# Real-time modeling and projections of the COVID-19 epidemic in Switzerland

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**Important note: This report is work in progress and has not been peer-review. The short-term projections need to be interpreted with caution (also see Notes).**

## Introduction

Switzerland reported its first case of coronavirus disease 2019 (COVID-19) on 25 Feb 2020. As of 12 Apr 2020, there have been 25535 confirmed cases and 1118 reported deaths (source (https://github.com/daenuprobst/covid19-cases-switzerland)). Interpreting trends in the daily numbers of reported cases can be challenging as a significant proportion of particularly mild or asymptomatic cases cannot be diagnosed and will go unreported (see here (https://cmmid.github.io/topics/covid19/severity/global_cfr_estimates.html) for estimates of under-reporting). Here, we aim to describe the COVID-19 epidemic in Switzerland by tracking the numbers of reported deaths. To this end, we fit a dynamic transmission model to the daily number of reported deaths, estimate the reduction in transmission after the strengthening of social distancing measures on 17 Mar 2020, and project the further course of the COVID-19 epidemic in Switzerland.

## Methods

We consider a SEIR transmission model with additional compartments for hospitalization and critical

care (ICU) (see R Markdown file (swiss_covid_epidemic.Rmd) and Table). We use a maximum likelihood framework to fit the model to the reported numbers of deaths (swiss_covid_epidemic.csv), assuming the daily numbers of deaths are Poisson distributed (see Althaus et al. (http://dx.doi.org/10.1016/j.epidem.2015.03.001) for further details on the methods). We assume constant uncontrolled transmission until the strengthening of social distancing measures on 17 Mar 2020 and then estimate the following reduction in transmission.

**Table. Parameters of the COVID-19 transmission model.**

| Parameter | Value | Source |
|---|---|---|
| Population size of Switzerland | 8.6 million | Federal Statistical Office (https://www.bfs.admin.ch/bfs/en/home/statistics/population.html) |
| Serial interval | 5.2 days | Ganyani et al. (https://www.medrxiv.org/content/10.1101/2020.03.05.20031815v1) |
| Duration from onset of symptoms to hospitalization | 5 days | Imperial College COVID-19 Response Team: Report 9 (https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf) |

| Parameter | Value | Source |
| --- | --- | --- |
| Duration of hospitalization | 16 days | Imperial College COVID-19 Response Team: Report 9 (https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf) |
| Duration in critical care (ICU) | 10 days | Imperial College COVID-19 Response Team: Report 9 (https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf) |
| Proportion hospitalized that require critical care | 30% | Imperial College COVID-19 Response Team: Report 9 (https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf) |

| Parameter | Value | Source |
|---|---|---|
| Proportion in critical care that will die | 50% | Imperial College COVID-19 Response Team: Report 9 (https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf) |
| Overall cate fatality ratio | 1.4% | Verity et al. (https://doi.org/10.1016/S1473-3099(20)30243-7) and Wu et al. (https://doi.org/10.1038/s41591-020-0822-7) |
| Basic reproduction number $R_0$ | 2.84 (95% CI: 2.53 - 3.22) | Estimated |
| Reduction in transmission after 17 March 2020 | 86% (95% CI: 78%-94%) | Estimated |

# Results

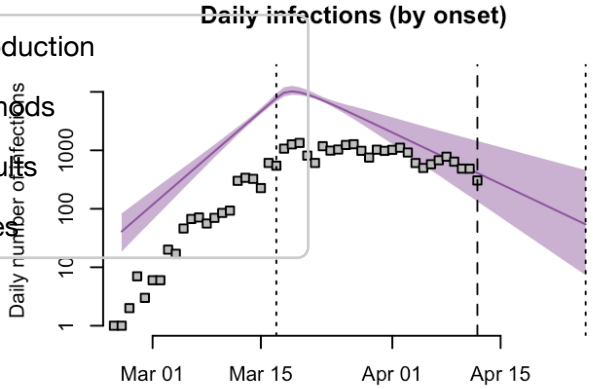
Before 17 Mar 2020, we estimate the basic reproduction number $R_0$ of COVID-19 at 2.84 (95% confidence interval, CI: 2.53 - 3.22). Transmission decreased with the strengthening of social distancing measures by 86% (95% CI: 78%-94%). This resulted in an effective reproduction number $R_e$ = 0.4 (95% confidence interval, CI: 0.22 - 0.63). Based on these estimates, we can project the future epidemic trajectory for the coming weeks (Figure). The number of daily infections, hospitalized patients, patients in ICU and deaths are expected to further decline until 26 March 2020. Note that the number of confirmed cases will lag behind the daily number of infections by onset of symptoms.

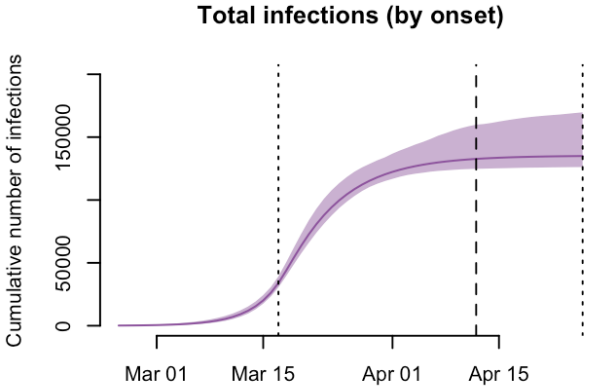
Introduction

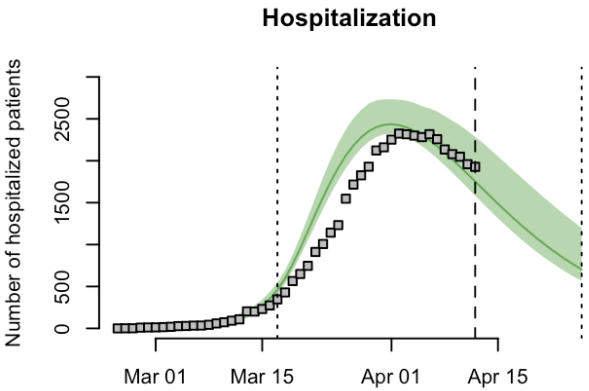
Methods

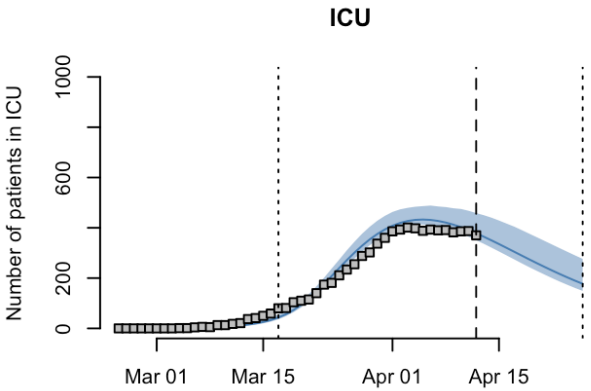
Results

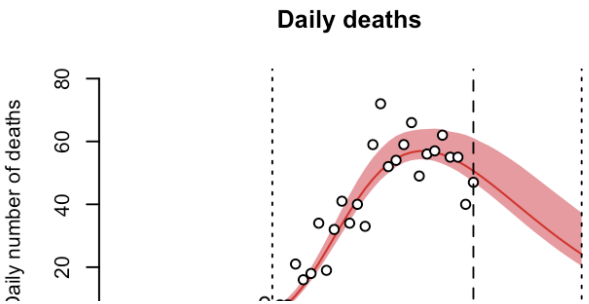
Notes



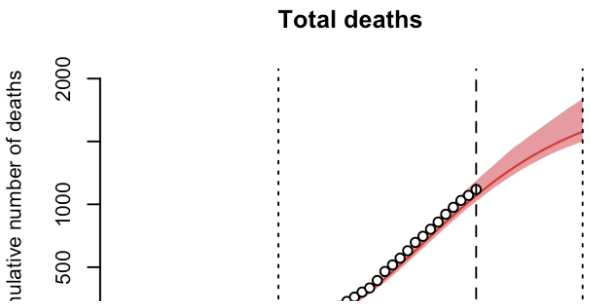



**Figure. Projected numbers of infections, hospitalizations, patients in ICU and deaths for the COVID-19 epidemic in Switzerland.** The model was fitted to daily numbers of reported deaths (white circles). Data about confirmed cases (by date of report), hospitalizations, and patients in ICU are shown for validation (gray squares). Vertical dotted and dashed lines indicate the time points of the strengthening and planned relaxation of social distancing measures (17 Mar 2020 and 26 Apr 2020, respectively) and the last data point (12 Apr 2020). Note the logarithmic vertical axis for the number of daily infections.

# Notes

- 14 Apr 2020: Updated model structure and parameters.
- 9 Apr 2020: Updated model structure and parameters. Data allows to estimate the reduction in transmission after the strengthening of social distancing measures.
- 24 Mar 2020: Shortening the generation time from 7.5 days (Li et al. (https://doi.org/10.1056/NEJMoa2001316)) to 5.2 days (Ganyani et al. (https://www.medrxiv.org/content/10.1101/2020.03.05.20031815v1)) results in a lower estimate of $R_0$, and consequently more optimistic projections about epidemic control.