Non-Pharmaceutical Interventions for Planning


In partnership with the Gauteng City-Region Observatory (GCRO) and IBM
Daily monitoring impact of non-pharmaceutical interventions in over 100 countries and States of the US. Include projections different countries (first phase)

World Map with Total Predicted Number of Positive Cases

https://www.covid19sa.org
The Dual SIRD Model
Worldwide Effectiveness of Various Non-Pharmaceutical Intervention Control Strategies on the Global COVID-19 Pandemic: A Linearised Control Model

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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)
Dual SIRD Model

Latent dynamics

"Herd immunity"

Observable dynamics

Reported cases

\[ \frac{\beta_S SI}{N} \]

\[ \frac{\beta_L SI_L}{N} \]

\[ \gamma_L I_L \]

\[ \delta_L I_L \]

\[ \varphi I_L \]

\[ \gamma I \]

\[ \delta I \]

\[ R_L \]

\[ I_L \]

\[ I \]

\[ S \]

\[ R \]

\[ D \]
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.

\( \alpha \)

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.
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

Overwhelming fraction of active cases will be mild, with a small fraction needing hospitalization. See other presentations for estimates of hospital beds needed.

Assumes adherence to social distancing same as before lockdown

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.

Predictions assume adherence to social distancing as before lockdown. Lower number of cases indicate stronger adherence to social distancing.

COVID-19 - Di-SIRD vs Data for Gauteng

Predictions assume adherence to social distancing as before lockdown. Lower number of cases indicate stronger adherence to social distancing.
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:

\[
\frac{1}{\alpha} \left( \frac{\partial \alpha_s}{\partial t} \right) \bigg|_c \geq - \frac{1}{p} \frac{\partial p}{\partial t} \bigg|_c
\]

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

\[20\% > 16.7\%\]

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

Total Cases in 5 Districts

- Johannesburg
- Ekurhuleni
- Sedibeng
- Tshwane
- West Rand
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