Daily report 24-07-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries
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
Globally the pandemic continues to grow unabated. We have surpassed 15 million confirmed cases and 250,000 new cases daily. Overall, more than 630,000 people have died. On average, in the last month we have more than 5,000 deaths a day. The pandemic continues and does not seem to be holding back at the moment. At the current rate, on August 10 we will reach 20 million cases and we will have exceeded 700,000 deaths.

In Europe we are worried about new outbreaks. Nevertheless, the problems in Europe are very small when comparing to what is occurring in other countries. If we look at the EU+EFTA+UK countries, those with highest daily new cases per 100,000 inhabitants are **Luxembourg** (degree 9 on the Biocom-Cov degree scale), **Romania** (6), **Spain** (6), **Sweden** (5) and **Bulgaria** (5).
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>BioCom-Cov degree</th>
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<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) \( \rho_7 \) 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 \( \rho_7 \) (empiric reproduction number). EPGEST is the product of estimated real 14-day attack-rate of lst 14 days per 10^5 inhabitants by \( \rho_7 \). 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).
Analysis: Index for the comparison among number of cases with different diagnosis rates in the same country at different times (II). Updating risk diagrams.

On Report #104\(^1\), we discussed the generalized increase in diagnostic rate and its implications when trying to compare current situation with that of 4 months ago. We proposed a way to rescale the number of cases in a new magnitude, considering the percentage of positive tests among total number of tests performed. Ideally, only tests devoted to new diagnosis should be included in that total number, since a significant percentage of tests are used for detecting cured patients. Nevertheless, if this data is not available, direct percentage of positive tests among total performed tests can be used.

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

We take as baseline the positivity proposed by WHO as threshold for identifying those countries that would be ready for de-escalation, which is 5%.

Let us start with two Spanish cities that are suffering secondary outbreaks: Barcelona and Lleida. These are their risk diagrams built with reported data from 1st May to 21st July, without rescaling procedure (Figure 1). It has to be mentioned that Lleida presents huge incidences, but these kind of situations are found when we descend to the local scale, where populations are lower and the incidence easily increases with a local outbreak.

![Barcelona and Lleida Risk Diagrams](image)

**Figure 1:** Risk diagrams of Barcelona (left) and Lleida (right), two Spanish cities.

Barcelona’s risk diagram suggests that current active cases per 100,000 inhabitants (around 140) are at the same level as active cases on 1st May. Are both situations comparable? If we look at Lleida, we see that current situation is worse than the situation in any other moment of the pandemic. Is that true? Let us build both risk diagrams but using the new magnitude for building them. The colour code will be translated from plain diagrams to rescaled ones, but it should be still revised in subsequent analyses.

\(^1\) https://upcommons.upc.edu/handle/2117/327195
We see that, on the one hand, the situation at the beginning of May was better in both cities. The positivity was low at that time, while it has increased last month. Looking at Barcelona, we see that current situation could be better than the one depicted by non-rescaled values, with a $\rho_7$ below 1. This has to be considered with caution, since this $\rho_7$ is not measuring real contagions but the trend to increase or decrease of the rescaled magnitude. In fact, we see that incidence is clearly increasing despite the rescaled magnitude could show a slight slowing down.

Assuming the same methodology, let us see how the risk diagrams of different European countries could change with the new magnitude. Figures 3-8 are shown in the following pages. For each country we show the original and rescaled risk diagrams, and a zoom in last month. Regarding United Kingdom, we only consider the period before the change in the reporting system, which caused discontinuities in data.

We see that the picture changes with the rescaled magnitude. In particular, we see that last month most of the plotted countries are moving in a more secure zone that the one suggested by reported data (shift from yellow to green). This is in accord with an increasing trend in diagnostic rate. Higher reported number of cases does not reflect the same worsening of the situation as 4 months ago. Nevertheless, this rescaled magnitude should still be revised for interpreting its meaning and tuning the colour scale in a more precise manner.
Figure 3: Original (up) and rescaled (down) risk diagrams of United Kingdom. Right: zoom of the last month.
Figure 4: Original (up) and rescaled (down) risk diagrams of Switzerland. Right: zoom of the last month.
Original risk diagrams

Risk diagrams with rescaled magnitude

**Figure 5:** Original (up) and rescaled (down) risk diagrams of Sweden. Right: zoom of the last month.
Figure 6: Original (up) and rescaled (down) risk diagrams of Italy. Right: zoom of the last month.
**Figure 7:** Original (up) and rescaled (down) risk diagrams of Belgium. Right: zoom of the last month.
Figure 8: Original (up) and rescaled (down) risk diagrams of Austria. Right: zoom of the last month.
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. EPG\textsubscript{REP} and EPG\textsubscript{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 2\textsuperscript{nd} July.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10\textsuperscript{5} inh.</th>
<th>Cumulative deaths</th>
<th>Mortality /10\textsuperscript{5} inh.</th>
<th>Active cases (last 14 days)</th>
<th>14-day attack rate /10\textsuperscript{5} inh.</th>
<th>Estimated active cases (last 14 days)</th>
<th>14-day attack rate /10\textsuperscript{5} inh.</th>
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</table>

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

\( \rho_T \) is the average of 7 consecutive \( \rho \), but can still fluctuate.\(^2,3\) EPG stands for Effective Growth Potential. EPG\textsubscript{REP} is the product of attack-rate of last 14 days per 10\textsuperscript{5} inhabitants by \( \rho_T \) (empiric reproduction number). EPG\textsubscript{EST} is the product of estimated real attack-rate of last 14 days per 10\textsuperscript{5} inhabitants and \( \rho_T \). Bio-com-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).
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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Other countries

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

Italy
Data from 24th July

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate [10^6 inh.]</th>
<th>Mortality [2/10^3 inh.]</th>
<th>Active cases (last 14 days)</th>
<th>24-day attack rate [10^6 inh.]</th>
<th>Estimated active cases (last 14 days)</th>
<th>EPGREP</th>
<th>EPGEST</th>
<th>Biocom-Cov degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lombardy</td>
<td>25,704</td>
<td>557.7</td>
<td>23.7</td>
<td>167.3</td>
<td>9,6</td>
<td>10,563</td>
<td>154.7</td>
<td>0.86</td>
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<td>Piedmont</td>
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<td>23</td>
<td>2,750</td>
<td>98.2</td>
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<tr>
<td>Campania</td>
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<td>119.3</td>
<td>8,6</td>
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<td>1,088</td>
<td>122.1</td>
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<td>Liguria</td>
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<td>1,088</td>
<td>122.1</td>
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<td>Lazio</td>
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<td>14</td>
<td>6,510</td>
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<td>Marche</td>
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<td>16.7</td>
<td>137.7</td>
<td>3.1</td>
<td>2788</td>
<td>13.6</td>
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<td>6,510</td>
<td>73.2</td>
<td>1.67</td>
<td>6</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. EPGREP is the product of attack-rate of last 14 days per 10^5 inhabitants by $\rho_7$ (empiric reproduction number). EPGEST 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).

Spain
Data from 14th July. Symptoms onset date.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate [10^6 inh.]</th>
<th>Mortality [2/10^3 inh.]</th>
<th>Active cases (last 14 days)</th>
<th>24-day attack rate [10^6 inh.]</th>
<th>Estimated active cases (last 14 days)</th>
<th>$\rho_7$</th>
<th>EPGREP</th>
<th>EPGEST</th>
<th>Biocom-Cov degree</th>
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<td>1,545</td>
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<td>1.33</td>
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<td>1,020.3</td>
<td>246.8</td>
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<td>1.76</td>
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<td>1,010</td>
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<td>332</td>
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<td>332</td>
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</tbody>
</table>

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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.

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

Evolution of empiric reproductive number $\rho_f$

Case fatality rate

Risk diagram

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

Spain 22-07-2020. Pop: 47.0M. Cumulative incidence: 575/10^5
France 23-07-2020. Pop: 65.3M. Cumulative incidence: 275/10^8

- Cumulative confirmed cases vs. Time (days)
- Cumulative confirmed deaths vs. Time (days)
- Number of cases vs. Time (days)
- Cases per 10^6 inhabitants vs. Time (days)

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

- Actual R₉ = 1.6

- Risk diagram
- Risk diagram (last 15 days)

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^8 inhabitants

Incident observed cases

Incident cases per 10^8 inh.

BiOCoM-Cov2 Degree = 5

Incident observed cases per 10^8 inh.

Actual ρ_{i} = 0.7

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases vs. cumulative confirmed deaths.

Incident observed cases over time.

Actual reproduction number (Rₚ) = 1.1

Case fatality rate over time.

Risk diagram vs. last 15 days.

- Cases
- Deaths
- Predictions

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Confirmed cases

Estimated cases

BIOCIBM-Cov2 Degree = 6

Incident observed cases

Incident cases per 10^3

Incident observed cases per 10^3

Actual \( p_2 = 1.4 \)

Case Fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

![Cumulative confirmed cases and deaths](image1)

![Number of cases and confirmed deaths](image2)

![BIOC-Cov2 Degree = 2](image3)

![Actual Rg = 1.0](image4)

![Case Fatality rate (%)](image5)

![Risk diagram](image6)

![Risk diagram (last 15 days)](image7)

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

Incident observed cases
- Confirmed
- Predicted

BIOCOM-Cov2 Degree = 4

Actual $r_2 = 1.6$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Denmark 23-07-2020. Pop: 5.8M. Cumulative incidence: 231/10^5

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

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 $p_2 = 1.5$

BIOCOM-Cov2 Degree = 3

Incident observed cases

Incident cases per 10^5 inh.

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

July 23

March 12

July 23

July 08
Finland  23-07-2020. Pop: 5.5M. Cumulative incidence: 133/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^3 inh.

Incident observed cases

Incident observed cases per 10^3 inh.

Actual $\rho_T$ = NA

Case fatality rate (A)

Risk diagram

Risk diagram (last 15 days)
Luxembourg 23-07-2020. Pop: 0.6M. Cumulative incidence: 951/10^5

- 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 = 9

- 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 $\rho_\gamma = 1.7$

- 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)
- Incident observed cases vs. Time (day)
- Incident cases per 10^3 inh. vs. Time (day)
- Actual ρ_f = 0.7
- Case Fatality rate (%) vs. Time (days)
- Risk diagram
- Risk diagram (last 15 days)

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

BIOCOM-Cov2 Degree = 3

Incident observed cases per 10^5 inh.

Actual $\rho_7 = 1.1$

Risk diagram

Risk diagram (last 15 days)

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

Actual $\rho_2 = 2.1$

Risk diagram

Risk diagram (last 15 days)
Lithuania 23-07-2020. Pop: 2.7M. Cumulative incidence: 72/10^5

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

Incident observed cases
- Confirmed
- Predicted

Incident cases per 10^5 inh.

Actual p_f = 2.0

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Iceland 23-07-2020. Pop: 0.3M. Cumulative incidence: 539/10^5

Not enough data

CASES

Incident observed cases

Incident cases per 10^5 inh.

Actual ρ_f = NA

Risk diagram

Risk diagram (last 15 days)
Latvia 23-07-2020. Pop: 1.9M. Cumulative incidence: 64/10^5
Cyprus 23-07-2020. Pop: 1.2M. Cumulative incidence: 87/10^5
(2) Analysis and prediction of COVID-19 for other countries

Brazil  23-07-2020. Pop: 212.6M. Cumulative incidence: 1076/10^5

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**BIOCOM-Cov2 Degree = 9**

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**Actual ρy = 1.1**

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**Risk diagram**

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**Risk diagram (last 15 days)**
India  23-07-2020. Pop: 1380.0M. Cumulative incidence: 93/10^5

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 10^3 inh. vs Time (day)

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

Actual \( p_2 = 1.0 \)

Case Fatality Rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)

July 23

May 12

July 08

Active cases per 10^5 inh. (last 14 days)
Peru 23-07-2020. Pop: 33.0M. Cumulative incidence: 1125/10^5

![Graphs showing cumulative cases, deaths, number of cases, incident observed cases, incident cases per 10^5 inh., and risk diagrams.](image-url)

BIOCOM-Cov2 Degree = 8

Actual ρ_7 = 1.0

Risk diagram

Risk diagram (last 15 days)
Saudi Arabia  23-07-2020. Pop: 34.8M. Cumulative incidence: 748/10⁵

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Predictions

- Number of cases
- Cases per 10⁵ inhabitants

- Incident observed cases
- Incident cases per 10⁵ inh.

- Actual ρ₂ = 0.9

- Case fatality rate (%)

- Risk diagram
- Risk diagram (last 15 days)
Turkey 23-07-2020. Pop: 84.3M. Cumulative incidence: 265/10^5

- [Graphs showing cumulative confirmed cases and deaths, as well as incident observed cases.]

- Actual $q = 1.2$

- Incident cases per 10^5 inh.

- Risk diagram

- Risk diagram (last 15 days)

Actual $p_f = 1.1$

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Cases per 10^6 inhabitants
- Incident observed cases
- Incident cases per 10^3 inh.
- Incident observed cases per 10^3 inh.
- Case fatality rate (%)

Actual $p_f = 1.4$

BIOCov2 Degree = 4

Risk diagram

Risk diagram (last 15 days)

Actual $R_0 = 0.9$
Japan 23-07-2020. Pop: 126.5M. Cumulative incidence: 22/10^5
South Korea 23-07-2020. Pop: 51.3M. Cumulative incidence: 27/10^5

![Graphs showing cumulative confirmed cases, cumulative deaths, number of cases, and cases per 10^3 inhabitants over time, along with incident observed cases and incident cases per 10^5 inh. for different time periods.]

Actual $p_2 = 1.0$

![Graph showing actual case fatality rate (%) over time, with risk diagram and risk diagram (last 15 days) indicating recent trends.]

73
Australia 23-07-2020. Pop: 25.5M. Cumulative incidence: 52/10^5

Actual $p_j = 1.3$
Andorra  23-07-2020. Pop: 0.1M. Cumulative incidence: 1151/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Confirmed cases

Estimated cases

Incident observed cases

Incident cases per 10^5 inh.

Incident observed cases

Cases per 10^5 inhabitants

Actual $\rho_f = NA$
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

Data updated on 24th July, data series built with the day of the symptoms’ onset, reliable until 17th July.

Spain 17-07-2020. Pop: 47.0M. Cumulative incidence: 608/10^5

[Graphs showing cumulative cases, deaths, and infections over time, with superimposed predictions.]

BIOCOM-Cov2 Degree = 5

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

Actual ρ_2 = 1.4

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

Risk diagram

[Risk diagram with active cases per 10^5 inh. (last 14 days).]

Risk diagram (last 15 days)

[Updated risk diagram with active cases per 10^5 inh. (last 14 days).]
Castilla Leon 17-07-2020. Pop: 2.4M. Cumulative incidence: 1120/10^5
C Valenciana 17-07-2020. Pop: 5.0M. Cumulative incidence: 308/10^5

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

Incident observed cases
Incident cases per 10^5

BIOCOM-Cov2 Degree = 3

Actual ρₗ = 1.7

Case fatality rate (%)

Risk diagram
Risk diagram (last 15 days)
Galicia 17-07-2020. Pop: 2.7M. Cumulative incidence: 409/10^5

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

Incident observed cases
Incident cases per 10^5 inh.

Actual ρ̂ = 0.6

Risk diagram
Risk diagram (last 15 days)
Aragon 17-07-2020. Pop: 1.3M. Cumulative incidence: 656/10^5
Navarra 17-07-2020. Pop: 0.7M. Cumulative incidence: 1268/10^5

Actual $\gamma = 1.9$
La Rioja 17-07-2020. Pop: 0.3M. Cumulative incidence: 1279/10^5

Actual $\rho_f = 3.3$

BIOCOM-Cov2 Degree = 4

Risk diagram

Risk diagram (last 15 days)
Murcia 17-07-2020. Pop: 1.5M. Cumulative incidence: 178/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^5 inhabitants

Incident observed cases

Incident cases per 10^3 inh.

Incident observed cases

Incident cases per 10^5 inh.

Actual $p_3 = 1.4$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

Actual $\rho_I = 1.2$

Risk diagram

Risk diagram (last 15 days)
Asturias 17-07-2020. Pop: 1.0M. Cumulative incidence: 239/10^5

![Graphs showing cumulative confirmed cases, number of cases, and incident observed cases over time](images)

- **Cumulative confirmed cases**
  - Time (days)
  - Cases, Deaths, Predictions
  - Curve showing increasing cumulative cases with time.

- **Number of cases**
  - Time (days)
  - Confirmed cases and estimated cases indicated.

- **Incident observed cases**
  - Time (days)
  - Confirmed and predicted cases shown.

- **Actual ρ_f = NA**
  - Time (days)
  - Scatter plot with points indicating the actual ρ_f.

- **Risk diagram**
  - Active cases per 10^5 inh. (last 14 days)
  - Observations from March 10 and July 17 highlighted.

- **Risk diagram (last 15 days)**
  - Active cases per 10^5 inh. (last 14 days)
  - Observations from July 17 and July 02 highlighted.
Ceuta 17-07-2020. Pop: 0.1M. Cumulative incidence: 263/10^5

- **Cumulative confirmed cases**
  - Cases: Circles
  - Deaths: Squares
  - Predictions: Triangles

- **Cumulative confirmed deaths**

- **Incident observed cases**

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

- **Actual ρ_f = NA**

- **Risk diagram**

- **Risk diagram (last 15 days)**

- **BIOCOM-Cov2 Degree = 2**

- **Not enough data**

96
(4) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: https://github.compcm-dpc/COVID-19/tree/master/dati-andamento-nazionale

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

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^6 inhabitants

Incident observed cases

Incident cases per 10^6

Incident observed cases per 10^6 inhabitants

Actual $p_2 = 0.9$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases:
- Actual cases
- Predicted cases

Cumulative confirmed deaths:
- Confirmed cases
- Estimated cases

Incident observed cases:
- Confirmed cases
- Predicted cases

BIOCOM-Cov2 Degree = 2

Actual $\rho_2 = 1.2$

Risk diagram

Risk diagram (last 15 days)
Toscana 24-07-2020. Pop: 3.7M. Cumulative incidence: 279/10^5
Liguria 24-07-2020. Pop: 1.6M. Cumulative incidence: 654/10^5

Actual $\rho_1 = 3.1$

BIOCov2 Degree = 3
Lazio 24-07-2020. Pop: 5.9M. Cumulative incidence: 145/10^5
Marche 24-07-2020. Pop: 1.5M. Cumulative incidence: 447/10^5

- Cases
- Deaths
- Predictions

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 \( p_x = 1.2 \)

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

Risk diagram

Risk diagram (last 15 days)
Trento 24-07-2020. Pop: 0.5M. Cumulative incidence: 921/10^5

BIOCOM-Cov2 Degree = 5

Actual $\rho_f = NA$

Risk diagram

Risk diagram (last 15 days)
Campania 24-07-2020. Pop: 5.8M. Cumulative incidence: 84/10^5

Cumulative confirmed cases vs Time (days)

Incident observed cases vs Time (day)

Actual p₂ = 1.8

BIOCOM-Cov2 Degree = 2

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases

Cumulative deaths

Predictions

Number of cases

Cases per 10^6 inhabitants

Confirmed cases

Estimated cases

BIOCOM-Cov2 Degree = 2

Incident observed cases

Incident cases per 10^6 inh.

Actual \(\rho_J = 2.1\)

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Abruzzo 24-07-2020. Pop: 1.3M. Cumulative incidence: 256/10^5

Cumulative confirmed cases

Cumulative confirmed deaths

Number of cases

Cases per 10^3 inhabitants

Incident observed cases

Incident cases per 10^3 inh.

Actual $p_3 = 1.9$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)
Sicilia 24-07-2020. Pop: 5.0M. Cumulative incidence: 63/10^5

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**Cumulative confirmed cases**

- Cases: Blue line (solid)
- Deaths: Red line (dashed)
- Predictions: Green line (dotted)

**Cumulative confirmed deaths**

- Green line: Confirmed cases
- Blue line: Estimated cases

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**Incident observed cases**

- Blue line: Confirmed
- Red line: Predicted

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

- Blue line: Confirmed
- Red line: Predicted

**Actual 𝑅_0 = 2.4**

**Case fatality rate (%)**

- Blue line: Case fatality rate

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**Risk diagram**

- July 24
- March 22

**Risk diagram (last 15 days)**

- July 24
- July 09
Umbria 24-07-2020. Pop: 0.9M. Cumulative incidence: 166/10^5

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)

Actual $\rho_\gamma = 1.6$

Case Fatal rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)
Sardegna 24-07-2020. Pop: 1.6M. Cumulative incidence: 84/10^5
Calabria 24-07-2020. Pop: 1.9M. Cumulative incidence: 64/10^5

![Cumulative confirmed cases](image)

![Cumulative confirmed deaths](image)

![Incident observed cases](image)

![Incident cases per 10^3 inh.](image)

Actual $p_f = 0.9$

![Risk diagram](image)

![Risk diagram (last 15 days)](image)
Methods
Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports, from European Centre for Disease Prevention and Control (ECDC) and from Ministerio de Sanidad. 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 ($t-1$):

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

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.

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2 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 \(^5\) 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:

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

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

- \(a\) is the velocity at which specific spreading rate is slowing down;
- \(K\) is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported 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:

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• 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 \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\(^7\) 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.