Temporal variation in transmission during the COVID-19 outbreak in Italy

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Summary

Aim: To identify changes in the reproduction number, rate of spread, and doubling time during the course of the COVID-19 outbreak in Italy whilst accounting for potential biases due to delays in case reporting.

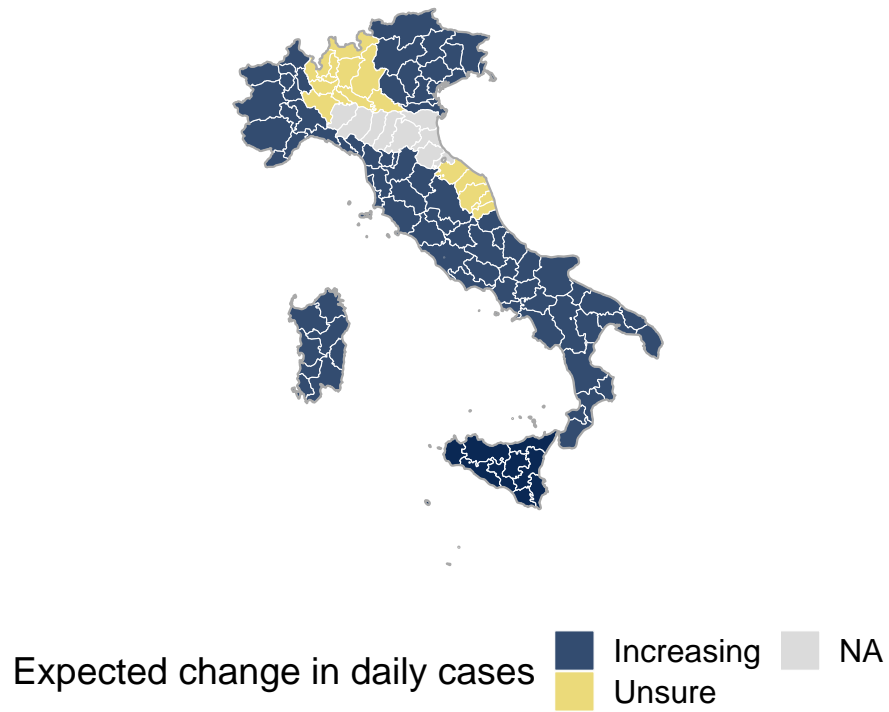**Latest estimates as of the 2020-03-15**

Map

Figure 1: Map of the expected change in daily cases based on data from the 2020-03-15.

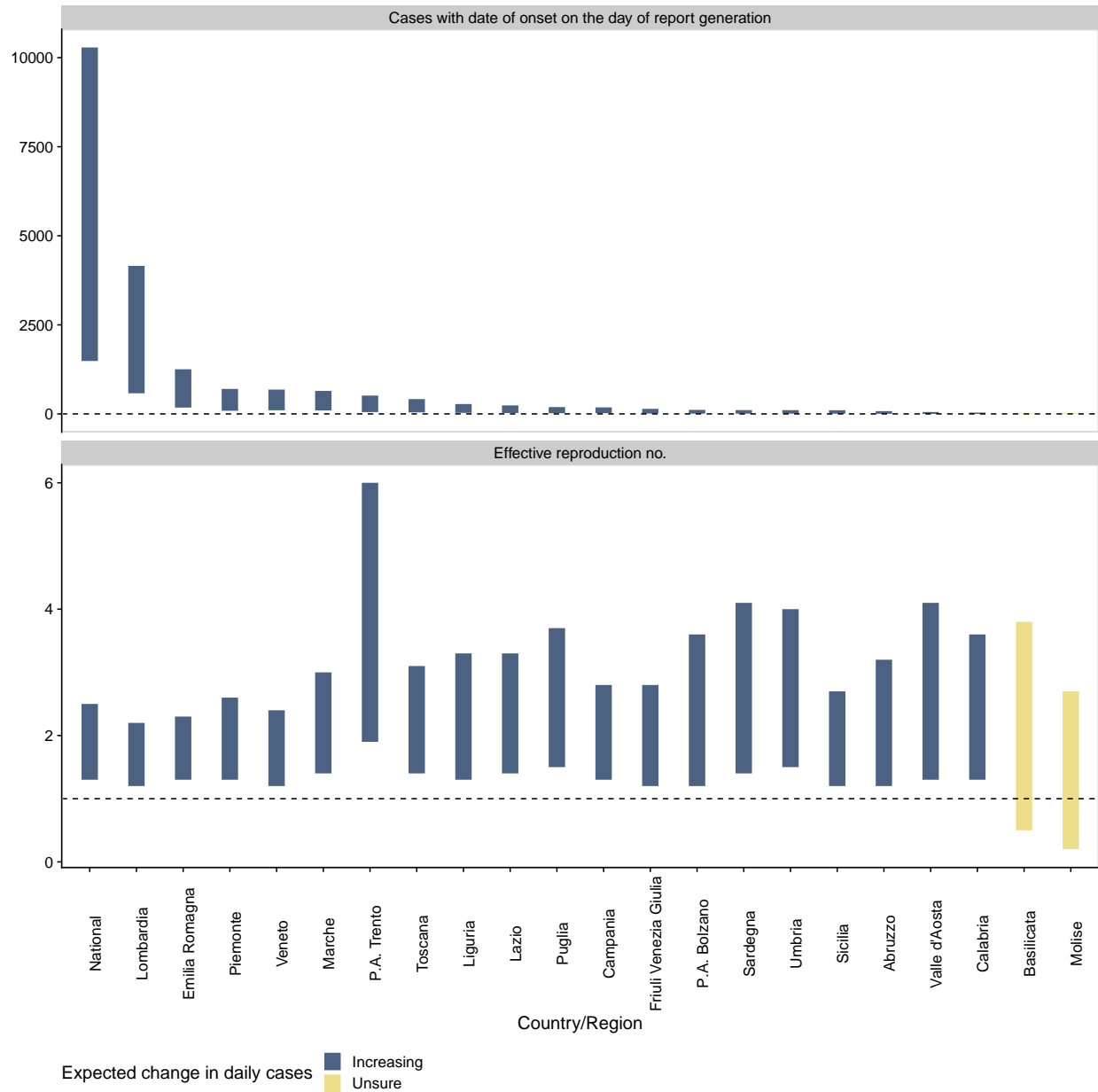**Summary of latest reproduction number and case count estimates**

Figure 2: Cases with date of onset on the day of report generation and the time-varying estimate of the effective reproduction number (bar = 95% credible interval) based on data from the 2020-03-15. Regions are ordered by the number of expected daily cases and shaded based on the expected change in daily cases. The dotted line indicates the target value of 1 for the effective reproduction no. required for control and a single case required fror elimination.

Reproduction numbers over time in the 5 regions with the most cases currently and nationally
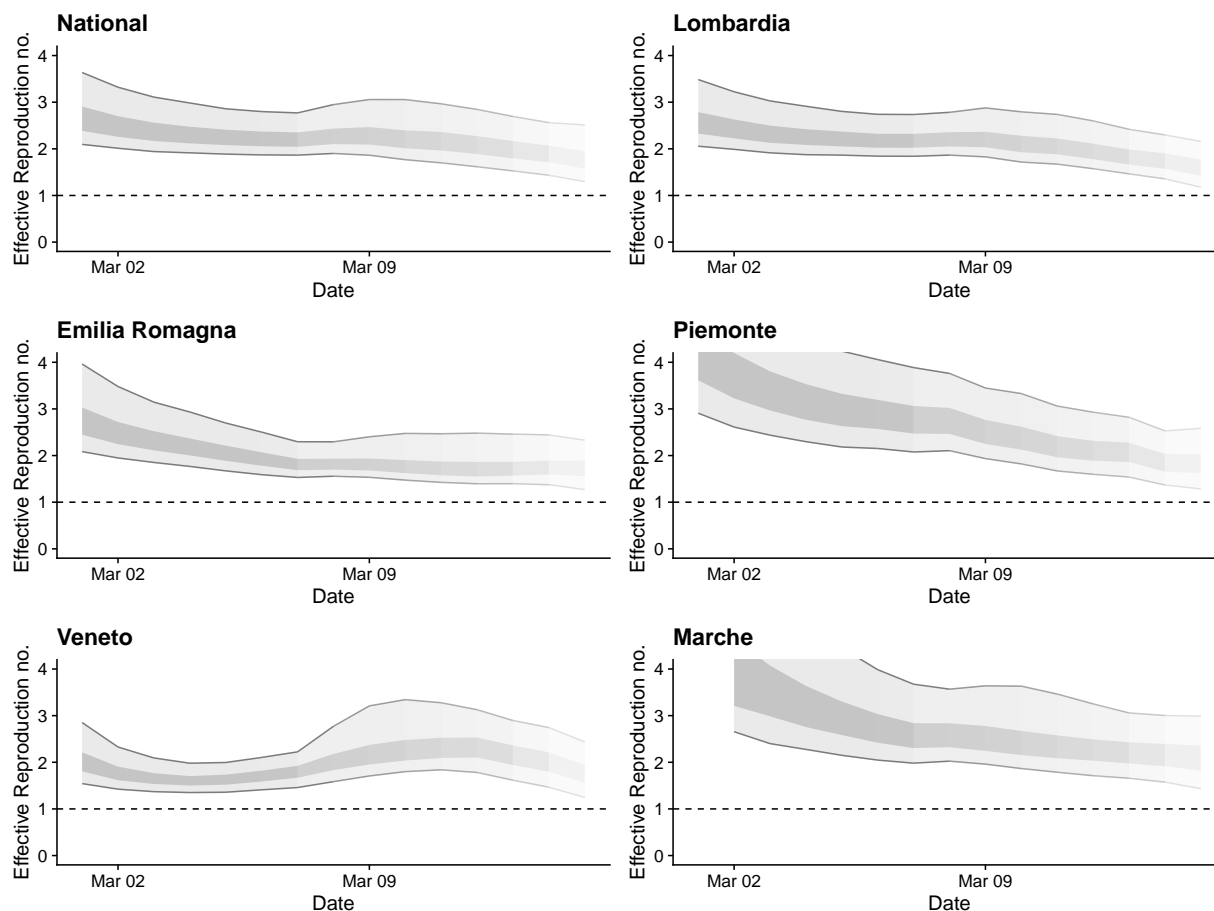

Figure 3: Time-varying estimate of the effective reproduction number (light grey ribbon = 95% credible interval; dark grey ribbon = the interquartile range) based on data from the 2020-03-15 in the regions expected to have the highest number of incident cases. Confidence in the estimated values is indicated by shading with reduced shading corresponding to reduced confidence. The dotted line indicates the target value of 1 for the effective reproduction no. required for control.

Latest estimates summary table

Table 1: Latest estimates of the number of cases by date of onset, the effective reproduction number, and the doubling time for the 2020-03-15 in each region included in the analysis. Based on the last 7 days of data. The 95% credible interval is shown for each numeric estimate. China excludes Hubei.

Country/Region	Cases with date of onset on the day of report generation	Expected change in daily cases	Effective reproduction no.	Doubling time (days)
National	1486 − 10286	Increasing	1.3 − 2.5	3.4 − Cases decreasing
Lombardia	580 − 4156	Increasing	1.2 − 2.2	3.9 − Cases decreasing
Emilia Romagna	178 − 1254	Increasing	1.3 − 2.3	2.9 − Cases decreasing
Piemonte	89 − 702	Increasing	1.3 − 2.6	2.2 − Cases decreasing
Veneto	103 − 684	Increasing	1.2 − 2.4	3.6 − Cases decreasing
Marche	98 − 646	Increasing	1.4 − 3	2.4 − 17
P.A. Trento	52 − 515	Increasing	1.9 − 6	1.2 − Cases decreasing
Toscana	44 − 417	Increasing	1.4 − 3.1	2.1 − Cases decreasing
Liguria	31 − 278	Increasing	1.3 − 3.3	2.7 − Cases decreasing
Lazio	26 − 239	Increasing	1.4 − 3.3	1.9 − 7.1
Puglia	20 − 193	Increasing	1.5 − 3.7	1.8 − 8.2
Campania	21 − 184	Increasing	1.3 − 2.8	2 − Cases decreasing
Friuli Venezia Giulia	12 − 143	Increasing	1.2 − 2.8	2.6 − Cases decreasing
P.A. Bolzano	8 − 114	Increasing	1.2 − 3.6	0.19 − Cases decreasing
Sardegna	8 − 108	Increasing	1.4 − 4.1	0.37 − Cases decreasing
Umbria	8 − 106	Increasing	1.5 − 4	1.6 − 10
Sicilia	8 − 104	Increasing	1.2 − 2.7	1.7 − Cases decreasing
Abruzzo	4 − 79	Increasing	1.2 − 3.2	1.7 − Cases decreasing
Valle d'Aosta	2 − 54	Increasing	1.3 − 4.1	0.35 − Cases decreasing
Calabria	1 − 38	Increasing	1.3 − 3.6	0.19 − Cases decreasing
Basilicata	1 − 20	Unsure	0.5 − 3.8	0.13 − Cases decreasing
Molise	1 − 20	Unsure	0.2 − 2.7	0.15 − Cases decreasing

Methods

Summary

- Case counts by date, stratified by region, were constructed from daily datasets made publically available by the Dipartimento della Protezione Civile [1].
- Case onset dates were estimated using case counts by date of report and a distribution of reporting delays fitted to a international line-lists.
- Censoring of cases was adjusted for by assuming that the number of cases is drawn from a binomial distribution.
- Time-varying effective reproduction estimates were made with a 7-day sliding window using *EpiEstim* [2,3] adjusted for imported cases and assuming an uncertain serial interval with a mean of 4.7 days (95% CrI: 3.7, 6.0) and a standard deviation of 2.9 days (95% CrI: 1.9, 4.9) [4].
- Time-varying estimates of the doubling time were made with a 7-day sliding window by iteratively fitting an exponential regression model.

Limitations

- The estimated onset dates are based on current data for the delay in reporting. These data may not be representative of the underlying reporting distribution.
- The estimate of not-yet-confirmed cases to scale up recent numbers is uncertain and relies on the observed delays to confirmation to remain constant over the course of the outbreak.
- All data used is at a national/regional level; diagnostic capabilities may vary in different parts of each region, adding uncertainty to the reported numbers.
- Trends identified using our approach are robust to under-reporting assuming it is constant but absolute values may be biased by reporting rates. Pronouced changes in reporting rates may also impact the trends identified.
- Data on imported cases was not available (either international imports or between regions).

Detail

Data

We used an international line-list that contained the date of symptom onset, date of confirmation and import status (imported or local) for each case [5] where available. Daily case counts by date of report and region were extracted from daily datasets made publically available by the Dipartimento della Protezione Civile [1].

Statistical analysis

We used the same approach as in our previous global study of the temporal variation in transmission during the COVID-19 outbreak (https://cmmid.github.io/topics/covid19/current-patterns-transmission/global-time-varying-transmission.html). However, due to a limited line-list of Italian cases we used combined linelist data from Germany, France, Italy, Austria, the Netherlands, Belgium, and Spain to estimate the report delay. We could also not account for imported cases (either international or between region) due to a shortage of data.

References

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3 Thompson R, Stockwin J, Gaalen R van *et al.* Improved inference of time-varying reproduction numbers during infectious disease outbreaks. *Epidemics* 2019;**29**:100356. doi:https://doi.org/10.1016/j.epidem.2019.100356

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