An age-structured compartmental model of SARS-CoV-2 transmission in Switzerland

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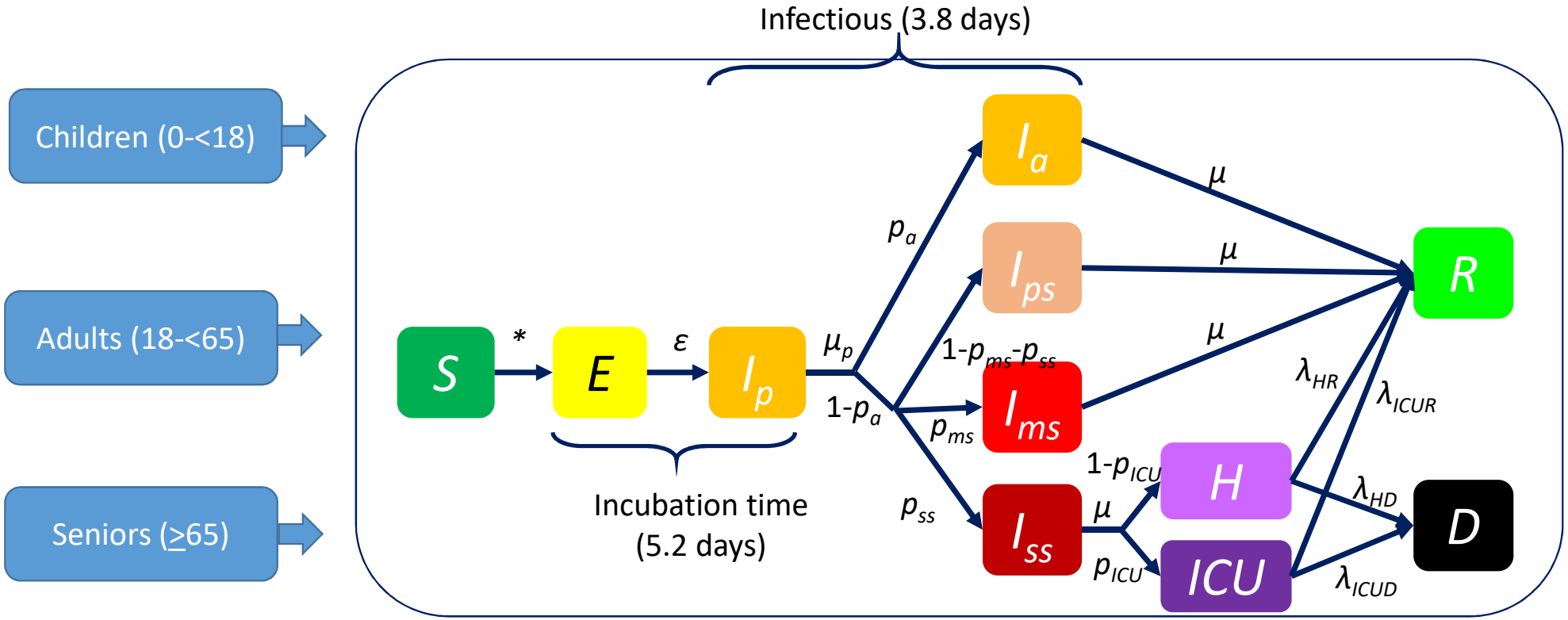
Methods

- Follows the structure of a model for Ile-de-France (Di Domenica *et al*)
- Compartmental discrete-time model (both deterministic and stochastic versions available)



*Depends on a fitted overall infectiousness parameter *β*, contact matrix *M* between age groups, proportions of infectious individuals in each age group and severity stage, and factor *rb* reducing the infectiousness of individual in compartments I_p, I_a and I_{ps}

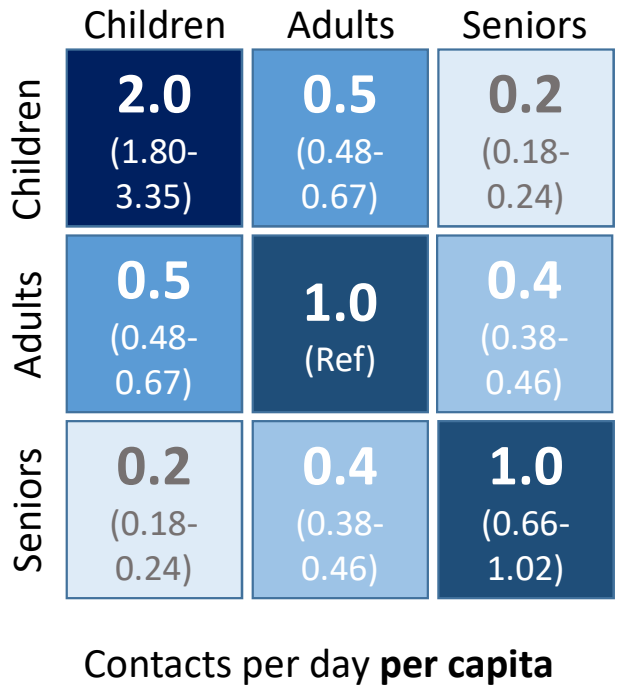
Model structure and parameterisation adapted from Di Domenica *et al* https://www.medrxiv.org/content/10.1101/2020.04.13.20063933v1.full.pdf+html

- Parameterisation of the model based on the French model
- Assumption: 15 exposed individuals introduced on February 5
- After preliminary model runs, some clear discrepancies with data were seen (too few deaths, too many hospitalizations in adults but too few in seniors)
- Free parameters fitted using maximum likelihood estimation to the daily new hospitalizations in adults and seniors

Variable	Description	Value	Source
μ_p^{-1}	Duration of prodromal phase	1.5	[3]
ϵ	Latency period	3.7	
p_a	Probability of being asymptomatic	0.5 for all age groups	[4]
p_{ps}	If symptomatic, probability of being paucisymptomatic	children: 1 adults and seniors:0.2	[5]
p_{ms}	If symptomatic, probability of develop mild symptoms	children: 0 adults: 0.7 seniors: 0.6	[5]
p_{ss}	If symptomatic, probability of develop severe symptoms	children: 0 adults: 0.03 seniors: 0.035	[5-7]
s	Serial interval	7.5 d	[8]
μ^{-1}	Infectious period for $I_a, I_{ps}, I_{ms}, I_{ss}$	s-θ^{-1} (2.3)	
r_β	Relative infectiousness of I_a, I_p, I_p	0.51	[9]
p_{icu}	If severe symptoms, probability to go to ICU	children: 0 adults: 0.36 seniors: 0.2	[10]
$\lambda_{H,R}$	If hospitalized, daily rate entering in R	children: 0 adults: 0.072 seniors: 0.022	[10]
$\lambda_{H,D}$	if hospitalized, daily rate entering in D	children: 0 adults: 0.0084 seniors: 0.056	[10]
$\lambda_{icu,R}$	if in ICU, daily rate entering in R	children: 0 adults: 0.05 seniors: 0.036	[10]
$\lambda_{icu,D}$	if in ICU, daily rate entering in D	children: 0 adults: 0.0148 seniors: 0.0116	[10]

Contact matrix between age groups

- Without intervention:



Contacts per day **per capita**

www.socialcontactdata.org

- Belgium (data from 2010; manuscript in preparation)
- France (Béraud *et al* PLoS One 2015)
- Germany (POLYMOD: Mossong *et al* PLoS Med 2008)
- Italy (POLYMOD)
- Other countries available; for this model, the values taken by reviewing the above four analyses

Interventions and other behavioural changes

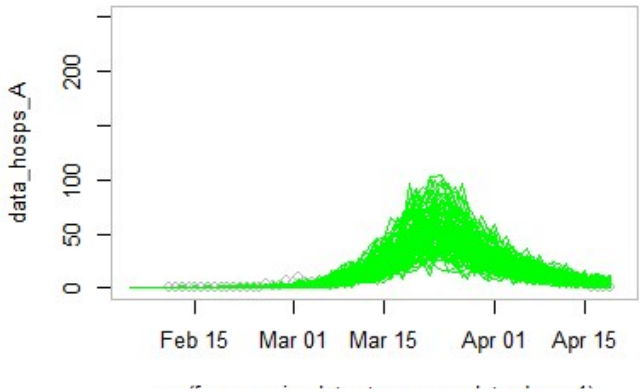
	CC	CA	CS	AA	AS	SS	Period
Social distancing (first level)	0.75	0.75	0.6	0.75	0.6	0.6	5 March –
Closing schools	0.05	0.8	1	1	1	1	16 March – 10 May
Social distancing (second level)	0.65	0.65	0.5	0.65	0.5	0.5	20 March – 10 May
Reduced workplace contacts	1	1	1	0.5	1	1	20 March – 31 August
Closing some shops services	1	1	1	0.67	0.67	0.67	16 March – 26 April
Closing most non-essential shops	1	1	1	0.75	0.75	0.75	16 March – 10 May
Closing restaurants	1	1	1	0.8	0.8	0.8	16 March – 9 June
School summer holiday	0.05	0.8	1	0.75	1	1	4 July – 9 August
Contact tracing, testing	?	?	?	?	?	?	8 June –

The numbers represent the reduction in contacts (compared to no intervention; CC=between children, CA=between children and adults, etc)

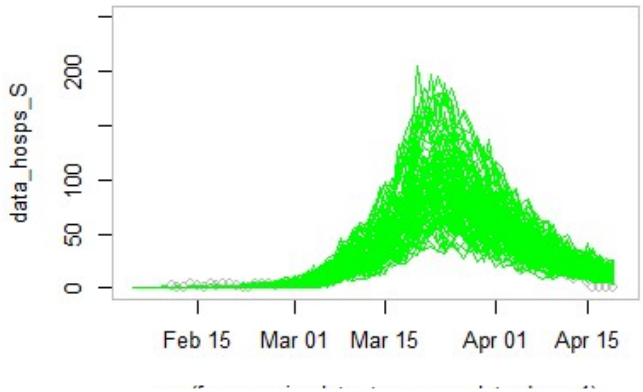
The interventions do not aim to represent precisely the exact policies (so the model cannot be used to compare the efficacy of the interventions), but rather the general trend in relative contact frequency

All hospitalizations

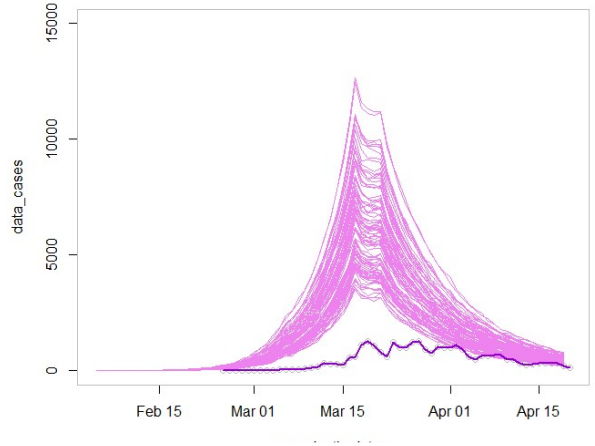
Adults



Seniors

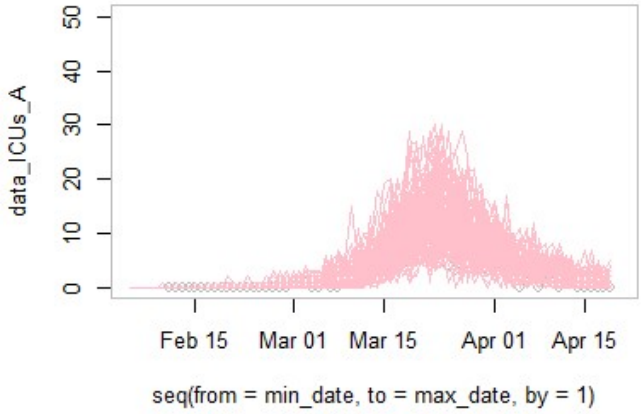


New infections (including asymptomatic)

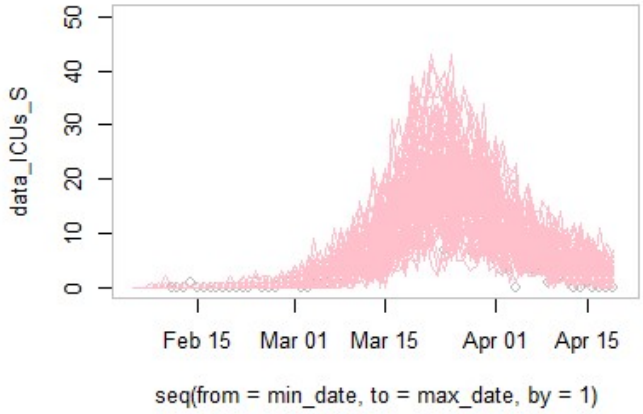


Hospitalizations with ICU

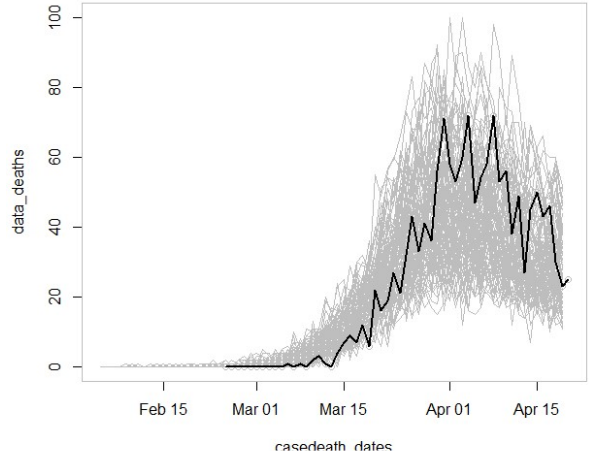
Adults



Seniors



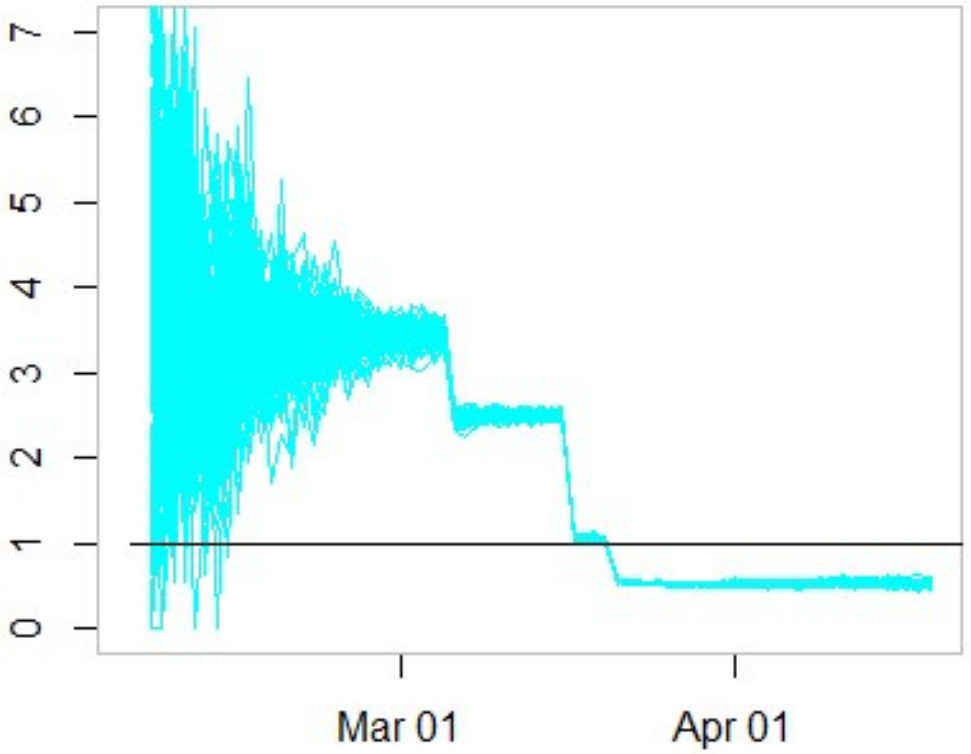
Deaths



Light-coloured curves show 100 runs of the model; dark curves data (corona-data.ch; confirmed new cases and new deaths)

Estimate of R_0 about 3-4

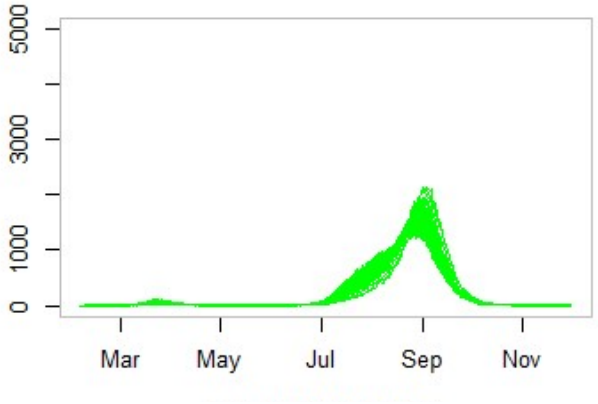
Currently, R_e clearly below 1 (about 0.4-0.6)



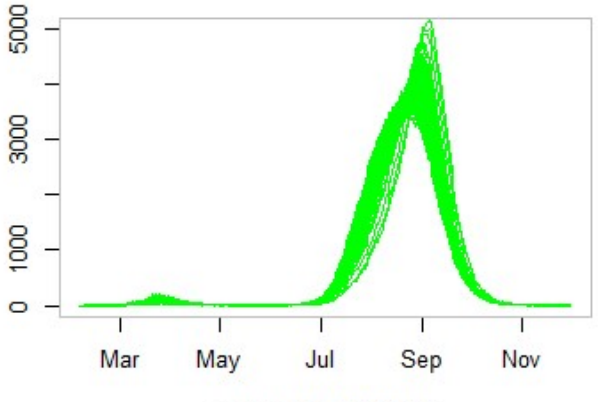
No further interventions after 8 June

All hospitalizations

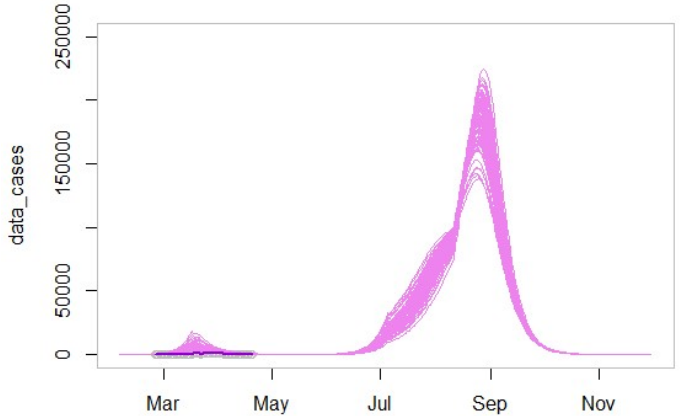
Adults



Seniors

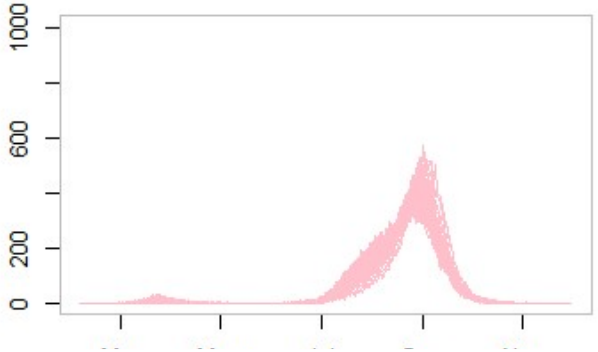


New infections (including asymptomatic)

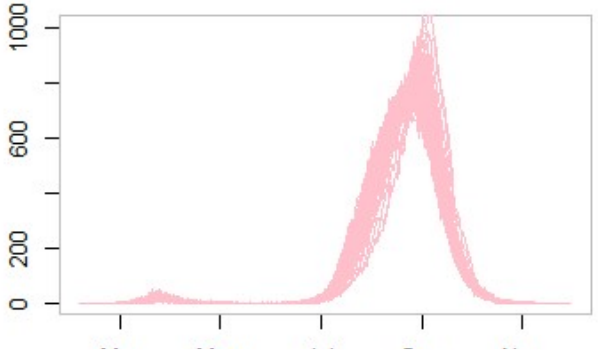


Hospitalizations with ICU

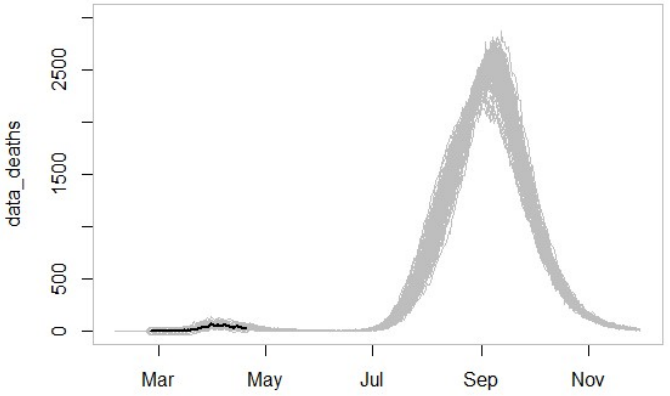
Adults



Seniors



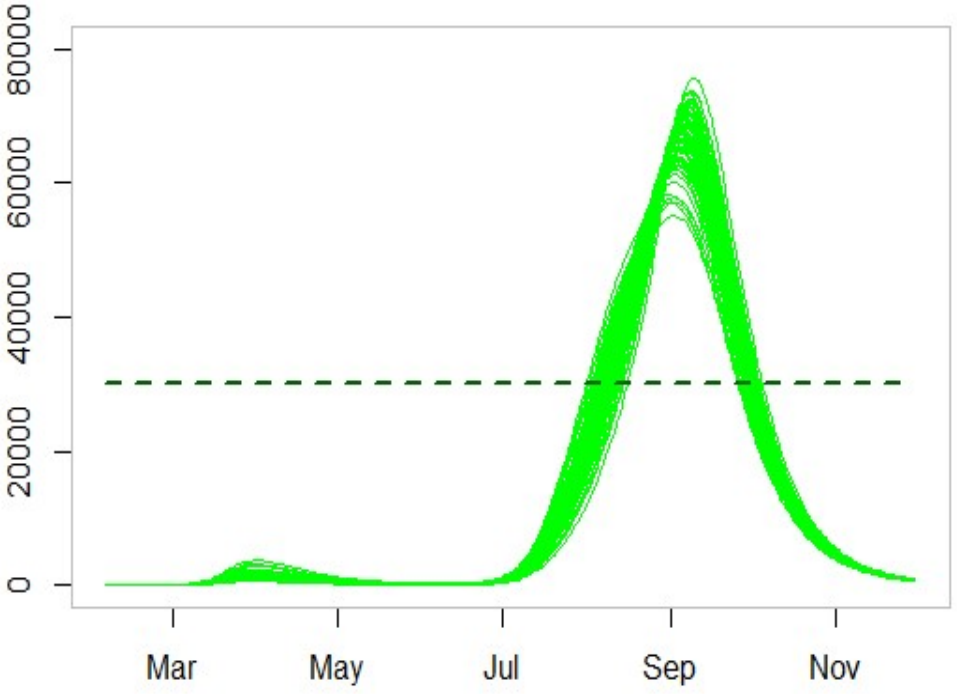
Deaths



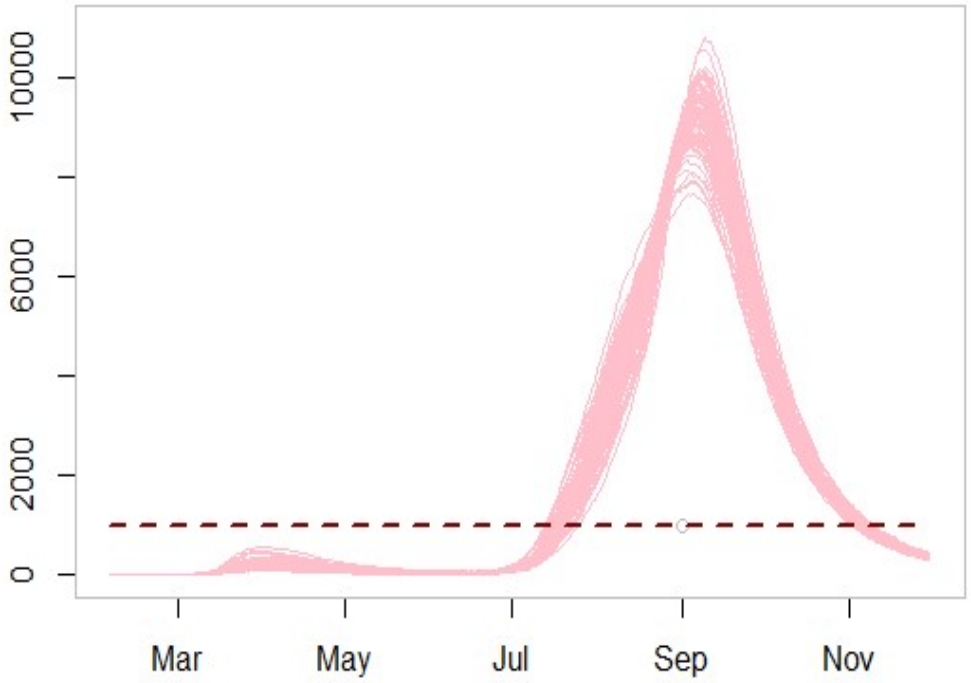
Light-coloured curves show 100 runs of the model; dark curves data

No further interventions after 8 June

Hospitalized patients

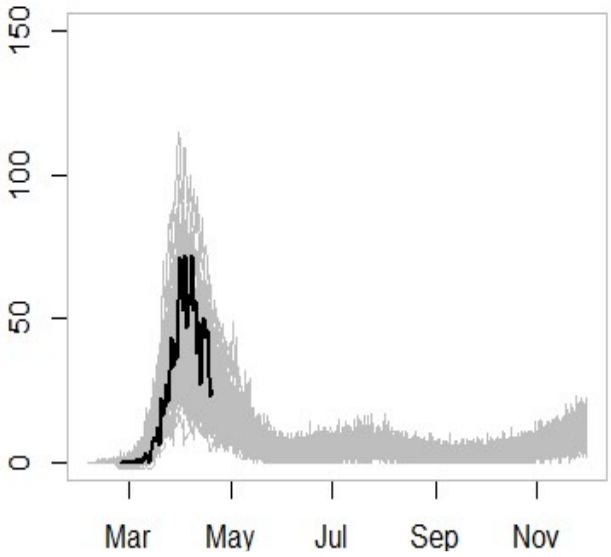


Patients in ICU

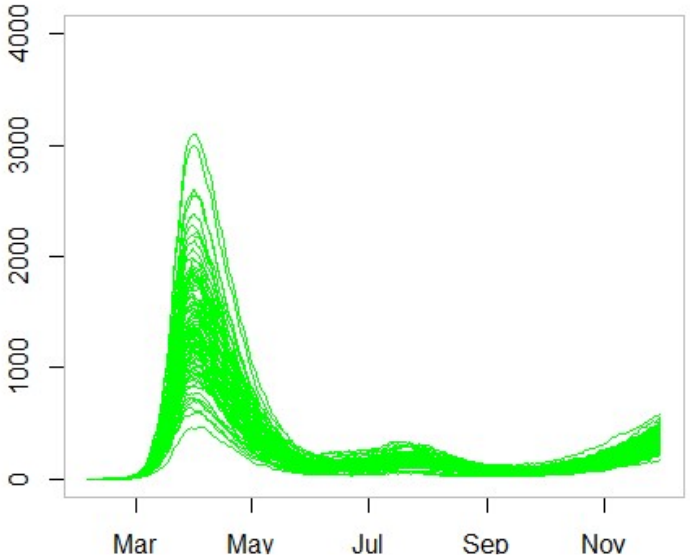


“Tracing/testing” intervention after 8 June: Effect equivalent to reducing <u>all</u> contacts by 52%

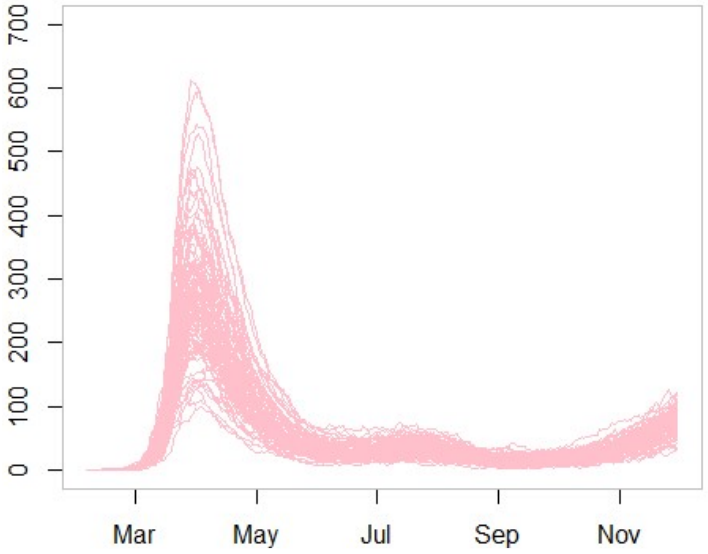
Deaths



Hospitalized patients

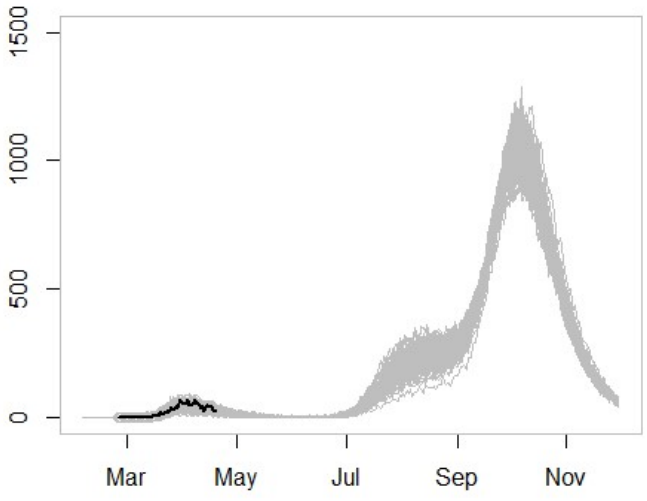


Patients in ICU

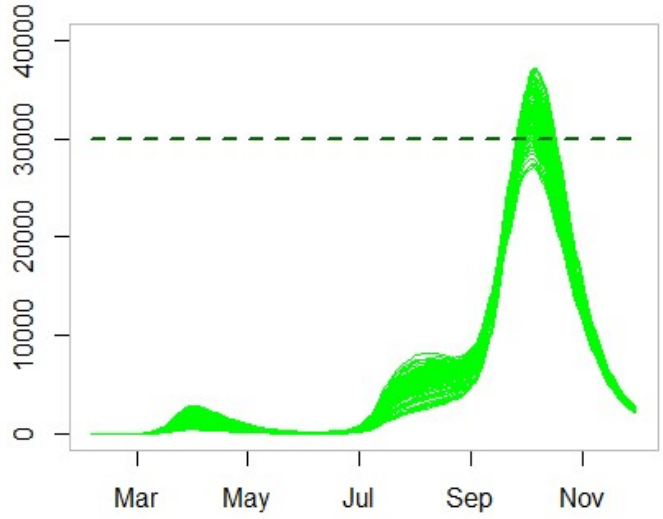


“Tracing/testing” intervention after 8 June: Effect equivalent to reducing contacts of <u>adults</u> by 90%

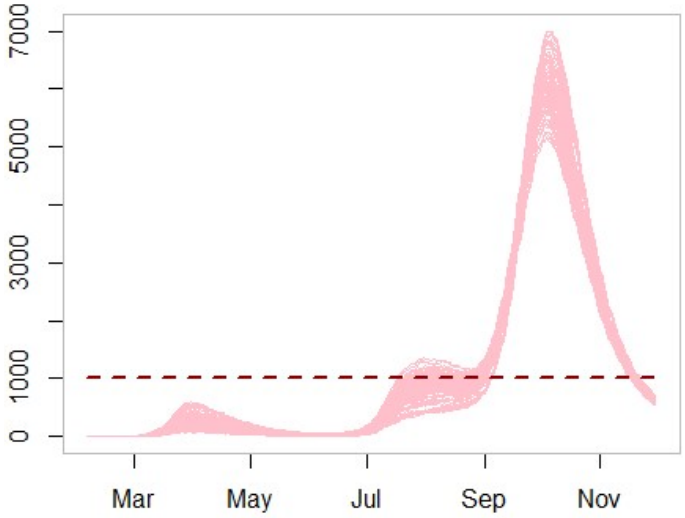
Deaths



Hospitalized patients



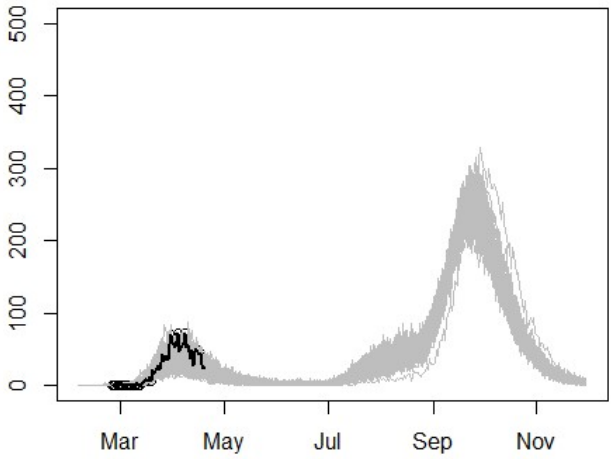
Patients in ICU



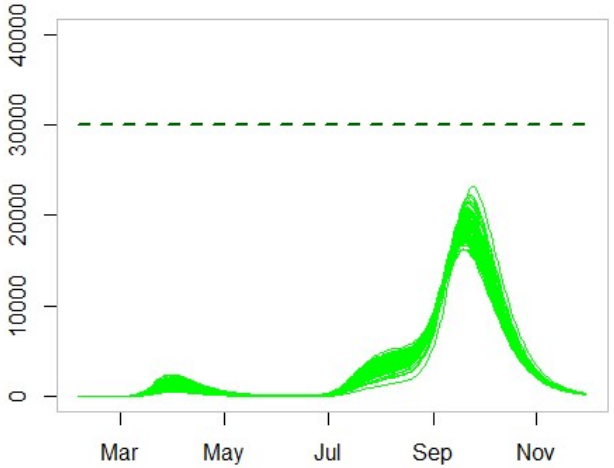
If tracing/testing intervention focuses mainly on adults, we expect about **half of the total population to have been infected** and **60,000 cumulative deaths** by end of 2020; intensive care **seriously overburdened in September-October**

“Tracing/testing” intervention after 8 June: Effect equivalent to reducing contacts of seniors by 90%

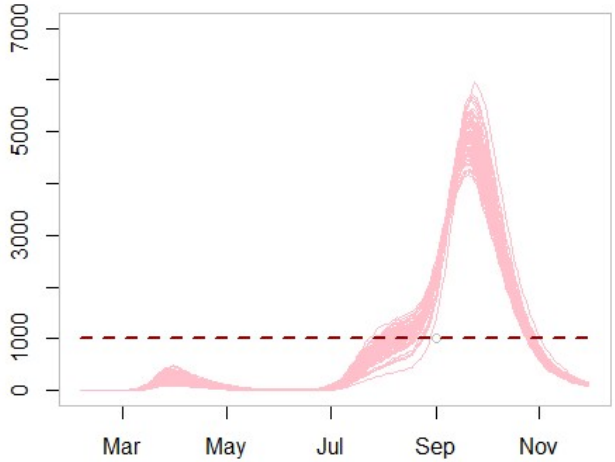
Deaths



Hospitalized patients



Patients in ICU



If we focus on reducing contacts of seniors only, we expect **two thirds of the total population to have been infected** and **13,000 cumulative deaths** by end of 2020 (but intensive care seriously overburdened in **September-October also in this option**)

Next steps

- Improving the fit by using Bayesian computation (still a large number of parameters with limited prior knowledge => MLE not very efficient)
- Running the model for individual cantons (epidemic in different phases across the country; more accurate data from some cantons)
- A more explicit modelling of the interventions beyond this summer
  - What is the optimal mix of preventions targeting different population groups?