Non-Pharmaceutical Interventions for Planning

D.Adams, M.Bashir, J.Choma, F.Correa, S.Dahbi, B.Dwolazky, L.Dwolazky, T.Gumani, K.Hayasi, G.Hillhouse, H.Hlomani, R.Katlego, T.Lebese, S.-M.Liao, L.Liyambo, L.Mundia, B.Lieberman, P.Makepe, C.Maslo, B.Mellado, M.Molepo, K.Monnakgotla, D.Musundire, J.Naude, R.Nemalili, A.Nkoana, J.Njagarah, C.M.Paulo, R.C.Saide, X.Ruan, R.Setso, E.Steere, F.Stevenson, O.Tikologo, M.Van der Ventel-Bark, et al.

In partnership with the Gauteng City-Region Observatory (GCRO) and IBM

Modeling Symposium, DoH, 21/05/20

Daily monitoring impact of non-pharmaceutical interventions in over 100 countries and States of the US. Include projections different countries (first phase)

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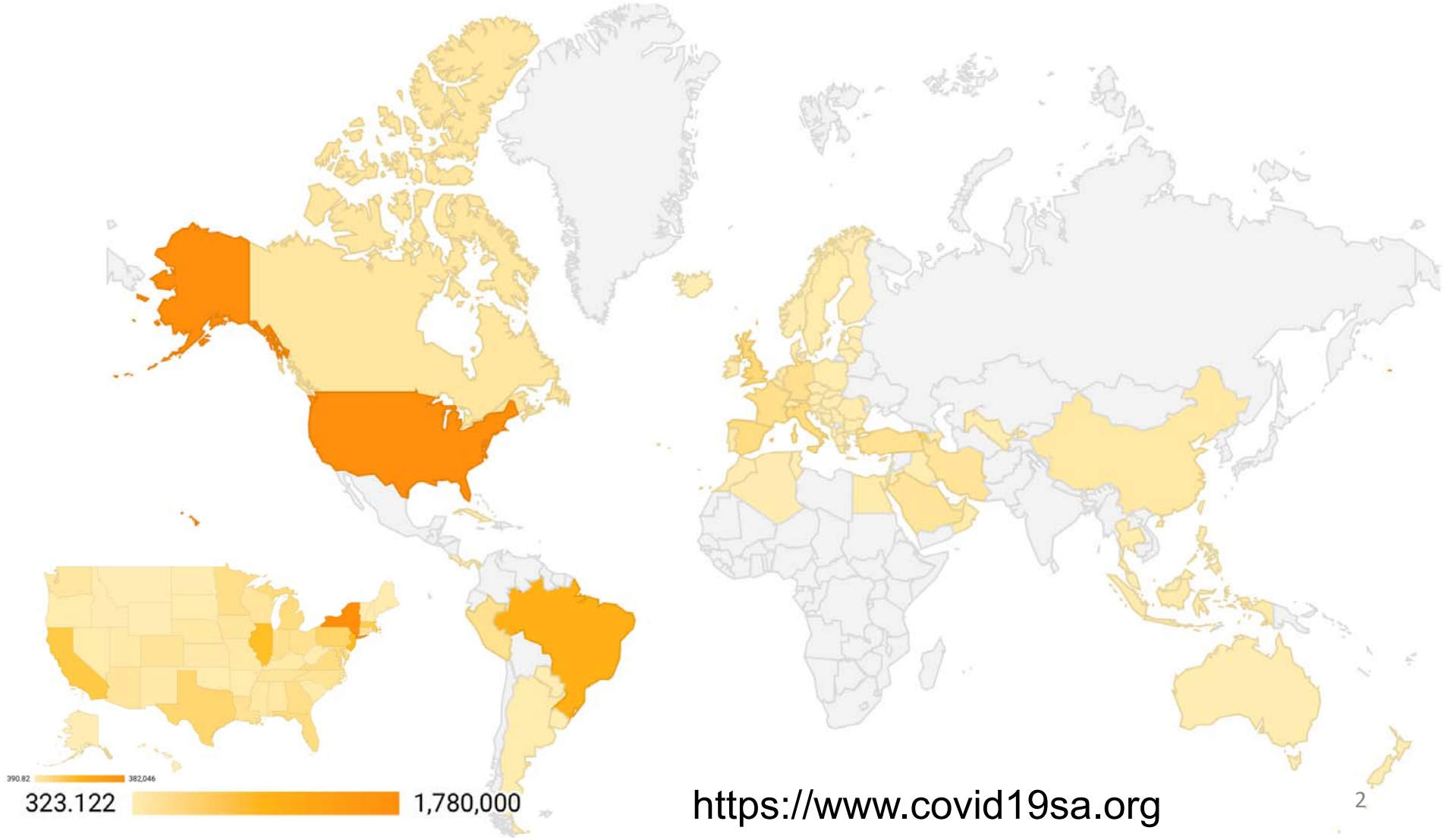
May 20, 2020, 9:45 PM

World Map with Total Predicted Number of Positive Cases



https://www.covid19sa.org

The Dual SIRD Model

https://www.medrxiv.org/content/10.1101/2020.04.30.20085316v2

Worldwide Effectiveness of Various Non-Pharmaceutical Intervention Control Strategies on the Global COVID-19 Pandemic: A Linearised Control Model

Joshua Choma[1], Fabio Correa, PhD[5], Salah-Eddine Dahbi, PhD[1], Barry Dwolatzky, PhD[4], Leslie Dwolatzky[3], Kentaro Hayasi[3], Benjamin Lieberman[1], Caroline Maslo, MD, PhD[6], Bruce Mellado, PhD[1,2], Kgomotso Monnakgotla[1], Jacques Naudé[7], Xifeng Ruan, PhD[1], Finn Stevenson[1]

Abstract

Background COVID-19 is a virus which has lead to a global pandemic. Worldwide, more than 100 countries have imposed severe restrictions regarding freedom of movement amongst their citizens in a bid to slow the spread of the virus. These restrictions, which are part of a set of non-pharmaceutical interventions, have recently been classified by the Oxford COVID-19 Government Response Tracker (OxCGRT) team and a nominal index measure has been defined for use by the wider international community. We address the use of this index measure to establish the degree and characteristics of control of the transmission rate of the virus within a representative sample of countries in the World and states in the United States of America.
Methods Country specific, Susceptible-Infected-Recovered-Deaths (SIRD)

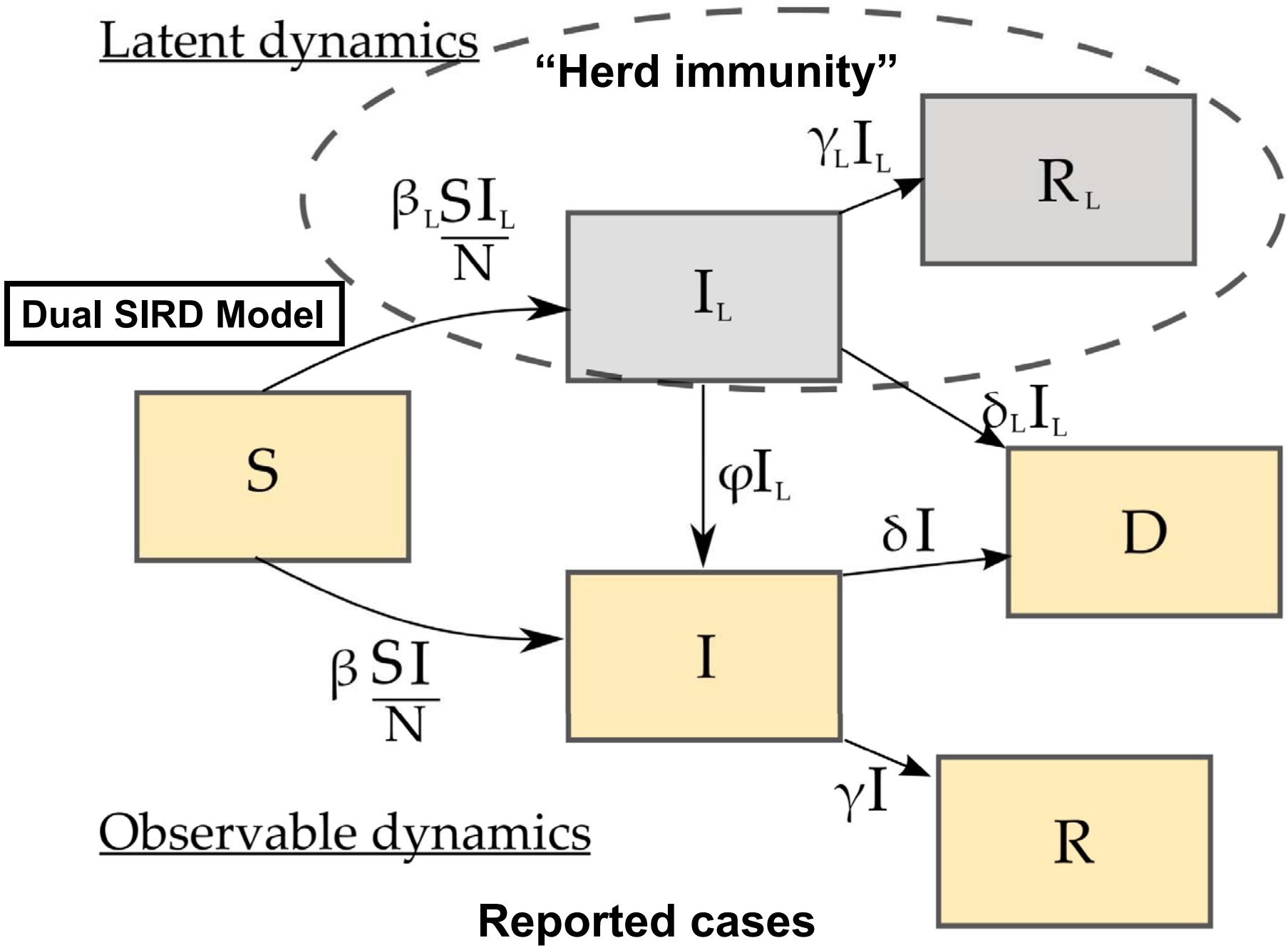
Risk Adjusted Non-Pharmaceutical Interventions in South Africa

Joshua Choma[1], Fabio Correa, PhD[5], Salah Dahbi-Eddine, PhD[1], Barry Dwolatzky, PhD[4], Leslie Dwolatzky[3], Kentaro Hayasi[3], Benjamin Lieberman[1], Caroline Maslo, MD, PhD[6], Bruce Mellado[1,2], Kgomotso Monnakgotla[1], Jacques Naudé[7], Xifeng Ruan, PhD[1], Finn Stevenson[1]

Abstract

A global analysis of the impact of non-pharmaceutical interventions (NPI)s on the dynamics of the spread of the COVID-19 indicates that these can be classified using the stringency index proposed by the Oxford COVID-19 Government Response Tracker (OxCGRT) team. The World average for the coefficient that linearises the level of transmission with respect to the OxCGRT stringency index is $\alpha_s = 0.01 \pm 0.0017$ (95% C.I.). The corresponding South African coefficient is $\alpha_s = 0.0078 \pm 0.00036$ (95% C.I.), compatible with the World average. Here, we implement the stringency index for the recently announced 5-tier regulatory alert system. Predictions are made for the spread of the virus for each alert level. Assuming constant rates of recovery and mortality, it is essential to increase α_s. For the system to remain sub-critical, the rate with which α_s increases should outpace that of the decrease of the stringency index. Monitoring of α_s becomes essential to controlling the post-lockdown phase.

Keywords: COVID-19, South Africa, Risk Adjusted Strategy, Control Interventions


Latent dynamics
"Herd immunity"
$\gamma_L I_L$
R_L
$\beta_L \frac{S I_L}{N}$
I_L
Dual SIRD Model
$\delta_L I_L$
S
φI_L
δI
D
$\beta \frac{S I}{N}$
I
γI
R
Observable dynamics
Reported cases

Important Parameters

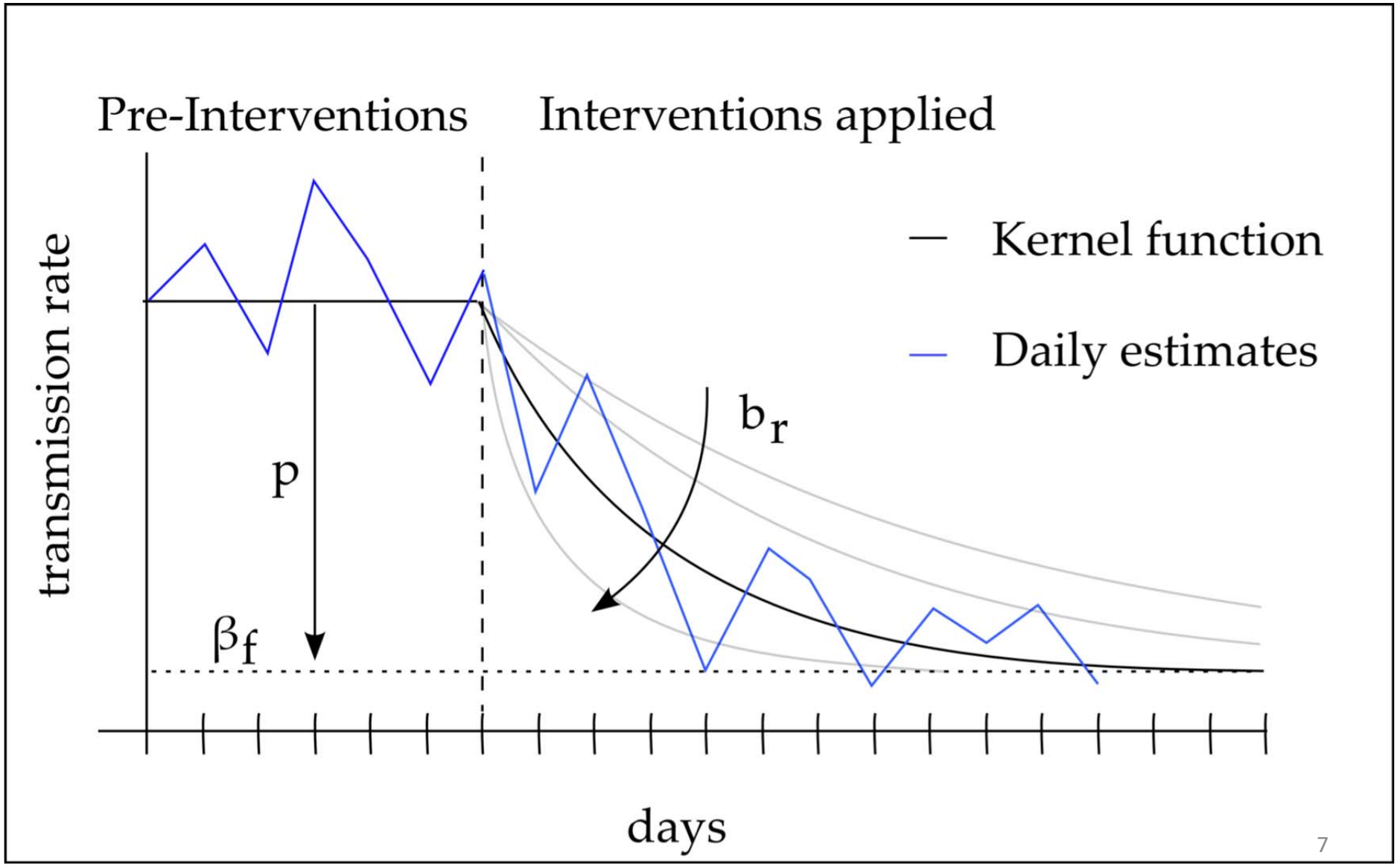
p

Stringency index of the NPI. Adapt Oxford COVID-19 Government Response Tracker (OxCGRT) index to South Africa in light of the 5-level alert regulatory system. Quantifies social distancing imposed by NPIs.

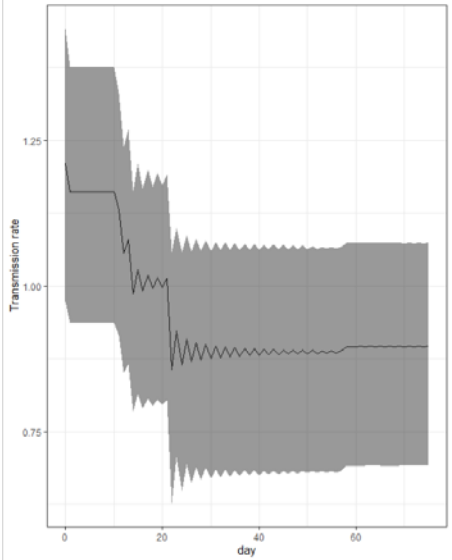
α

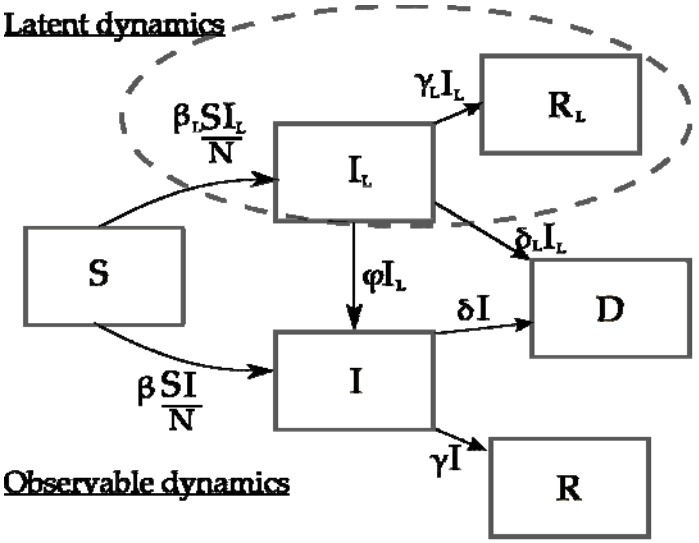
Efficiency of the NPI. It can be interpreted as the level of adherence to social distancing. The larger the index the larger the adherence. Parameter is extracted from the data.

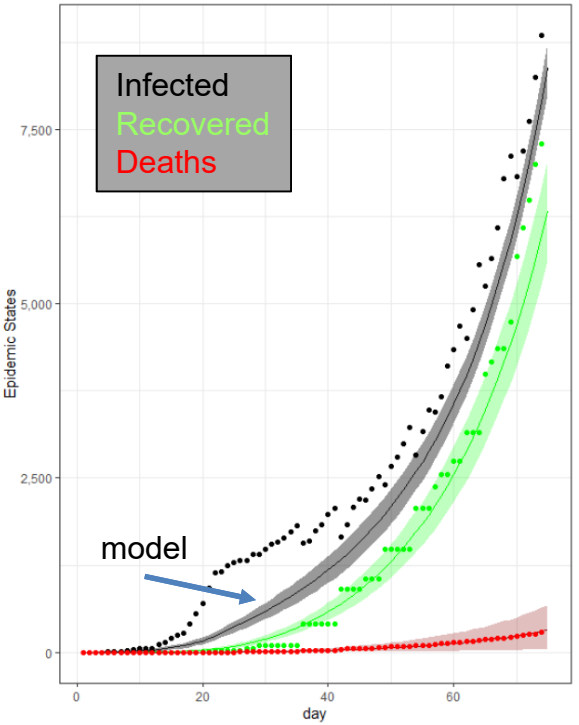
Quantify how transmission rate and the reproductive factor depend on non-pharmaceutical interventions. Demonstrated that mathematical frameworks works for many countries, including South Africa.

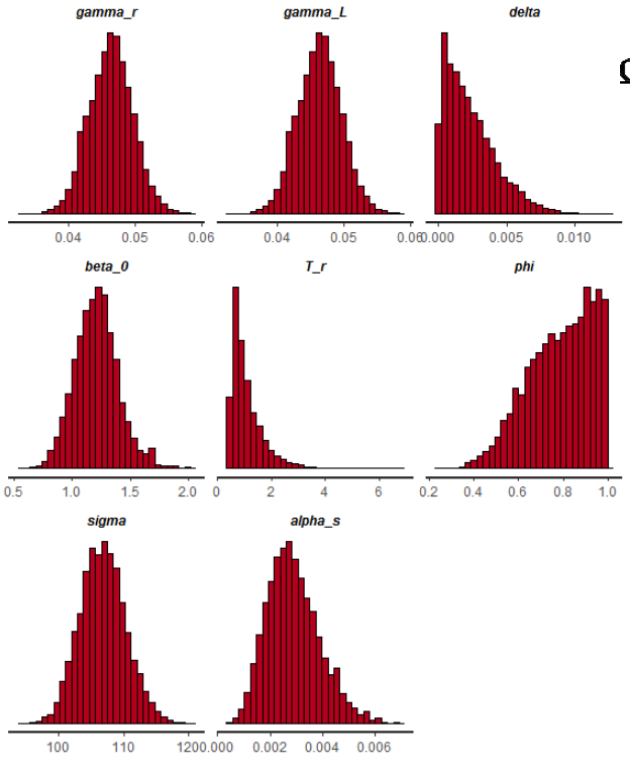


A Bayesian implementation of model

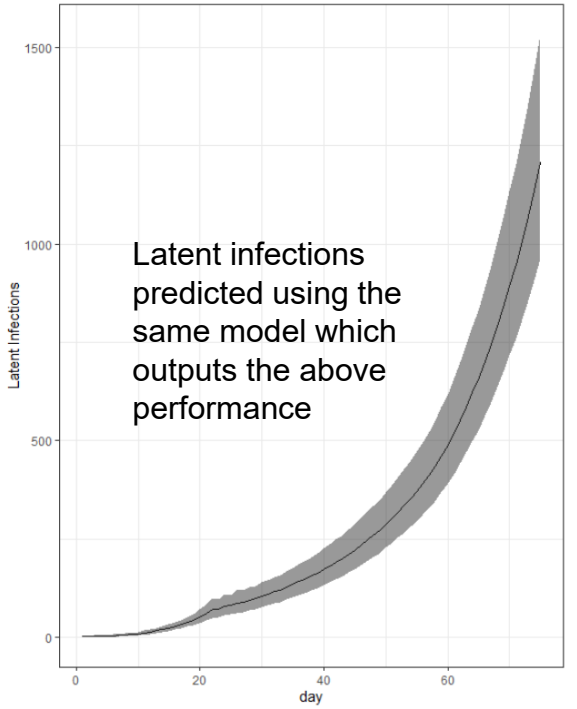






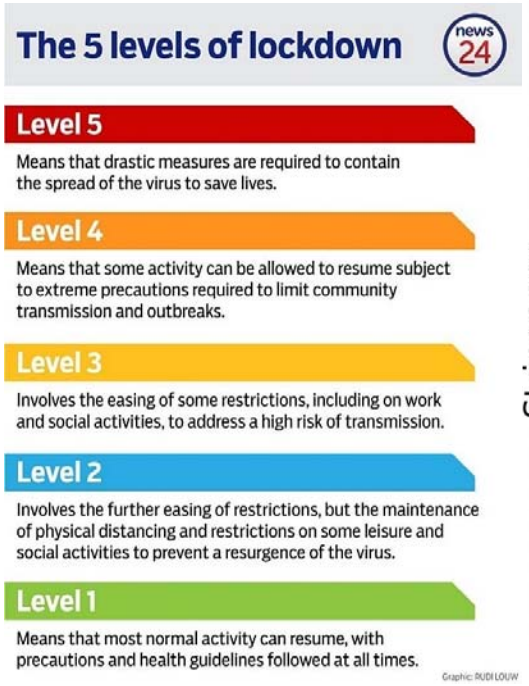


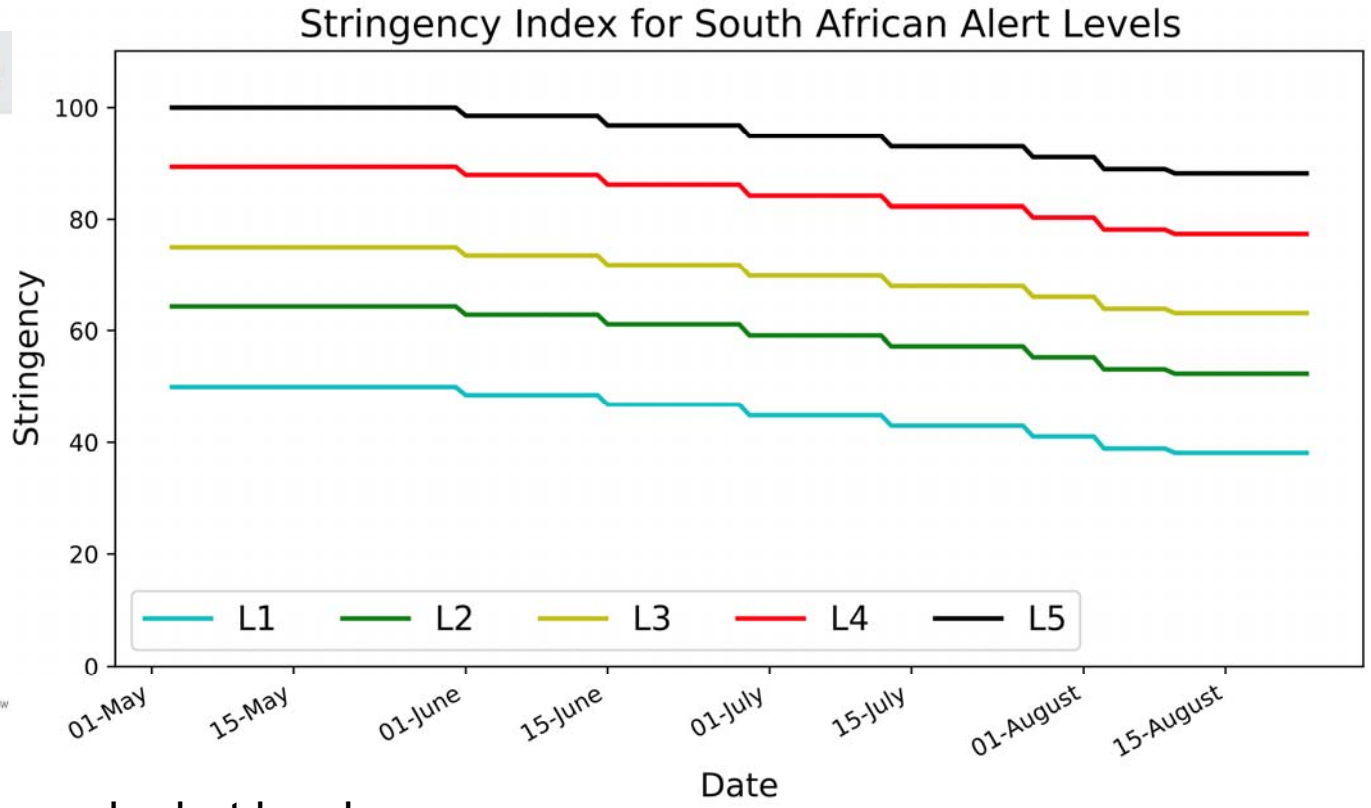
It is capable of estimating the latent infections, and hence can estimate "herd immunity", using observed data.



Caveat: there may be numerical instabilities in the estimated latent transmission rate which would affect the latent infection prediction. These estimates may change with new data.

Predictions for South Africa





The stringency index for each alert level was calculated by scoring the indicators appropriately based on the description of the Alert Levels provided by the government.

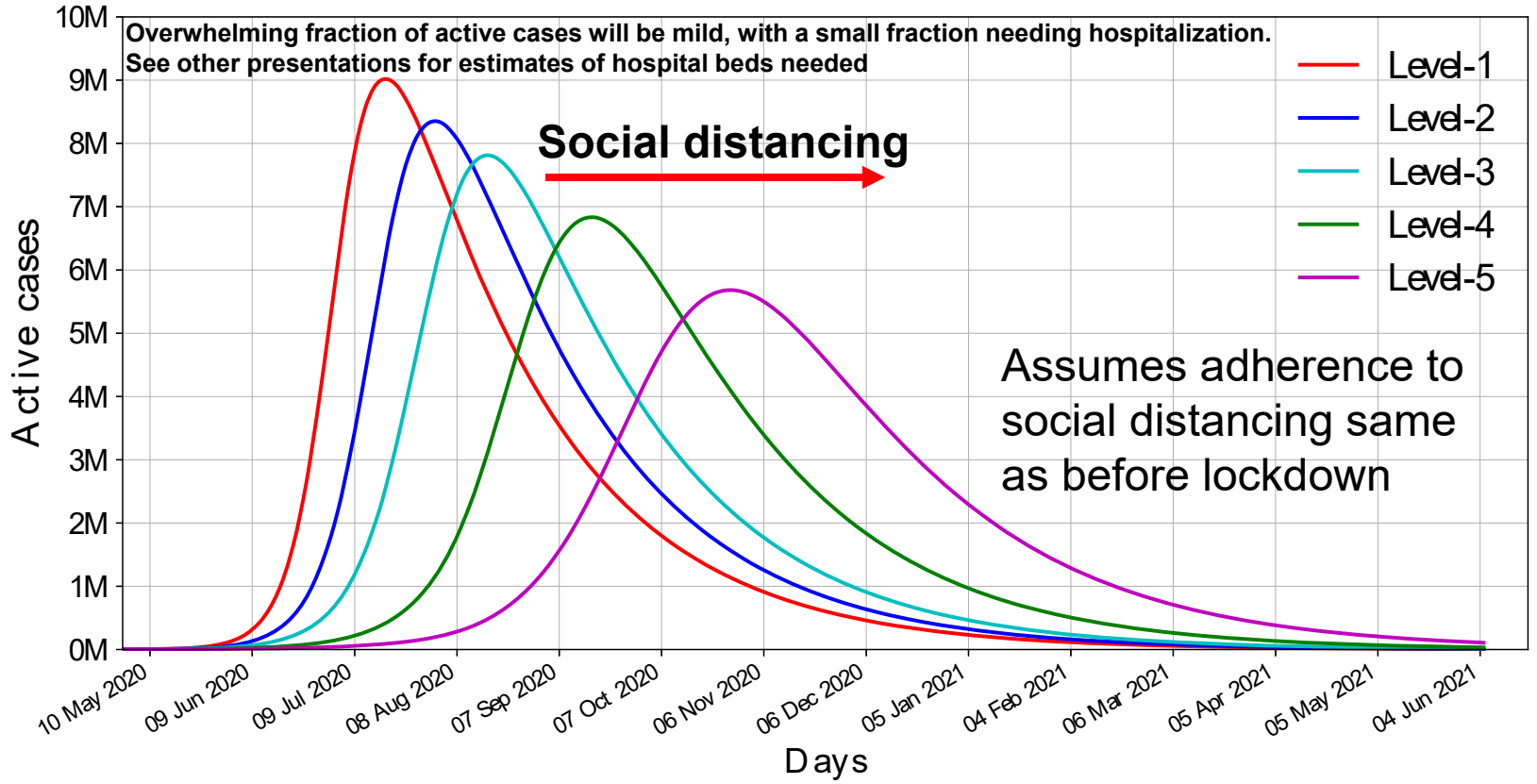
This includes the time dependence introduced by staged re-opening of schools

Use currently available information on employment contribution by sector and economic sector regulation at each alert level

OxCGRT Indicator	Intervention Response
S1:	School closure
S2:	Workplace closure
S3:	Cancel public events
S4:	Close public transport
S5:	Public information campaign
S6:	Domestic travel bans
S7:	International travel bans

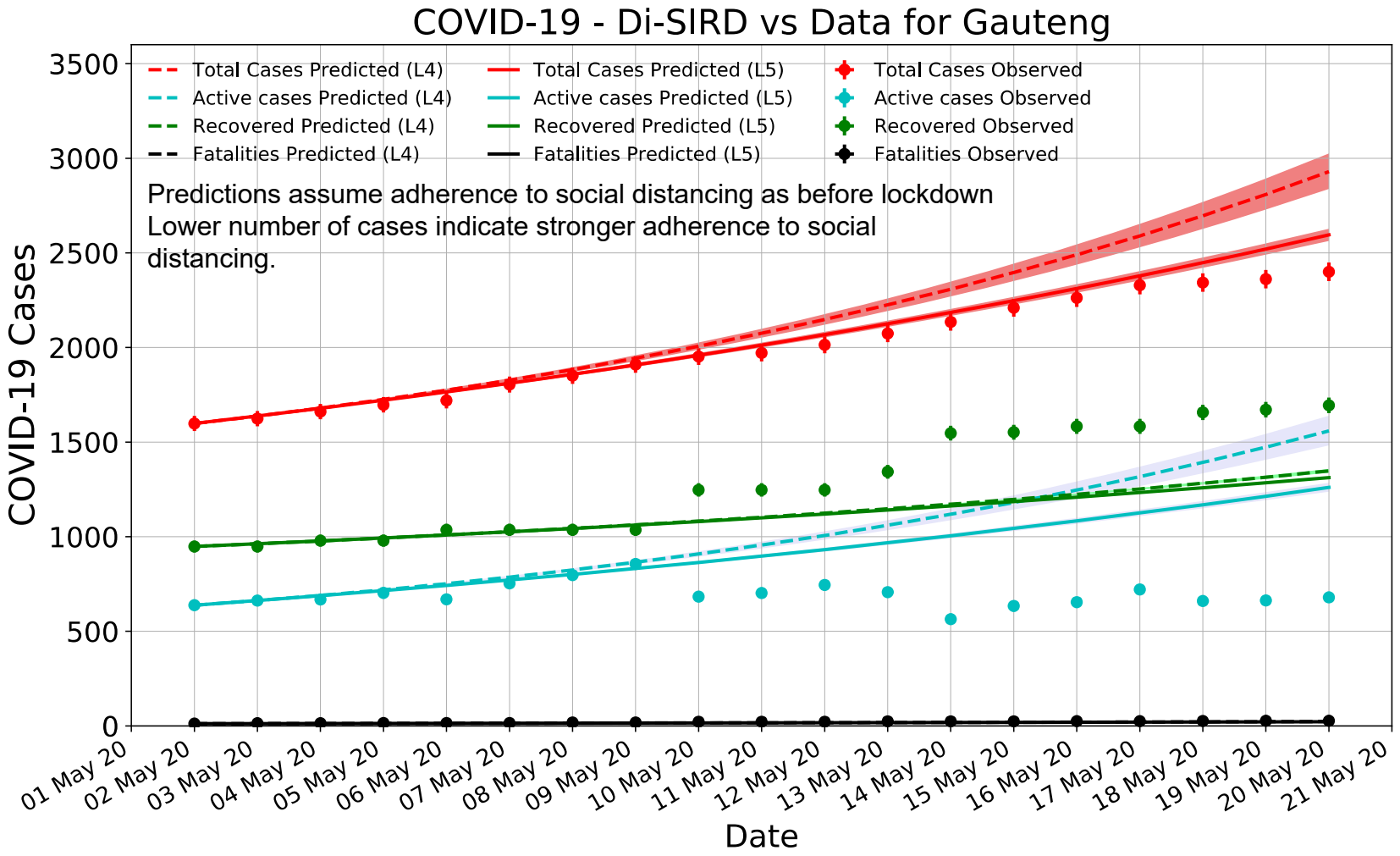
Predictions available for SA and provinces for the 5-level alert system issued by central Government. This is based on stringency modelling that works with data from all over the Globe. This assumes that efficiency of Non-pharmaceutical interventions is same as before lockdown, which is hopefully pessimistic.

With better adherence to social distancing curves move to the right

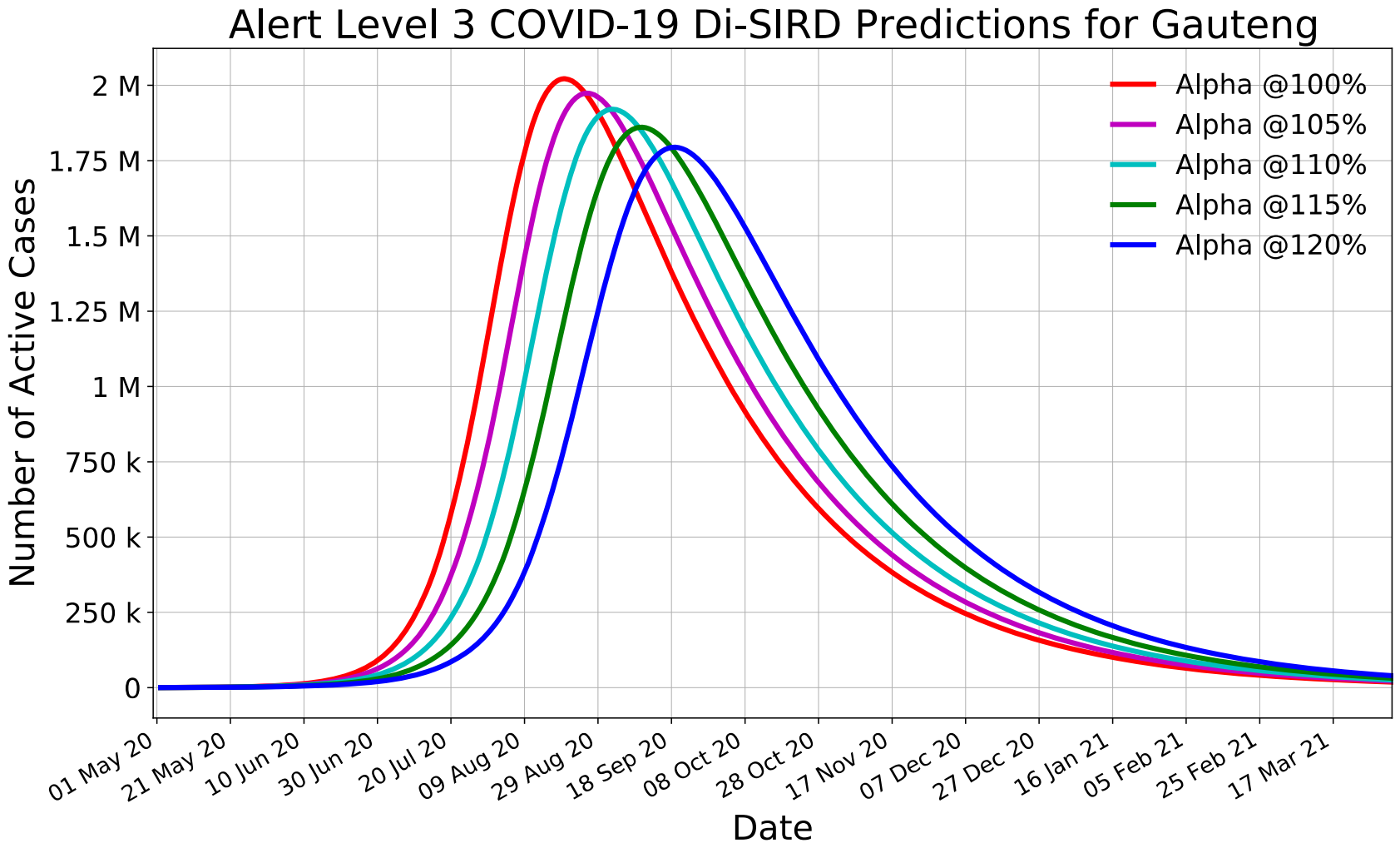


Using 25% as fraction of symptomatic cases, as assumed by NICD

Relatively low numbers in Gauteng seem indicative that additional mobility applied in Level 4 does not seem to have significantly impacted community transmission.
Data consistent with increase of social adherence of 20% with respect to before lockdown.
Apparent increase in adherence to social distancing warrants transition to Level 3



Impact of moderate increase in adherence to social distancing for the Gauteng province assuming Level 3. Baseline of 100% corresponds to adherence to social distancing before lockdown.



Prescription to move levels

- Equation to control the pandemic when moving from one level to the next to remain below criticality:

$$\left.\frac{1}{\alpha}\frac{\partial \alpha_s}{\partial t}\right|_c \geq -\left.\frac{1}{p}\frac{\partial p}{\partial t}\right|_c$$

This can be approximated to:

Relative increase of adherence to social distancing during a level →

$$\frac{\Delta\alpha}{\alpha} \geq -\frac{\Delta p}{p}$$

← Relative decrease of stringency due to moving to a lower level

Gauteng's Relative increase of adherence to social distancing so far during Level 4 →

$$20\% > 16.7\%$$

← Relative decrease of stringency due to moving from Level 4 to Level 3

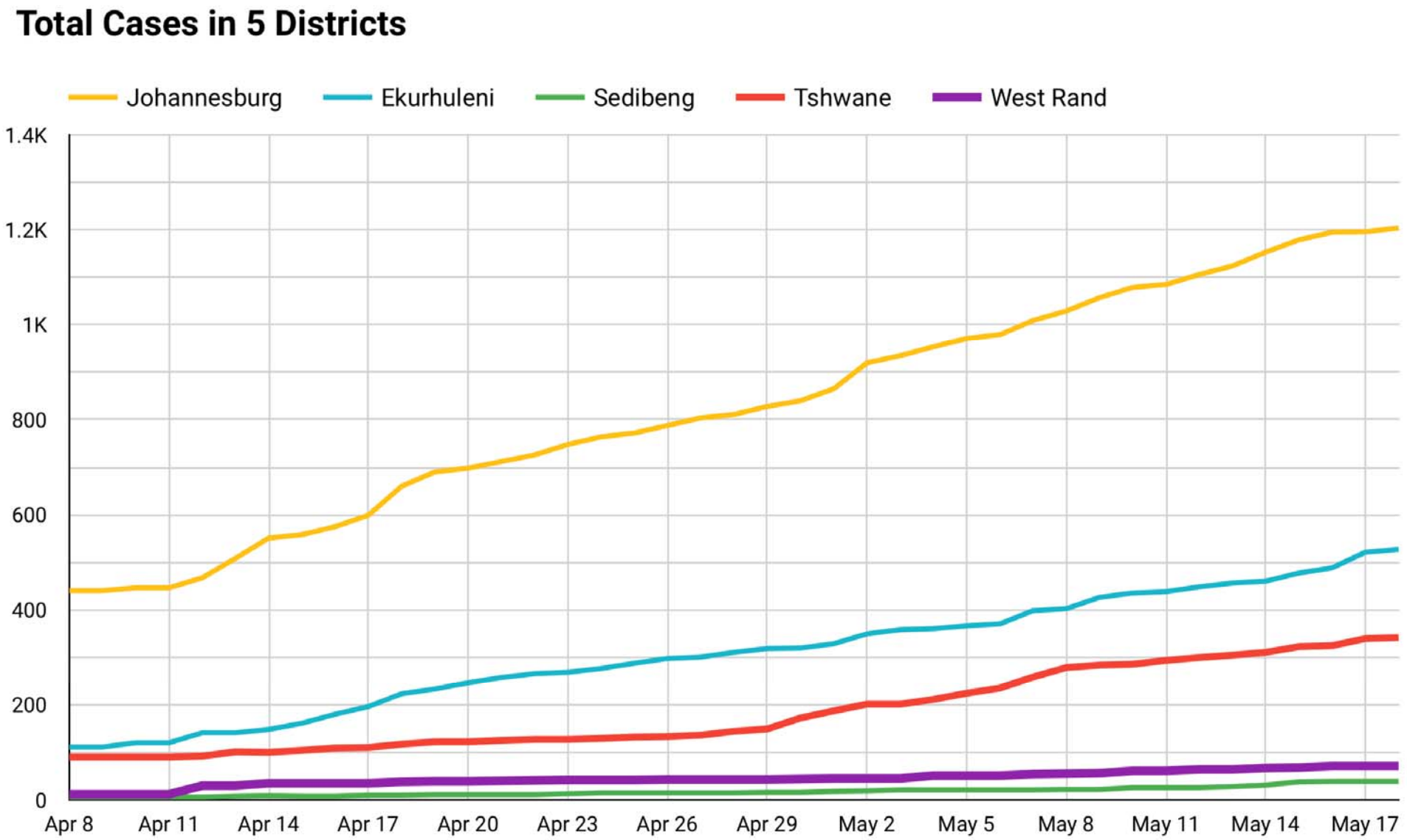
Gauteng currently meets the criterium to move to level 3

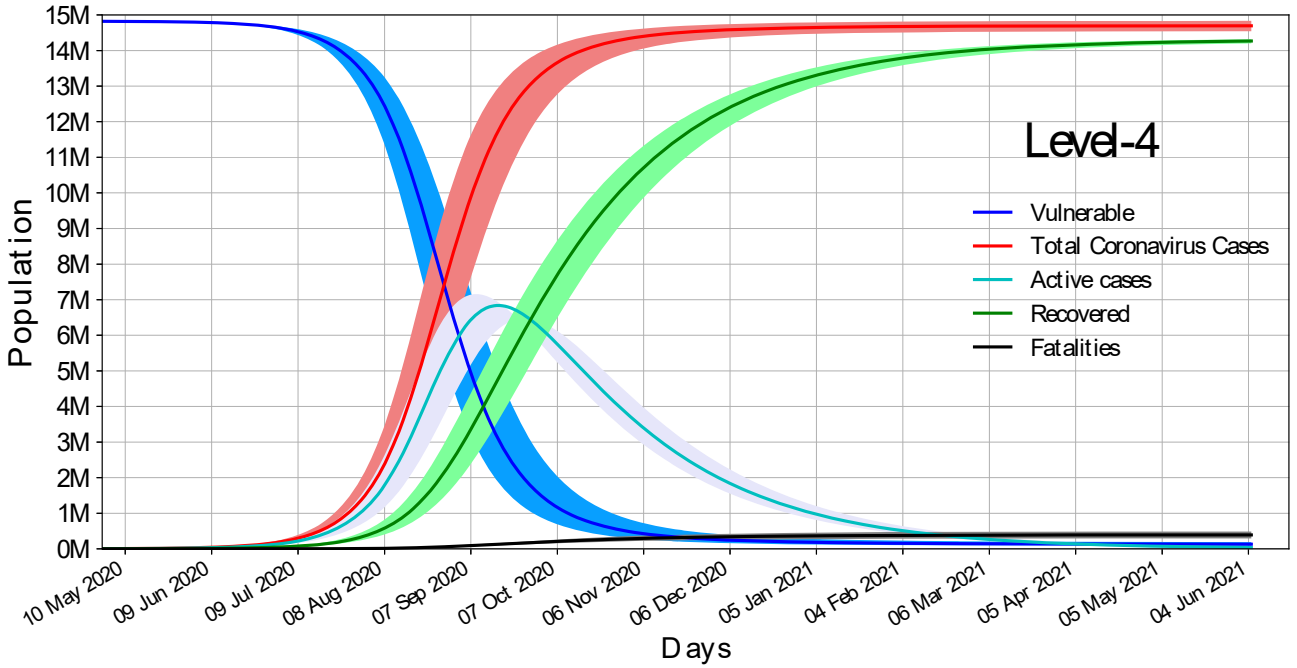
Conclusions

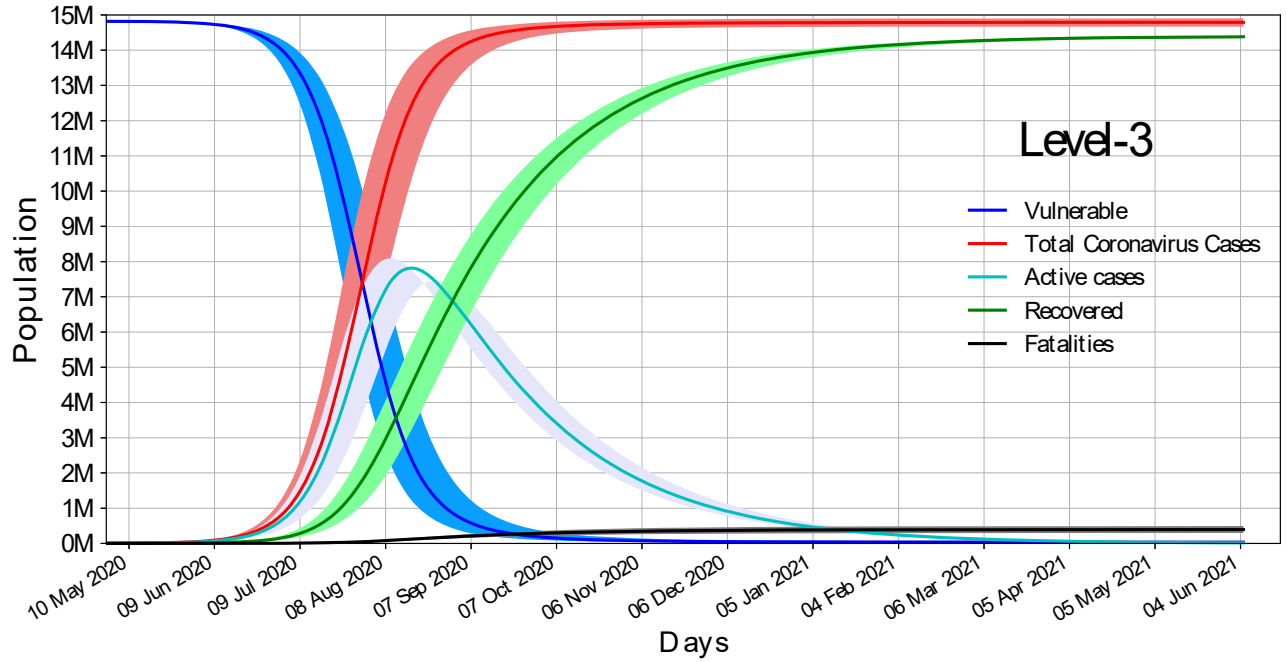
- Model developed to predict spread of the pandemic in conjunction with “herd immunity”
  - The Dual SIRD model
- Developed complete stringency indexing for South Africa’s 5-level alert level system
- Provide prescription for administrative units to move from one level to another
- Used Gauteng’s data as a showcase to demonstrate readiness of a province to move to a lower level, level 3

Extra Slides

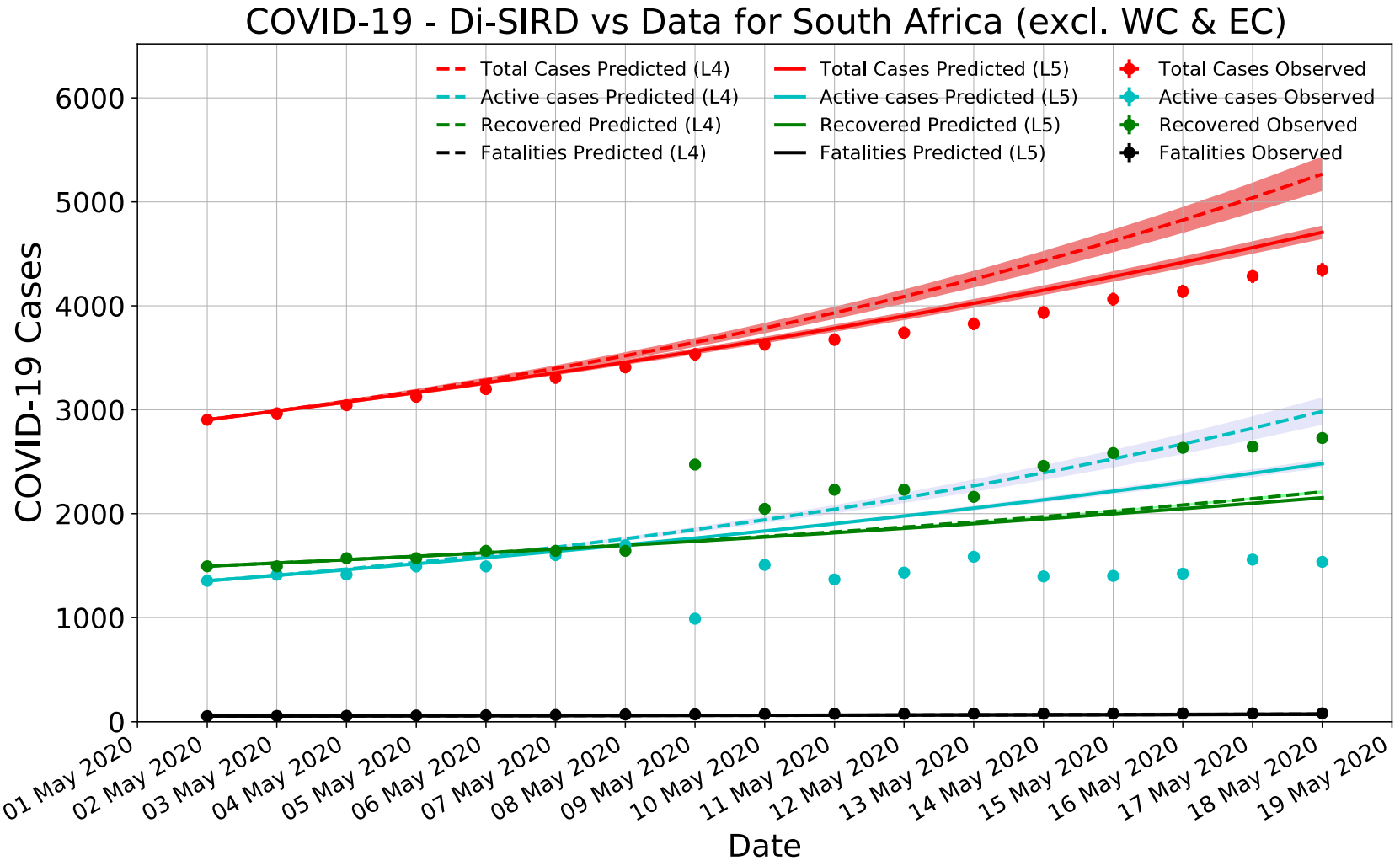
Gauteng Regions



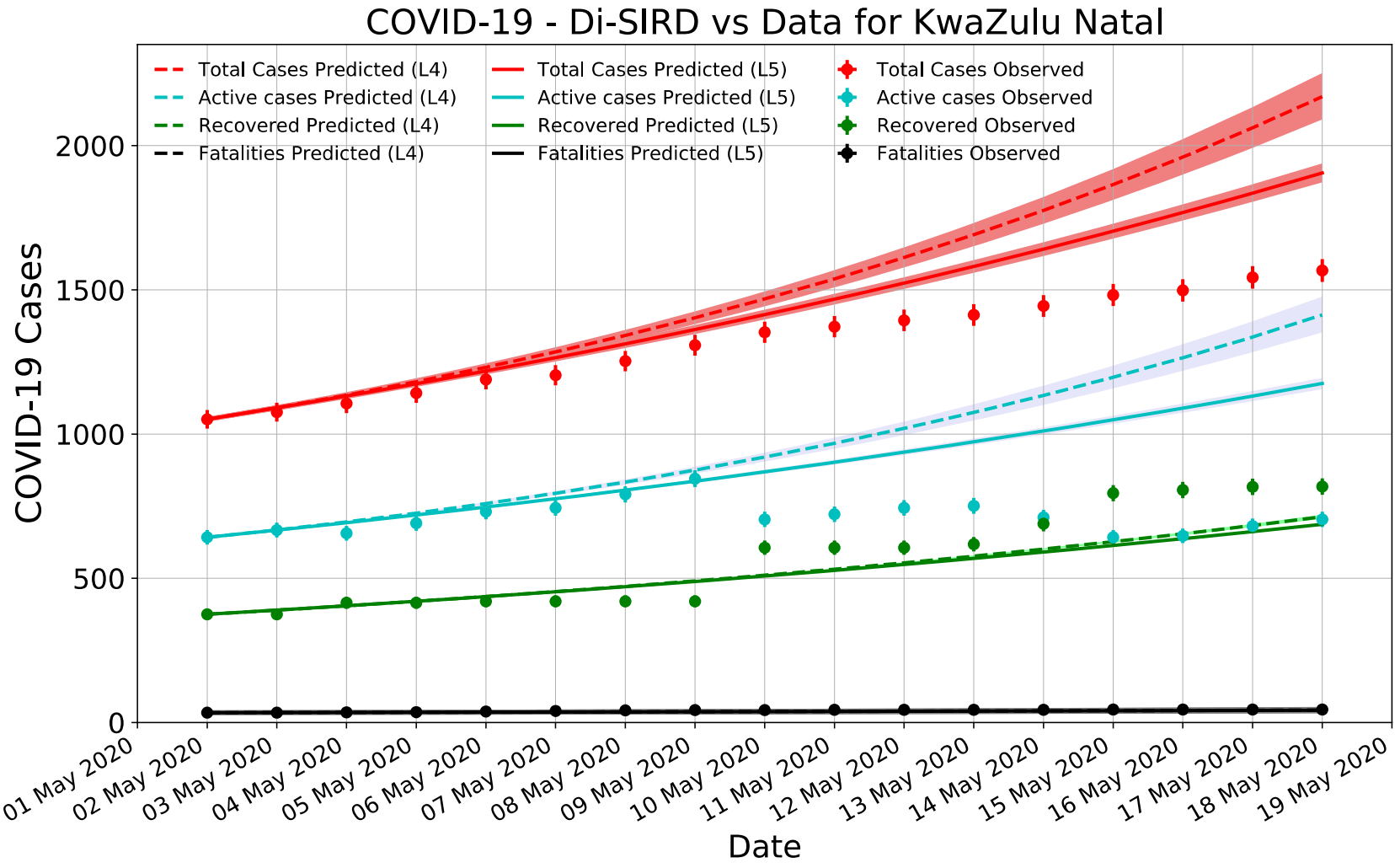

Level-4
Vulnerable
Total Coronavirus Cases
Active cases
Recovered
Fatalities
Population
Days
15M
14M
13M
12M
11M
10M
9M
8M
7M
6M
5M
4M
3M
2M
1M
0M
10 May 2020
09 Jun 2020
09 Jul 2020
08 Aug 2020
07 Sep 2020
07 Oct 2020
06 Nov 2020
06 Dec 2020
05 Jan 2021
04 Feb 2021
06 Mar 2021
05 Apr 2021
05 May 2021
04 Jun 2021


Level-3
Vulnerable
Total Coronavirus Cases
Active cases
Recovered
Fatalities
Population
Days
15M
14M
13M
12M
11M
10M
9M
8M
7M
6M
5M
4M
3M
2M
1M
0M
10 May 2020
09 Jun 2020
09 Jul 2020
08 Aug 2020
07 Sep 2020
07 Oct 2020
06 Nov 2020
06 Dec 2020
05 Jan 2021
04 Feb 2021
06 Mar 2021
05 Apr 2021
05 May 2021
04 Jun 2021

Most of the country, except for the WC, and the EC have seen number of cases consistent or somewhat lower compared to Level-5 despite having moved to Level-4. Systemic delay in reporting seems less likely by the day to explain relatively lower number of cases.

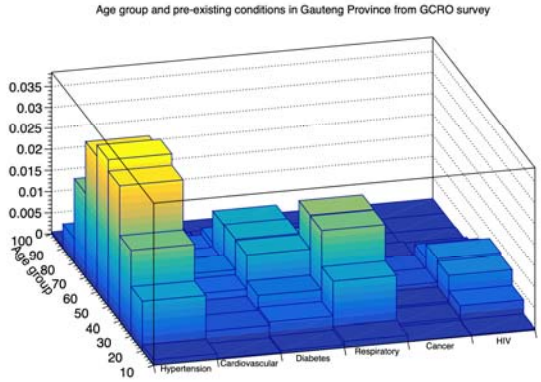


The graph of cases for SA that excludes the WC and EC undershoots predictions for Level 5. This is mostly driven by the numbers from KZN.



Modelling Mortality in SA

Developed model for mortality that uses inputs from Wuhan and raw data from the GCRO pertaining to surveys of prevalence of diseases and other inputs. Model is able to explain total mortality rate and differential with age.



Data seems inconsistent with large mortality rate for HIV