Daily report 15-06-2020

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
Global EU+EFTA+UK trends and needs

Globally in the EU + EFTA + UK the pandemic is in its final stages, yet covid-19 is still present everywhere. UK and Sweden alone still have more than 1,000 cases a day.

Globally, we have exceeded 1.5 million confirmed cases, a huge number. This corresponds to around 286 cases per 100,000 inhabitants. The death toll is also huge, with more than 173,000 deaths. Gompertz’s model is forecasting a total amount of 180,000 deaths by the end of this wave.

Since May 21, the daily new case curve has stopped declining. We still have a significant number of active cases, up to 74,366 last 14 days, which corresponds to 14 cases per 100,000 inhabitants. The average number of new cases in the last seven days is about 5,300. This value corresponds to 1 case per 100,000 inhabitants (grade 3 on the Biocom-Cov scale).

The analysis is focused on the situation in Pernambuco, a Brazilian state.

Highlights for specific countries

The number of deaths in Spain has not been updated for the last 7 days, since historical series is under revision. Sweden remains at the level of 1,000 daily new cases, with a $\rho_7$ of 1.1 and an EPG of 153 (high risk). The only country at intermediate risk is Portugal, with an EPG of 40, a $\rho_7$ of 1 and 40 active cases per 100,000 inhabitants. UK is at low-intermediate risk, thanks to a $\rho_7$ of 0.87. Bulgaria should be watched out the next days, since a $\rho_7>1$ is starting to be pushed by an increasing number of active cases, although reported data present some inconsistencies that could mask the real trends.

The map in the left shows current A14. The map in the right shows current EPG.
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.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10^3 inh.</th>
<th>Cumulative deaths /10^3 inh.</th>
<th>Mortality /10^3 inh.</th>
<th>Active cases (last 14 days)</th>
<th>14-day attack rate /10^3 inh.</th>
<th>Estimated active cases (last 14 days)</th>
<th>Estimated 14-day attack rate /10^3 inh.</th>
<th>Biocom-Cov degree</th>
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<td>2.0</td>
<td>100</td>
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Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).
The epidemiological situation in Brazil is very worrying. The country presents more than 800,000 confirmed cases with, lately, 30,000 new daily cases. The death toll is also large with more than 40,000 cumulative deaths. The latest official figures also indicate more than 1,000 deaths daily. Reality could be worse. In this analysis we use risk diagrams as a good tool to easily understand the epidemiological situation and assess its possible evolution. Looking at the average risk diagram of all Brazil we see how each data point (new day) is consistently moving to the right in the diagram, showing an increase in the number of active cases. Right now, we also observe that $\rho$ persists at a level which seems a little bit higher than 1.

Brazil is a huge and diverse country. To grasp the real situation on the ground, we need to look at a lower geographical scale. We need to analyze the data coming from different states and the different cities. We find that it is enlightening to study the situation in Pernambuco.

The risk diagram of the state of Pernambuco shows a better epidemiological situation than the average of Brazil as a whole. Despite reaching a rather high level of active cases, at a certain point a clear process of reduction of new cases and general improvement ensued. Yet, it is still in the red zone of the diagram, the
high-risk zone, where we consider test and tracing to be impossible to succeed. If control measures are relaxed, it is likely that \( \rho_7 \) will rise again above 1 and the graph may shift again to the right. From an epidemiological perspective, maintaining measures to minimize the appearance of new cases seems the proper policy until reaching the green area of the figure. Once it is reached, opening of the economy and the consequent increase in contacts can help to test the ability to diagnose new cases and control their contacts.

We can proceed now at an even lower geographical scale, looking at the evolution of cities. It might help us think about what is the most probable short-term scenario. We can begin by analyzing the evolution of the epidemic in Recife, the state capital, a city of approximately 1.5 million inhabitants. Since March 24, the situation has worsened as we see in the following graph where we see the evolution of the EPG.

On May 16 (line 1) a partial closure of the city was decreed, people mostly stayed in their homes. As we have seen in European countries, in a few days we see how the situation begins to improve. The EPG grew to a value close to 600, a very large value, which shows a very complex epidemiological situation. The partial closure of the city stops the growth and the EPG begins to decline significantly. On May 31, the authorities decree the end of the closure, the rate of decline of the EPG slows down, and finally stabilizes.

The risk diagram below shows the same behavior. The effects of the partial confinement have managed to slow down the spread of the epidemics, the graph is moving to the left, approaching the green color. However, they still have a very large \( A_{14} \) value, and \( \rho_7 \) is growing. If the propagation speed exceeds the value of 1, the curve can probably move to the right again. It would be advisable to extend the containment measures until they get closer to the green area of the diagram.

Next map shows the location of the main cities in the state.
The incidence has been much higher in cities closer to the coast, although this may be a reality that will change over time. At present, we observe a different behavior between cities that have made partial closures and those that have not.

A behavior similar to that observed in Recife is found in the other four cities in the state that have implemented partial closures, all close to Recife: Olinda (370k inhabitants), Jaboatão dos Guarapes (335k inhabitants), Camaragibe (144k) and São Lourenço da Mata (112k). All risk diagrams are evolving to the left, reducing the level of active cases.

The last points of the Camaragibe risk diagram are difficult to interpret. We can zoom in to see more closely the evolution during the last days. Then, we see how Camaragibe has actually improved but the reduction in number of active cases has slowed down.
We proceed to look at the behavior of Caruaru, a city of about 278,000 inhabitants located about 140 km from the coast where no partial closure measures were taken.

We do not see a decrease in the EPG and the risk diagram shows that each day the number of active cases increases (it moves to the right). The situation at the moment is worse than in some of the coastal cities we have mentioned before. In Caruaru the EPG is 101, while in São Lourenço da Mata it is 56. The situation can certainly get worse. If the situation gets worse, measures to limit the mobility of the population might need to be implemented in order to contain the local transmission.

Finally, a small city worth mentioning in this assessment is Palmares, a small town of about 59,000 inhabitants, located about 120 km south of Recife. Probably the city with the worst epidemiological situation in the state. At no point did the city restrict the mobility and contacts of the population.
We can take the evolution of this city as an example of the need to take steps to reduce the spread of
COVID-19. A sober assessment of the Brazilian demographics suggests a lethality of the virus for the country
at around 0.2% in the best-case scenario and around 0.5% in the worst-case. Using a 2/3 herd immunity
threshold to obtain a back of the envelope calculation of the number of deaths required to obtain it, we
would be talking of about a quarter million deaths in the optimistic scenario, and half a million as a reasonable
estimation. If the virus proceeds without interruption, we expect the daily toll to reach 2,000 shortly. As we
can see, even if they were to stabilize, in three months they could be close to herd immunity levels with
200,000 more people dead.
Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. 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.

<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>42,280</td>
<td>121.4</td>
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<th>Worst</th>
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<td>Best</td>
<td>Best</td>
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<td>Best</td>
<td>Best</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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

(1) $\rho_7$ is the average of 7 consecutive $\rho$, but can still fluctuate. (2,3) EPG stands for Effective Growth Potential. 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).
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).

**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>
<td>113</td>
<td>11</td>
<td>16</td>
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<tr>
<td>Germany</td>
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<td>United Kingdom</td>
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<td>Greece</td>
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<td>Slovenia</td>
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<td>Estonia</td>
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<td>Ireland</td>
<td>93</td>
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<td>Poland</td>
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<td>17</td>
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<td>15</td>
<td>66</td>
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<tr>
<td>Luxembourg</td>
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<td>30</td>
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<td>Croatia</td>
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<td>Hungary</td>
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<td>Latvia</td>
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<td>Lithuania</td>
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<td>9</td>
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<tr>
<td>Cyprus</td>
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</table>
### Other countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Days since the first 100 cases</th>
<th>Time interval between 1 and 10 cases / $10^5$ inh. (days)</th>
<th>Time interval between 10 and 100 cases / $10^5$ inh. (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>110</td>
<td>11</td>
<td>42</td>
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<tr>
<td>United States of America</td>
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<td>8</td>
<td>15</td>
</tr>
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<td>Canada</td>
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<td>Qatar</td>
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<td>Brazil</td>
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<td>20</td>
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<td>Saudi Arabia</td>
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<td>Chile</td>
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<td>India</td>
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<td>Ecuador</td>
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<td>Argentina</td>
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</tr>
<tr>
<td>Belarus</td>
<td>77</td>
<td>10</td>
<td>18</td>
</tr>
</tbody>
</table>
Long-term predictions

Evaluated with the whole historical series. Up-left: Predictions of maximum incidences per country at the end of the first wave (total final expected attack rate per $10^6$ 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).
## Situation and trends in Italian regions

### Situation and trends

<table>
<thead>
<tr>
<th>Country</th>
<th>Cumulative cases</th>
<th>Attack rate /10^5 inh.</th>
<th>Mortality /10^5 inh.</th>
<th>Active cases</th>
<th>Active attack rate /10^5 inh.</th>
<th>Estimated active cases (last 14 days)</th>
<th>Estimated 14-day attack rate /10^6 inh.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lombardy</td>
<td>35,012</td>
<td>75.3</td>
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<td>Liguria</td>
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<tr>
<td>Sicilia</td>
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<td>35.9</td>
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<tr>
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<td>0.3</td>
<td>875</td>
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<td>875</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. \( \rho_T \) is the average of 7 consecutive \( \rho \), but can still fluctuate. 2. 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 attack-rate of last 14 days per 10^5 inhabitants and \( \rho_T \). Biocom-Cov degree is an epidemiological situation scale based on the level of last week’s mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

### Long-term predictions

Are not shown any more, since all Italian regions are already in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

---

2 Spain: Historical series have not been updated. Therefore, regional analysis is not shown
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 \( \rho \)

Case fatality rate

Risk diagram

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


Cumulative confirmed cases vs. time (days)

Cumulative confirmed deaths vs. time (days)

Incident observed cases vs. time (day)

Confirmed vs. Prediction

Actual $R_0 = 0.9$

Case fatality rate % vs. time (day)

Risk diagram

Risk diagram (last 15 days)
Italy 14-06-2020. Population: 60.5M. Current cumulative incidence: 392/10^5

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Predictions

- Number of cases
- Estimated cases
- Cases per 10^3 inhabitants

- Incident observed cases
- Incident cases per 10^3

- Incident observed cases per 10^3 inhabitants

- Actual $\rho = 0.9$

- Case fatality rate (%)

- Active cases per 10^3 inhabitants (last 14 days)

- Risk diagram

- Risk diagram (last 15 days)

**Cumulative confirmed cases**

- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

- Confirmed cases
- Estimated cases

**Incident observed cases**

- Confirmed
- Prediction

**BIOCOM-Cov2 Degree = 2**

**Actual p2 = 1.4**

**Risk diagram**

**Risk diagram (last 15 days)**

- Cumulative confirmed cases and deaths
- Predicted cases

- Number of cases and confirmed deaths
- Estimated cases

- Incident observed cases
- Predicted cases

- Actual $R_t = 0.8$

- Case fatality rate (%)

- Risk diagram

- Risk diagram (last 15 days)

- [Graph showing cumulative confirmed cases over time]
- [Graph showing cumulative confirmed deaths over time]
- [Graph showing number of cases over time]
- [Graph showing cases per 10^5 inhabitants over time]

**Actual ρ = 1.2**

**BIOCOM-Cov2 Degree = 3**

**Risk diagram**

**Risk diagram (last 15 days)**

![Graphs showing cumulative confirmed cases, number of cases, cumulative deaths, and incident observed cases.](image)

Actual $\rho_f = 1.1$

![Graph showing incident cases per 10^3 inh.](image)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases through time.

Cumulative confirmed deaths through time.

Incident observed cases through time.

BIOCOM-Cov2 Degree = 2

Actual $\rho_2 = 1.2$

Cases Fatality rate (%) through time.

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases over time (days)

Cumulative confirmed deaths over time (days)

Number of cases over time (days)

Cases per 10⁵ inhabitants over time (days)

Incident observed cases over time (days)

Incident cases per 10⁵ inh. over time (days)

Actual $\rho_2 = 2.0$

Case identification rate (%) over time (days)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases and deaths:

- Cases: Blue line
- Deaths: Red line
- Predictions: Dotted line

Number of cases per 10^5 inhabitants:

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

Incident observed cases per 10^5 inhabitants:

- Confirmed: Blue line
- Predicted: Red line

Actual $R_t = 3.4$

Case Fatality rate (%):

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases and deaths over time.

Incident observed cases over time.

Actual $\rho_1 = 2.5$

Risk diagram and risk diagram (last 15 days)

Cumulative confirmed cases vs. Time (days)

Cumulative confirmed deaths vs. Time (days)

Number of cases vs. Time (day)

Cases per 10^7 inhabitants vs. Time (day)

Incident observed cases vs. Time (day)

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

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

Actual β̂ = 1.8

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

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases
- Number of cases
- Cases per 10^5 inhabitants
- Incident observed cases
- Incident cases per 10^5
- Incident observed cases per 10^5
- Case fatality rate (%)

Actual ρ_f = 0.8

Risk diagram

Risk diagram (last 15 days)
**Cyprus 14-06-2020. Population: 1.2M. Current cumulative incidence: 81/10^5**

**Incident observed cases**

- **Actual 𝜋₂ = 1.2**

**Risk diagram**

- June 14
- March 24

**BIOCRA-Cov2 Degree = 2**

- Incident observed cases per 10^3 inh.

**Risk diagram (last 15 days)**

- June 14
- May 30
(2) Analysis and prediction of COVID-19 for other countries


Cumulative confirmed cases

- Cases
- Deaths
- Predictions

Cumulative confirmed deaths

Cases per 10⁵ inhabitants

Incident observed cases

- Confirmed
- Prediction

Incident cases per 10⁵ inh.

BIOCOM-Cov2 Degree = 7

Incident observed cases per 10⁵ inh.

Actual $R_0 = 1.0$

Case fatality rate (%)

Risk diagram

June 14
April 13

Risk diagram (last 15 days)

June 14
May 30

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 (days)

Incident observed cases vs time (days)

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

Incident observed cases per 10^7 inh. vs time (days)

BIOC-20 Deg 3

Actual r_0 = 1.1

Case fatality rate (%) vs time (days)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases

- Cases
- Deaths
- Predictions

Cumulative confirmed deaths

Number of cases

- Confirmed cases
- Estimated cases

Cases per 10^5 inhabitants

Incident observed cases

- Confirmed
- Predicted

Incident cases per 10^3 inh.

Incident observed cases per 10^3 inh.

Actual $p_0 = 1.1$

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

Actual $\rho_f = 1.2$

[Graphs showing cumulative confirmed cases, cumulative confirmed deaths, number of cases, cases per 10^5 inhabitants, incident observed cases, incident observed cases per 10^3 inh., case fatality rate (%) over time.]

Actuarial \( \rho_f = 1.3 \)

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases vs. time

Cumulative confirmed deaths vs. time

Number of cases vs. time

Cases per 10^5 inhabitants vs. time

Incident observed cases vs. time

Incident cases per 10^5 inh. vs. time

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

Actual $\rho_2 = 1.1$

Case fatality rate (%) vs. time

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases and deaths over time (days).

Number of cases and confirmed deaths over time (days).

Incident observed cases and predicted cases over time (days).

Incident cases per 10^5 inhabitants over time (days).

Case fatality rate (%) over time (days).

Risk diagram showing active cases per 10^5 inhabitants (last 14 days).

[Graphs showing cumulative confirmed cases and deaths over time, with predictions.

Incident observed cases per 10⁵ inh.

Actual ρ = 1.1

Case fatality rate (%)

Risk diagram

Risk diagram (last 15 days)

[Graphs showing cumulative cases and deaths, incident observed cases, incident cases per 10^5 inh., and risk diagrams for active cases per 10^5 inh. (last 14 days) and for the last 15 days.]
(4) Analysis and prediction of COVID-19 for Italy and its regions

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

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 $p_f = 1.0$

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

Risk diagram

Risk diagram (last 15 days)

Actual $\rho_\gamma = 1.2$

Risk diagram

Risk diagram (last 15 days)

Cumulative confirmed cases:
- Cases
- Deaths
- Predictions

Cumulative confirmed deaths:

Number of cases per 10^5 inhabitants:

Cases per 10^5 inhabitants:

Incident observed cases:
- Confirmed
- Prediction

Incident cases per 10^3 inh.

Incident observed cases:
- Confirmed
- Prediction

Actual R_0 = 1.4

Case fatality rate (%):

Risk diagram:
- June 15
- March 17

Risk diagram (last 15 days):
- June 15
- May 31

Cumulative confirmed cases vs Time (days)

Cumulative confirmed deaths vs Time (day)

Incident observed cases vs Time (day)

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

BIOCOM-Cov2 Degree = 1

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

Actual μγ = -14.8

Case fatality rate (%) vs Time (day)

Risk diagram

Risk diagram (last 15 days)

- Cumulative confirmed cases
- Cumulative deaths
- Predictions

- Number of cases
- Confirmed cases
- Estimated cases

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

- Actual $\rho_3 = 3.0$

- Case fatality rate (%)

- Risk diagram
- Risk diagram (last 15 days)

- June 15
- March 11
- June 15
- May 31

**Cumulative confirmed cases**

- Cases
- Deaths
- Predictions

**Cumulative confirmed deaths**

- Number of cases
- Estimated cases

**Incident observed cases**

- Confirmed
- Prediction

**BIOCOM-Cov2 Degree = 1**

**Actual p_f = 1.1**

**Case fatality rate (%)**

**Risk diagram**

**Risk diagram (last 15 days)**

- Cumulative confirmed cases over time.
- Incidence observed cases per 10^5 inh.
- Actual $\nu_1 = \text{Inf}$
- Risk diagram

- Case Fatality rate (%) over time.
- Risk diagram (last 15 days)

Cumulative confirmed cases and deaths over time.

Incident observed cases over time.

Confirmed and predicted cases per 10³ inh.

Actual $\mu_2 = -\infty$

Case fatality rate (%) over time.

Risk diagram and risk diagram (last 15 days).

June 15
March 19

Risk diagram.

- Cumulative confirmed cases
- Cumulative confirmed deaths
- Number of cases
- Cases per 10^7 inhabitants

- Incident observed cases
- Incident observed cases per 10^3 inh.
- Incident observed cases per 10^4 inh.

- Actual $\rho_f$ = NA

- Case fatality rate (%)

- Risk diagram
- Risk diagram (last 15 days)

Cumulative confirmed cases and deaths over time.

Incident observed cases per 10^3 inh. over time.

Actual $\nu_f = \infty$

Case fatality rate (%) over time.

Risk diagram and risk diagram (last 15 days).
Methods
Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports\(^2\), from European Centre for Disease Prevention and Control (ECDC)\(^3\) and from Ministerio de Sanidad\(^4\). 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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(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:

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

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

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

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

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

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

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

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

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

• Group A: prediction of expected cumulated cases for the following 3-5 days\(^6\);
• 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\(^7\) 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.

\(^6\) 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.