Deep Learning to Improve Breast Cancer Detection on Screening Mammography - A summary

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Outline

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Bayesian inference for the rescue!

Model

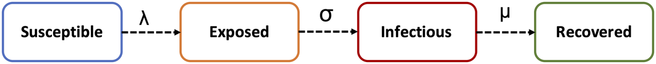
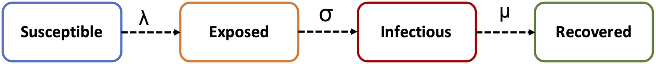


Figure: SEIR model [MM20]



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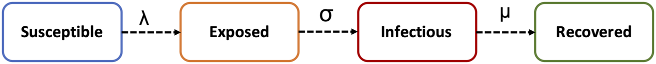
$$\frac{dS}{dt} = -\frac{\lambda SI}{N}$$
$$\frac{dE}{dt} = \frac{\lambda SI}{N} - \sigma E$$
$$\frac{dI}{dt} = \sigma E - \mu I$$
$$\frac{dR}{dt} = \mu I$$

S(E)IR



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- Basic reproductive number $R_0 = \frac{\lambda}{\mu}$
- Delay D in becoming infected (I^{new}) and being reported
- λ time-varying with change points corresponding to NIPs

Bayesian model

Parameter	Prior Distribution
Spreading rate λ_0	LogNormal(log(0.4),0.5)
Spreading rate λ_1	LogNormal(log(0.4),0.7)
Spreading rate λ_2	LogNormal(log(0.4),0.7)
Incubation to infectious rate σ	LogNormal(log(1/5),0.5)
Recovery rate μ	LogNormal(log(1/8),0.2)
Reporting Delay D	LogNormal(log(8),0.2)
Initial Infectious I_0	Half-Cauchy(20)
Initial Exposed E_0	Half-Cauchy(20)
Change Point t_1	Normal(2020/03/18,1)
Change Point t_2	Normal(2020/03/28,1)

https://doi.org/10.1371/journal.pone.0237126.t001

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- Likelihood function Student-T distribution
- Initial $R_0 = 3.278$ (CI[2.715, 3.73])
- Hamiltonian Monte Carlo (HMC) method to sample from posterior distribution
    - No-U-Turn Sampling (NUTS)
    - 5000 samples with 1000 burn-in

Results I

Model	Change Points	LOO	Effective Parameters
SIR	2	448.00	10.27
SEIR	1	457.77	11.60
SEIR	2	459.94	12.00
SIR	1	463.03	8.51
SEIR	0	464.69	16.14
SIR	0	517.72	4.72

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Results I

Model	Change Points	LOO	Effective Parameters
SIR	2	448.00	10.27
SEIR	1	457.77	11.60
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SIR	1	463.03	8.51
SEIR	0	464.69	16.14
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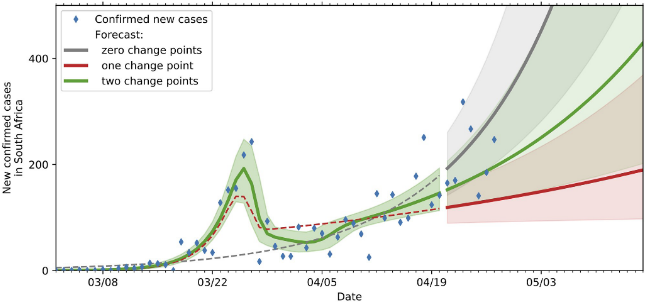
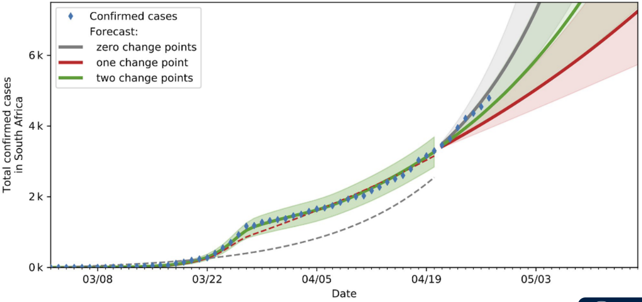
- SIR model with two change points yields lowest LOO cross entropy loss

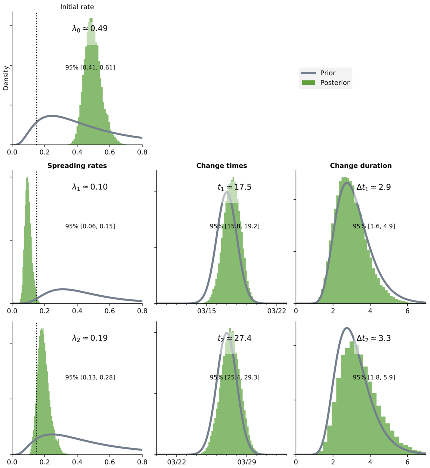


Confirmed new cases
Forecast:
zero change points
one change point
two change points
New confirmed cases in South Africa
400
200
0
03/08
03/22
04/05
04/19
05/03
Date



Confirmed cases
Forecast:
zero change points
one change point
two change points
Total confirmed cases in South Africa
6 k
4 k
2 k
0 k
03/08
03/22
04/05
04/19
05/03
Date

Results II



Initial rate
$\lambda_0 \simeq 0.49$
95% [0.41, 0.61]
Density
Prior
Posterior
Spreading rates
$\lambda_1 \simeq 0.10$
95% [0.06, 0.15]
Change times
$t_1 \simeq 17.5$
95% [15.8, 19.2]
Change duration
$\Delta t_1 \simeq 2.9$
95% [1.6, 4.9]
$\lambda_2 \simeq 0.19$
95% [0.13, 0.28]
$t_2 \simeq 27.4$
95% [25.4, 29.3]
$\Delta t_2 \simeq 3.3$
95% [1.8, 5.9]
0.0 0.2 0.4 0.6 0.8
03/15 03/22
03/22 03/29
0 2 4 6

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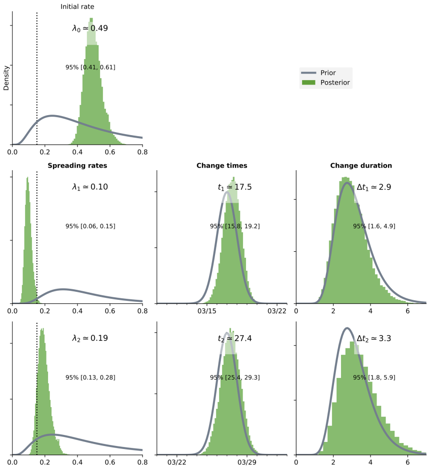

- Change points peak on 18/03 (travel ban, social distancing) and 28/03 (mass testing)

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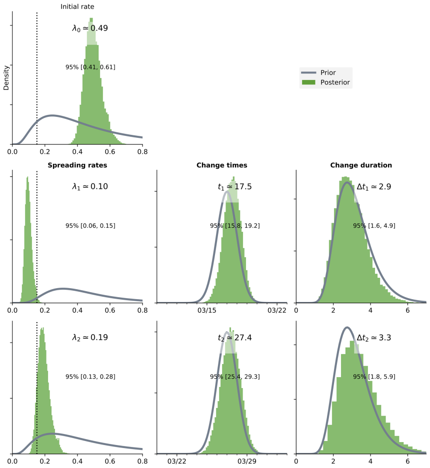

- Change points peak on 18/03 (travel ban, social distancing) and 28/03 (mass testing)
- Drop of spreading rate by 80% ($R_0 = 0.655$ (CI[0.430, 0.960])) and 60% ($R_0 = 1.304$ (CI[0.887, 1.7748])) respectively

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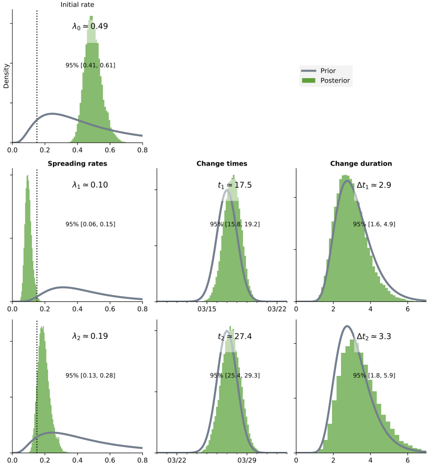

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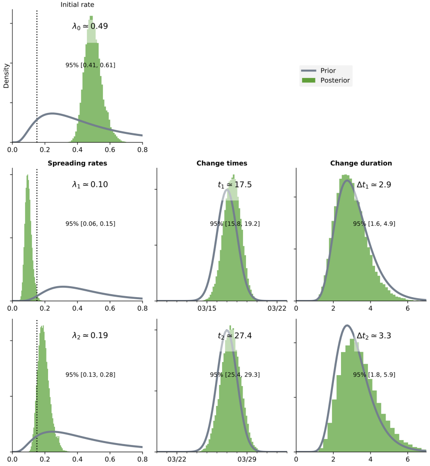

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- Recovery rate $\mu \approx 0.151$ implies mean infectious period of 6.62 days

Discussion

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- Assumptions on prior distributions?
- Take into account local, provincial developments

Rendani Mbuvha and Tshilidzi Marwala.
Bayesian inference of covid-19 spreading rates in south africa.
04 2020.