland 07-07-2020. Pop: 8.7M. Cumulative incidence: 373/10^5

---

**Cumulative confirmed cases**

- Cases: blue line
- Deaths: red line
- Predictions: dotted line

**Cumulative confirmed deaths**

- Confirmed cases: green line
- Estimated cases: dotted line

**Incident observed cases**

- Confirmed: blue line
- Prediction: red line

**BIOC-M-Cov2 Degree = 3**

**Actual ρ̇ = 1.5**

**Case Fatality rate (%)**

**Risk diagram**

**Risk diagram (last 15 days)**
Denmark 07-07-2020. Pop: 5.8M. Cumulative incidence: 223/10^5

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

Incident observed cases
- Confirmed
- Prediction

BIOCOM-Cov2 Degree = 2

Actual ρ2 = 0.8

Risk diagram

Risk diagram (last 15 days)
Norway 07-07-2020. Pop: 5.4M. Cumulative incidence: 165/10^5
Finland  07-07-2020. Pop: 5.5M. Cumulative incidence: 131/10^5

[Graphs showing cumulative confirmed cases, number of cases, incident observed cases, incident cases per 10^3 inh., case fatality rate (%), and risk diagrams.]

**Risk diagram**

July 07

April 29

**Risk diagram (last 15 days)**

July 07

June 22
Luxembourg 07-07-2020. Pop: 0.6M. Cumulative incidence: 735/10\(^5\)

BIOCOM-Cov2 Degree = 1

Actual $p = 1.1$
Greece 07-07-2020. Pop: 10.4M. Cumulative incidence: 34/10^5

**Cumulative confirmed cases**

![Graph showing cumulative confirmed cases over time.]

**Cumulative confirmed deaths**

![Graph showing cumulative confirmed deaths over time.]

**Number of cases**

![Graph showing the number of cases over time.]

**Cases per 10^5 inhabitants**

![Graph showing cases per 10^5 inhabitants over time.]

**Incident observed cases**

![Graph showing incident observed cases over time.]

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

![Graph showing incident cases per 10^5 inhabitants over time.]

**BIOCIM-Cov2 Degree = 2**

![Graph showing BIOCIM-Cov2 Degree over time.]

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

![Graph showing incident observed cases per 10^5 inhabitants over time.]

**Actual \(\rho_1 = 1.4\)**

![Graph showing actual \(\rho_1\) over time.]

**Case Fatality rate (%)**

![Graph showing case fatality rate over time.]

**Risk diagram**

![Graph showing risk diagram with points indicating active cases per 10^5 inh. (last 14 days).]

**Risk diagram (last 15 days)**

![Graph showing risk diagram with points indicating active cases per 10^5 inh. (last 10 days).]
Croatia 07-07-2020. Pop: 4.1M. Cumulative incidence: 80/10^5

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 vs time (day)

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

Actual \( p_y = 1.3 \)

Case fatality rate (%) vs time (day)

Risk diagram

Risk diagram (last 15 days)
Iceland 07-07-2020. Pop: 0.3M. Cumulative incidence: 549/10^5

Not enough data

Actual $p_f = 1.5$

Risk diagram

Risk diagram (last 15 days)
Lithuania 07-07-2020. Pop: 2.7M. Cumulative incidence: 68/10^5
Slovakia 07-07-2020. Pop: 5.5M. Cumulative incidence: 32/10^5

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 ρ̂ = 2.1

Case Fatality Rate (%) vs Time (Days)

Risk diagram

Risk diagram (last 15 days)
Latvia 07-07-2020. Pop: 1.9M. Cumulative incidence: 60/10^5
Cyprus 07-07-2020. Pop: 1.2M. Cumulative incidence: 83/10^5

![Incident observed cases](image)

**Actual ρ_2 = 1.1**

![Risk diagram](image)

![Risk diagram (last 15 days)](image)
Malta 07-07-2020. Pop: 0.4M. Cumulative incidence: 152/10^5
(2) Analysis and prediction of COVID-19 for other countries

USA 07-07-2020. Pop: 331.0M. Cumulative incidence: 905/10^5
Brazil 07-07-2020. Pop: 212.6M. Cumulative incidence: 785/10^5
Russia  07-07-2020. Pop: 145.9M. Cumulative incidence: 476/10^5
Chile 07-07-2020. Pop: 19.1M. Cumulative incidence: 1575/10^5
Iran 07-07-2020. Pop: 84.0M. Cumulative incidence: 293/10^5

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

![Graph showing cumulative deaths over time.](Image)

![Graph showing number of cases and cases per 10^6 inhabitants over time.](Image)

![Graph showing incident observed cases and incident observed cases per 10^3 inh. over time.](Image)

![Graph showing actual $\rho_t = 1.0$.](Image)

![Graph showing case fatality rate (%) over time.](Image)

![Risk diagram.](Image)

![Risk diagram (last 15 days).](Image)

- Cases
- Deaths
- Predictions

- Confirmed cases
- Estimated cases

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

- Actual R_t = 1.0

- Case Fatality rate (%)

- Risk diagram
- Risk diagram (last 15 days)
Turkey 07-07-2020. Pop: 84.3M. Cumulative incidence: 247/10^5

[Graphs showing cumulative confirmed cases, number of cases, incident observed cases, actual ρ_f = 0.9, case fatality rate (%), risk diagrams for July 07, March 29, June 22, and July 07 for last 15 days.]
Canada 07-07-2020. Pop: 37.7M. Cumulative incidence: 281/10^5
Qatar 07-07-2020. Pop: 2.9M. Cumulative incidence: 3504/10^5

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 $p_2 = 0.8$

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 10^5 inhabitants vs. Time (day)

Incident observed cases vs. Time (day)

Actual p_f = 1.3

Incident cases per 10^5 inh.

BIOCOM-Cov2 Degree = 7

Incident observed cases per 10^5 inh.

Risk diagram

Risk diagram (last 15 days)
Israel 07-07-2020. Pop: 8.7M. Cumulative incidence: 372/10^5
South Korea 07-07-2020. Pop: 51.3M. Cumulative incidence: 26/10^5

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Cases per 10^5 inhabitants
- Incident observed cases
- Incident observed cases per 10^5 inh.

Actual \( p_f = 1.1 \)

- Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Malaysia 07-07-2020. Pop: 32.4M. Cumulative incidence: 27/10^5

[Graphs and charts showing cumulative confirmed cases, cumulative confirmed deaths, number of cases, cases per 10^5 inhabitants, incident observed cases, incident cases per 10^5 inh., and risk diagrams for July 07, December 30, July 07, June 22 with active cases per 10^5 inh. (last 14 days).]
Andorra 07-07-2020. Pop: 0.1M. Cumulative incidence: 1107/10^5

- Cumulative confirmed cases vs. Time (days)
- Cumulative confirmed deaths vs. Time (days)
- Incidence observed cases vs. Time (days)
- Incident cases per 10^5 inh. vs. Time (days)
- Actual ρ_f = NA
- Case fatality rate (%) vs. Time (days)
- Risk diagram
- Risk diagram (last 15 days)
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

Data updated on 6th July, data series built with the day of the symptoms’ onset, reliable until 1st July.

Spain 01-07-2020. Pop: 47.0M. Cumulative incidence: 582/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 3

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)

Deaths series currently under revision

Actual $p_f = 0.9$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Catalunya 01-07-2020. Pop: 7.7M. Cumulative incidence: 752/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 5

Incident cases per 10^5 inh.

Risk diagram

Risk diagram (last 15 days)
Castilla Leon 01-07-2020. Pop: 2.4M. Cumulative incidence: 1113/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 2

Risk diagram

Risk diagram (last 15 days)
Castilla-La Mancha 01-07-2020. Pop: 2.0M. Cumulative incidence: 1103/10^5

Deaths series currently under revision

BIOCOC-Cov2 Degree = 3

Risk diagram

Risk diagram (last 15 days)
Andalucía 01-07-2020. Pop: 8.4M. Cumulative incidence: 201/10^5

Deaths series currently under revision

BIOCOS-Cov2 Degree = 2

Risk diagram

Risk diagram (last 15 days)
C Valenciana 01-07-2020. Pop: 5.0M. Cumulative incidence: 299/10^5

Deaths series currently under revision

Actual $p_f = 1.2$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Euskadi 01-07-2020. Pop: 2.2M. Cumulative incidence: 664/10^5

Deaths series currently under revision

Actual $\rho_I = 1.2$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Galicia 01-07-2020. Pop: 2.7M. Cumulative incidence: 402/10^5

Deaths series currently under revision

Actual $p_2 = 2.5$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Aragon 01-07-2020. Pop: 1.3M. Cumulative incidence: 535/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 4

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Extremadura  01-07-2020. Pop: 1.1M. Cumulative incidence: 534/10^5

Deaths series currently under revision

Actual $r_\gamma = 3.0$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
La Rioja 01-07-2020. Pop: 0.3M. Cumulative incidence: 1261/10^5

Deaths series currently under revision

Actual $\rho_I = NA$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Canarias 01-07-2020. Pop: 2.2M. Cumulative incidence: 117/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 1

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Murcia 01-07-2020. Pop: 1.5M. Cumulative incidence: 167/10^5

Deaths series currently under revision

Actual $p_2 = 0.9$

Deaths series currently under revision

Risk diagram
Asturias 01-07-2020. Pop: 1.0M. Cumulative incidence: 238/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 1

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Baleares  01-07-2020. Pop: 1.1M. Cumulative incidence: 206/10^5

Deaths series currently under revision

Actual $p_f = 0.8$

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Cantabria 01-07-2020. Pop: 0.6M. Cumulative incidence: 406/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 2

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
Ceuta  01-07-2020. Pop: 0.1M. Cumulative incidence: 262/10^5

Deaths series currently under revision

BIOCOM-Cov2 Degree = 0

Deaths series currently under revision

Risk diagram

Risk diagram (last 15 days)
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 \((t-1)\):

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

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


(4) **Fitting a mathematical model to data**

Previous studies have shown that Gompertz model\(^6\) 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:

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

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:

• Group A: prediction of expected cumulated cases for the following 3-5 days;
• 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 `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 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.

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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.