Comparison of mathematical models for COVID-19 in Switzerland (27.4.2020)

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Table 1: Model specifications

Imperial (V.10, V2.0) Flaxman et al.	**EPFL and JHU** Joseph Lemaitre, Javier Perez-Saez et al.	**University of Bern** Christian L. Althaus	**University of Bern** Anthony Hauser and Julien Riou	**ETH Zurich** Tanja Stadler et al.	**UNIGE** Janne Estill et al.
Model type					
Semi-mechanistic Bayesian hierarchical: calculating backwards from the deaths observed over time to estimate transmission that occurred several weeks prior, allowing for the time lag between infection and death.	1.Inference Model 2. Scenario Model: Spatial Stochastic SEIR model based on the template of the inference.	Deterministic, population-based transmission model, maximum likelihood estimation.	Deterministic, population-based transmission model, Bayesian Hamiltonian Monte Carlo Methods	Calculating a posterior distribution for R(t) using Bayesian methodology	Compartmental discrete-time model (both deterministic and stochastic versions available)
Infection structure					
Discrete renewal process: it is related to the Susceptible-Infected-Recovered model, except the renewal is not expressed in differential form.	SEIR with added compartments for ICU use and hospitalization	SEIR with added compartments for ICU use and hospitalization	SEIR with additional compartments for asymptomatic infection, hospitalization and ICU	Analysing transmissibility throughout an epidemic from the analysis of time series using the data of the confirmed cases , deaths and hospitalizations	SEIR with 33 compartments including hospitalisations and ICU care, four levels of symptom severity, and three age groups
Language					
R	R ,Python	R	R and Stan	R package EpiEstim	R
Purpose					
1. Forecast country specific deaths 2. Estimate country specific time varying R(t) 3. Estimate impact of interventions	1. Estimate time varying R(t) 2. Modelling intervention scenarios for planning : Number of hospitalized , deaths etc using R(t) simulated from the inference model	1. 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.	1. Estimate the reproduction number R_0 and the effect of control measures. 2. Capture the dynamics of positive tests (accounting for variation in testing), hospital admissions, ICU admissions, and deaths among non-hospitalised, hospitalised and hospitalised with ICU.	1.Quantifying the effective reproductive number for the epidemic in Switzerland and in 10 out of the 26 cantons forming the Swiss Confederation	1.Assess the current epidemic situation in Switzerland 2.Compare the impact of interventions that focus on different age groups

Table 1: continued

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Age breakdown					
10 year age bands starting at 0 and ending at 80+.	1. None 2. None	None	None	None	Three age-bands: 0-18, 18-<65 and >65.
Stages of infection					
- Susceptible - Infected - Recovered	- Susceptible - Exposed - Infected (three stages) -Id (infected severely symptomatic that will die), -Hn (hospitalized that will survive without ICU) -Hd (hospitalized that will die without ICU) -H (hospitalized that will go to ICU) -Un (ICU that will survive) -Ud (ICU that will die) - R (recovered) - D(Dead)	- Susceptible - Exposed - Infected - Progressing - Hospitalized - ICU - Recovered - Death	- Susceptible - Exposed - Preclinical (infectious with reduced transmissibility) - Asymptomatically infected - Symptomatically infected - Removed - Symptomatically infected but not infectious anymore - Hospitalised - Admitted in ICU - Dead (3 stages depending from which stage the death occurred)	No compartments	- Susceptible - Exposed - Infected: prodomic phase - Asymptomatically infected - Paucisymptomatically infected - Infected with mild symptoms - Infected with severe symptoms - Hospitalised - Admitted in ICU - Dead - Recovered
Interventions included					
- Social distancing (16/3/2020) - Self- isolation - School closure (21/3/2020) - Public events banned (24/3/2020) - Lockdown (24/02/2020)	- Current Measures Stopped May 1st - School closure on March 14 - Physical distancing measures progressively established from March 14 to March 20.	-Social distancing measures on 17th March 2020	- Control measures modelled by a logistic step function starting on 17th of March	- March 13th schools closure - March 16th, non-essential shops, bars, and restaurants closure - March 17th Lockdown - March 20th prohibition of gatherings of more than five people in public spaces.	- Social distancing (2 levels) - Closing schools - Reduced workplace contacts - Shop closure (2 levels) - Closing restaurants - School summer holiday - Contact tracing, testing

Table 1: continued

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Geographic resolution					
National	1. Cantonal (all cantons) 2. Cantonal (13 cantons) each separate	National	Regional	Cantonal (10 regions)	National
Data Sources					
- Daily real time deaths data from European Centre of Disease Control (ECDC)	- Data for model fit: **openZH** and **Probst's GitHub** - Data for hospitalization: Vaud cantonal hospitalization data	- Data from : **reported number of deaths**	- hospitalized data from Federal Office of Public Health (FOPH).	- Confirmed Cases , deaths : **GitHub** - Disease progression, hospitalizations and testing: FOPH data until March 31: Bruderholzspital (Basel-Landschaf) and University Hospital Basel (Basel-Stadt)	-FOPH hospitalization data - Contact matrix: **Here** Data from Belgium, France, Germany and Italy)
Code repository					
GitHub: Flaxman et al.	**GitHub: EPFL, JHU**	**Christian L. Althaus**	Not available yet	**GitHub: Tanja Stadler et al.**	**GitLab: Janne Estill et al.**
Link to the report					
Flaxman et al.	**EPFL, JHU**	**Christian L. Althaus**	Not available yet	**Tanja Stadler et al.**	Not available yet

Table 2: Model parameters

Imperial (V.10, V2.0) Flaxman et al.	**EPFL and JHU** Joseph Lemaitre, Javier Perez-Saez et al.	**University of Bern** Christian L. Althaus	**University of Bern** Anthony Hauser and Julien Riou	**ETH Zurich** Tanja Stadler et al.	**UNIGE** Janne Estill et al.
Initial R0					
R0 = 2.4	-	-	-	-	-
Incubation period					
Modelled as Gamma function(5.1,0.86)	5.2 days (IQR 1.5 – 7.21) [2]	2.6days	5 days [6]	mean 5.3days , (sd 3.2) [3]	5.2 days (of which the last 1.5 infectious) [
Duration of infectiousness					
None	1.3 – 3 days	2.6 days serial interval :5.2 days[4]	0.2days	Serial interval mean 4.8days, (sd 2.3) [9]	3.8 days (includes 1.5 days belonging to the incubation period)
Time to hospitalization from symptoms					
None	3.42 days (IQR 2.01 - 5.83)	5days	6.0 days (95% CI: 5.5 – 6.4)	mean 6.6days , (sd 4.6)	2.3 days
Proportion cases hospitalised					
None	Fitted to the data	3.5%	-	-	Age dependant
Duration of hospitalization					
Fitted to the data	Depends on compartments	16days [4]	-	-	Age and severity dependant
Duration of onset of disease to death					
Distribution	Depends on the flow of the compartments	21days	Depends on the flow of the compartments	mean 15days(sd 6.9) from [2]	Age dependant
Proportion hospitalised admitted to ICU					
None	20% (fitted to the data)	30% [4]	-		Age dependant
Duration in critical care (ICU)					
None	Fitted to the data	10 days [4]	-		Age dependant
Case-fatality ratio					
	0.75 % - 1.2% [2]	1.4% [5]	Prior 1.5 +- 0.7 % [8] (of symptomatics) Posterior: 2.0 (1.1 – 3.8)		
Proportion critical cases that will die					
None	Fitted to the data	50% [4]	Death among ICU: 48.1% (37.7 - 60.1)		Age dependant

Table 3: Model results

Imperial (V.10, V2.0) Flaxman et al.	**EPFL and JHU** Joseph Lemaitre, Javier Perez-Saez , Andrew Azman, Andrea Rinaldo and Jacques Fellay	**University of Bern** Christian L. Althaus	**University of Bern** Anthony Hauser and Julien Riou	**ETH Zurich** Tanja Stadler et al.	**UNIGE** Janne Estill et al.
Population prevalence					
3.2% [95% CI : 1.3%-7.6%]					
R0					
11 country average: 3.87 (95% CI :3.01-4.66)	Until 14th March 3.2 (95% CI: 2.8-3.5)	2.78 (95% CI: 2.51 - 3.11)	1.8 (95% CI: 1.7-1.9)	Earliest estimate for March 7th : 1.8 [1.7-1.9]	3 .5
Re					
After the complete lockdown (introduced on 20 March 2020) is in [0.6,0.9] 95% credible interval as of 4th April 2020	In the period of March 28 - April 2nd: 0.52 (95% QR: 0.38-0.7 95%)	After 17th March: 0.32 (95% CI: 0.2 - 0.47)	0.09 (95% CI: 0.004-0.29)	Daily updates on : Here	*Re* < 1 (about 0.4-0.6) after March 20
Impact of interventions					
	In the first part of the epidemic is observed a non-linear decrease of the R0 from the first announcement 1 of March and then it did go below R=1 around 24 March (95% QR 18-26). Reduction by 83% (95% QR: 77%-88%).	Transmission decreased with the strengthening of social distancing measures by 89% (95% CI: 83%-94%)	Control measures led to a decrease of transmissibility by 95.1% (84.5-99.8), leading to an effective reproduction number of 0.09 (0.004-0.29) after 17th of March.	From March 21, the Re is significantly below 1	-Re decreased gradually from 3-4 (before any intervention measures), to about 0.5 (after March 20).

References :

1. Zhang, J.

2. Lauer et al.

3. Linton et al.

4. Neil Ferguson, Daniel Laydon et al.

5. Verity et al. and Wu et al.

6. Qifang Bi, Yongsheng Wu, Shujiang Mei, Chenfei Ye et al.

7. N. Linton,T. Kobayashi et al.

8. R. Verity et al. and Anthony Hauser, Michel J Counotte, Charles C Margossian, Garyfallos Konstantinoudis et al.

9. Nishiura et al.