

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 2020-03-17

Region map

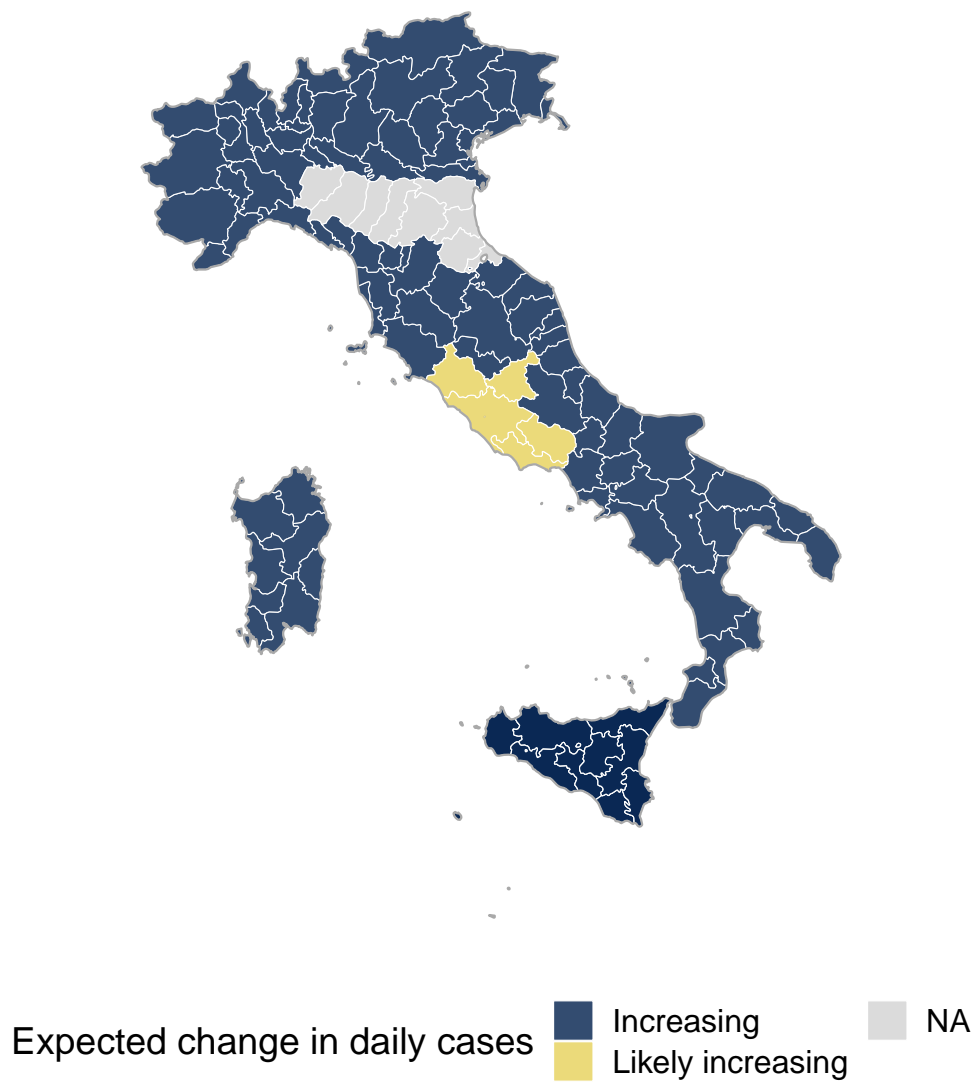


Figure 1: Regional map of the expected change in daily cases based on data from the 2020-03-17.

Summary of latest reproduction number and case count estimates

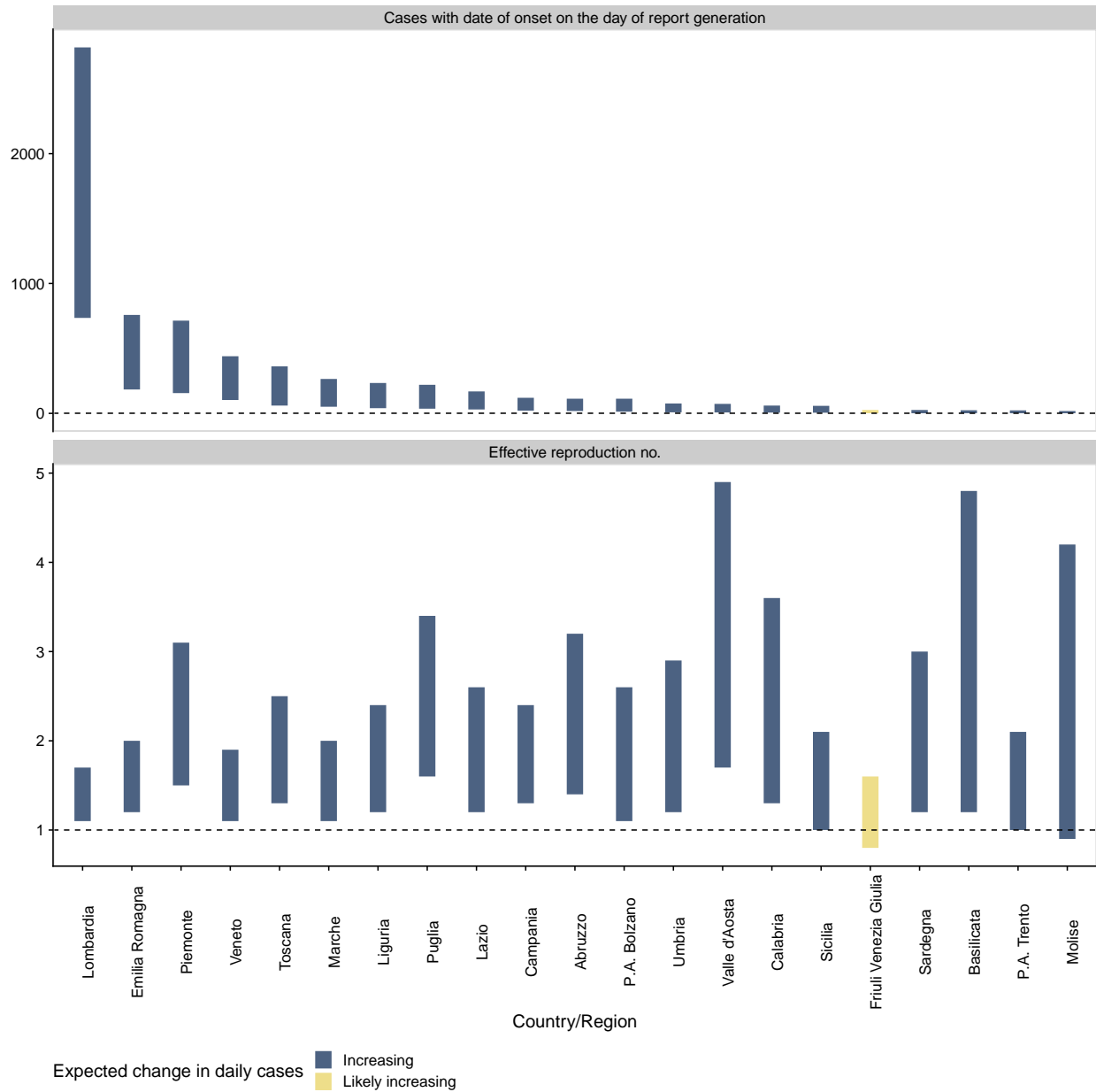


Figure 2: Cases with date of onset on the day of report generation and the time-varying estimate of the effective reproduction number (bar = 95% credible interval) based on data from the 2020-03-17. Regions are ordered by the number of expected daily cases and shaded based on the expected change in daily cases. The dotted line indicates the target value of 1 for the effective reproduction no. required for control and a single case required for elimination.

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

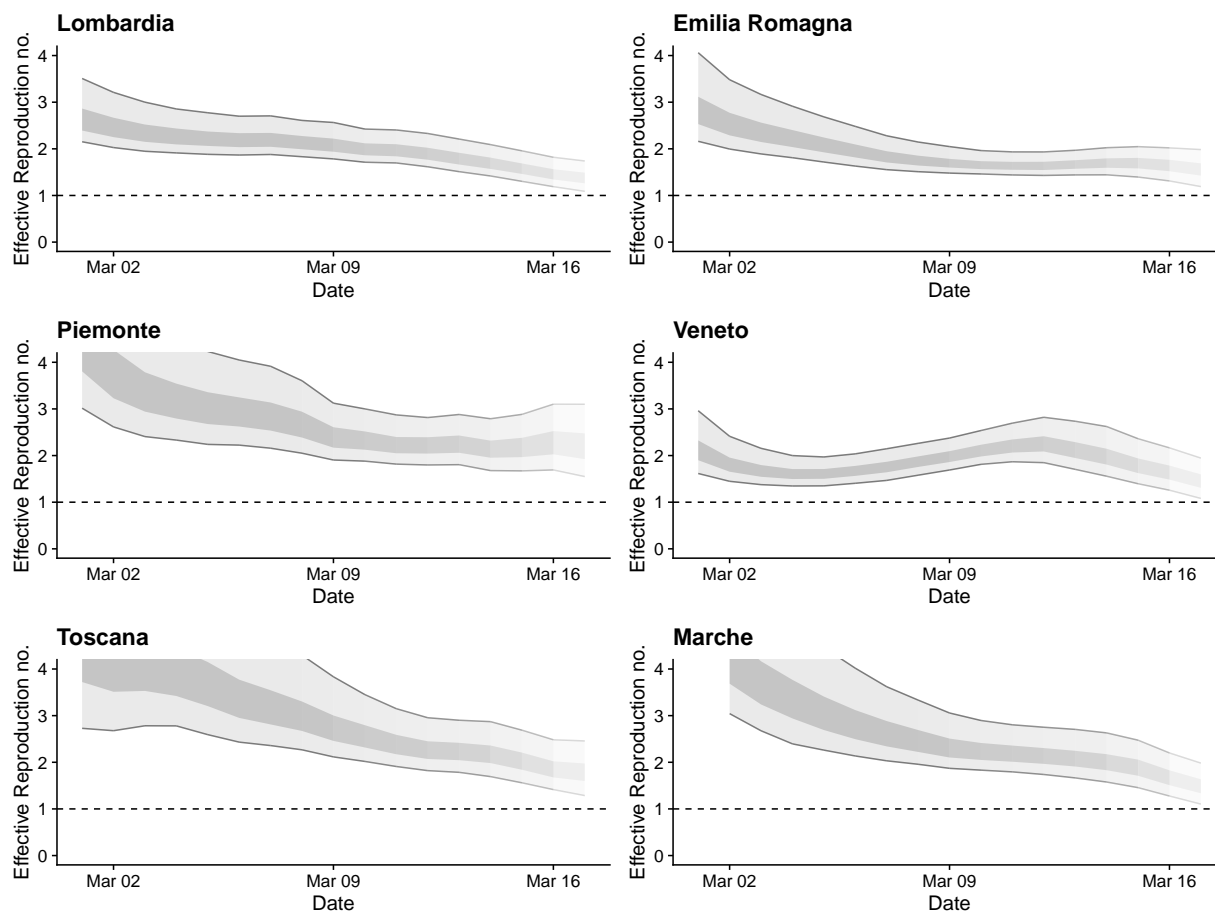


Figure 3: Time-varying estimate of the effective reproduction number (light grey ribbon = 95% credible interval; dark grey ribbon = the interquartile range) based on data from the 2020-03-17 in the regions expected to have the highest number of incident cases. Confidence in the estimated values is indicated 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 2020-03-17 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.

Country/Region	Cases with date of onset on the day of report generation	Expected change in daily cases	Effective reproduction no.	Doubling time (days)
Lombardia	735 – 2818	Increasing	1.1 – 1.7	6.2 – Cases decreasing
Emilia Romagna	184 – 758	Increasing	1.2 – 2	3.9 – 18
Piemonte	156 – 714	Increasing	1.5 – 3.1	2.1 – 11
Veneto	103 – 440	Increasing	1.1 – 1.9	7.4 – Cases decreasing
Toscana	60 – 362	Increasing	1.3 – 2.5	3.2 – Cases decreasing
Marche	51 – 265	Increasing	1.1 – 2	4 – Cases decreasing
Liguria	40 – 234	Increasing	1.2 – 2.4	3.9 – Cases decreasing
Puglia	36 – 220	Increasing	1.6 – 3.4	1.9 – Cases decreasing
Lazio	30 – 169	Increasing	1.2 – 2.6	3.2 – Cases decreasing
Campania	21 – 120	Increasing	1.3 – 2.4	3.2 – Cases decreasing
Abruzzo	18 – 113	Increasing	1.4 – 3.2	1.3 – Cases decreasing
P.A. Bolzano	13 – 113	Increasing	1.1 – 2.6	2.3 – Cases decreasing
Umbria	8 – 76	Increasing	1.2 – 2.9	2.6 – Cases decreasing
Valle d’Aosta	7 – 73	Increasing	1.7 – 4.9	1.4 – 9.7
Calabria	6 – 60	Increasing	1.3 – 3.6	0.93 – Cases decreasing
Sicilia	5 – 58	Increasing	1 – 2.1	3.5 – Cases decreasing
Friuli Venezia Giulia	1 – 26	Likely increasing	0.8 – 1.6	92 – Cases decreasing
Sardegna	1 – 26	Increasing	1.2 – 3	1.7 – Cases decreasing
Basilicata	1 – 24	Increasing	1.2 – 4.8	0.13 – Cases decreasing
P.A. Trento	1 – 23	Increasing	1 – 2.1	2.3 – Cases decreasing
Molise	1 – 18	Increasing	0.9 – 4.2	0.13 – 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 [1,2].
- Case onset dates were estimated using case counts by date of report and a distribution of reporting delays fitted to a European line-list.
- 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* [3,4] 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) [5].
- Time-varying estimates of the doubling time were made with a 7-day sliding window by iteratively fitting an exponential regression model.
- The methods in this report are based on our previous study of the global temporal variation during the COVID-19 outbreak [6].

Limitations

- The estimated onset dates are based on current European 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. Pronounced changes in reporting rates may also impact the trends identified.
- Data on imported cases was not available (either international imports or between region imports).

Detail

Data

We used a European line-list that contained the date of symptom onset, date of confirmation and import status (imported or local) for each case [2,7] 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 [1,2].

Statistical analysis

We used the same approach as in our previous global study of the temporal variation in transmission during the COVID-19 outbreak [6]. However, due to a limited line-list of Italian cases we used a combined linelist of cases 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. Code and results from this analysis can be found here and here.

References

1 Dipartimento della Protezione Civile. **Dati COVID-19 Italia**. <https://github.com/pcm-dpc/COVID-19>

- 2 Abbott S, Hellewell J, Munday JD *et al.* NCoVUtils: Utility functions for the 2019-ncov outbreak. - 2020;-:-. doi:10.5281/zenodo.3635417
- 3 Cori A. *EpiEstim: Estimate time varying reproduction numbers from epidemic curves.* 2019. <https://CRAN.R-project.org/package=EpiEstim>
- 4 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>
- 5 Nishiura H, Linton NM, Akhmetzhanov AR. Serial interval of novel coronavirus (2019-nCoV) infections. *medRxiv* Published Online First: 2020. doi:10.1101/2020.02.03.20019497
- 6 S. Abbott, J. Hellewell, J. D. Munday, J. Y. Chun, R. N. Thompson, N. Bosse, Y. D. Chan, T. W. Russell, C. I. Jarvis, CMMID COVID team, S. Flasche, A. J. Kucharski, R. M. Eggo, S. Funk. **Temporal variation in transmission during the COVID-19 outbreak.** <https://cmmid.github.io/topics/covid19/current-patterns-transmission/global-time-varying-transmission.html>
- 7 Xu B, Gutierrez B, Hill S *et al.* Epidemiological Data from the nCoV-2019 Outbreak: Early Descriptions from Publicly Available Data. 2020.