

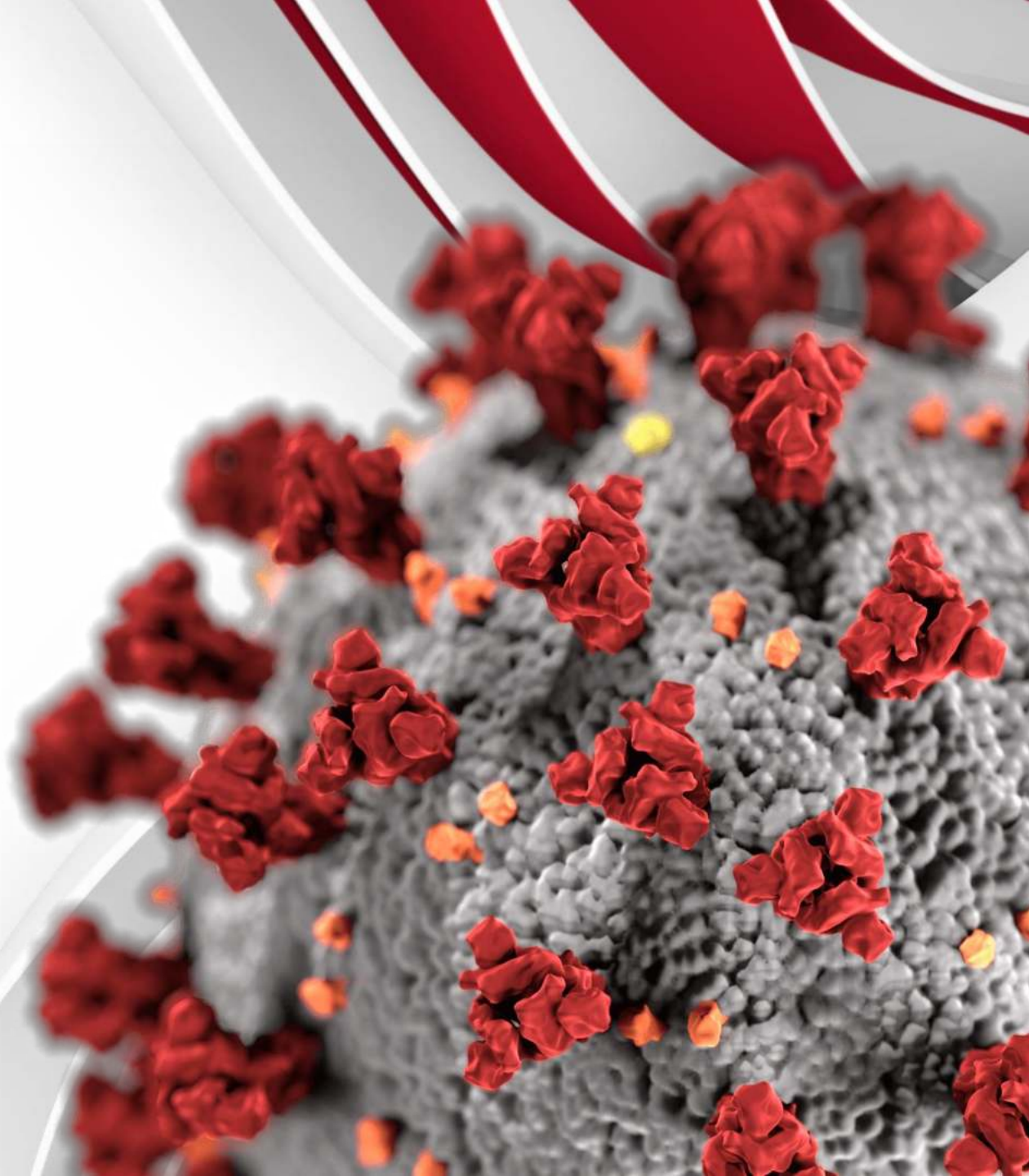


## **Keeping up with COVID-19**

**What's next and what have we learnt?**

Louis Rossouw

**Session Starting at 10h05**





# Agenda

- Quick terminology overview
- Where are we?
- What do the models say about what is next?
- What about population immunity?
- What have I learnt?

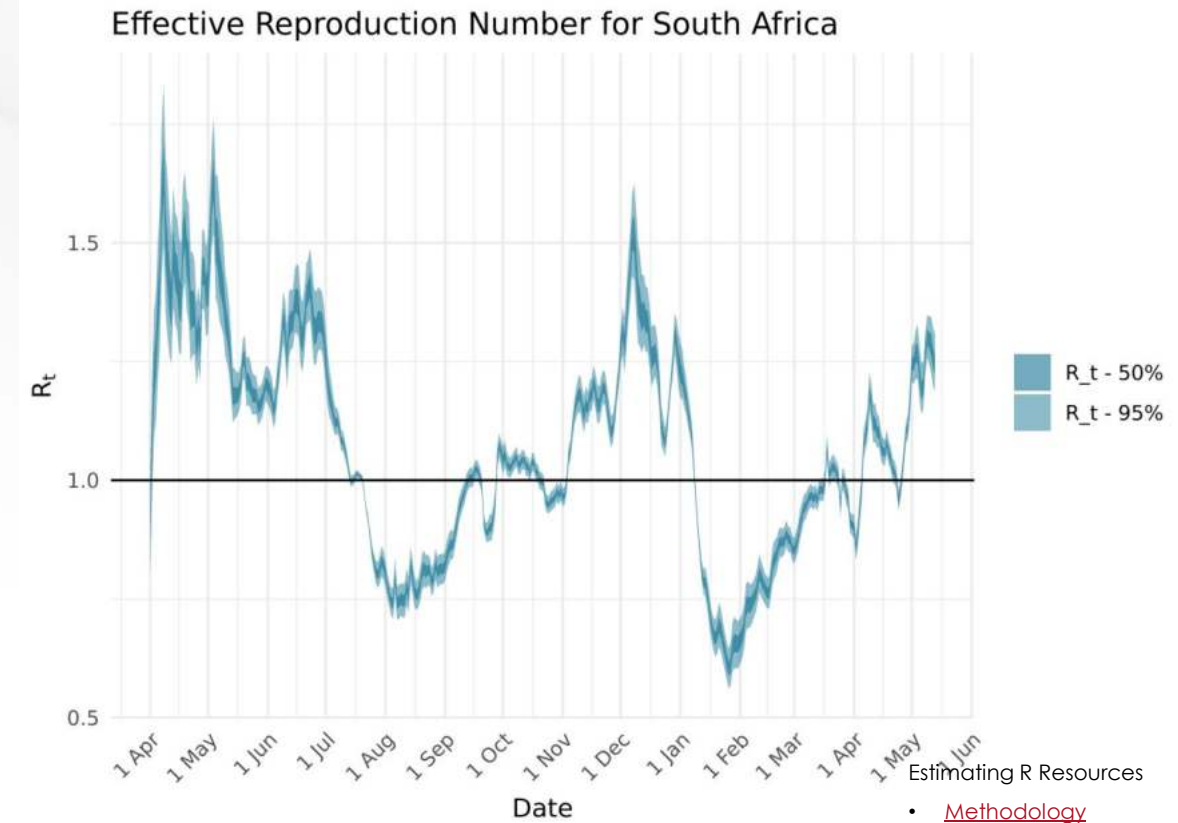
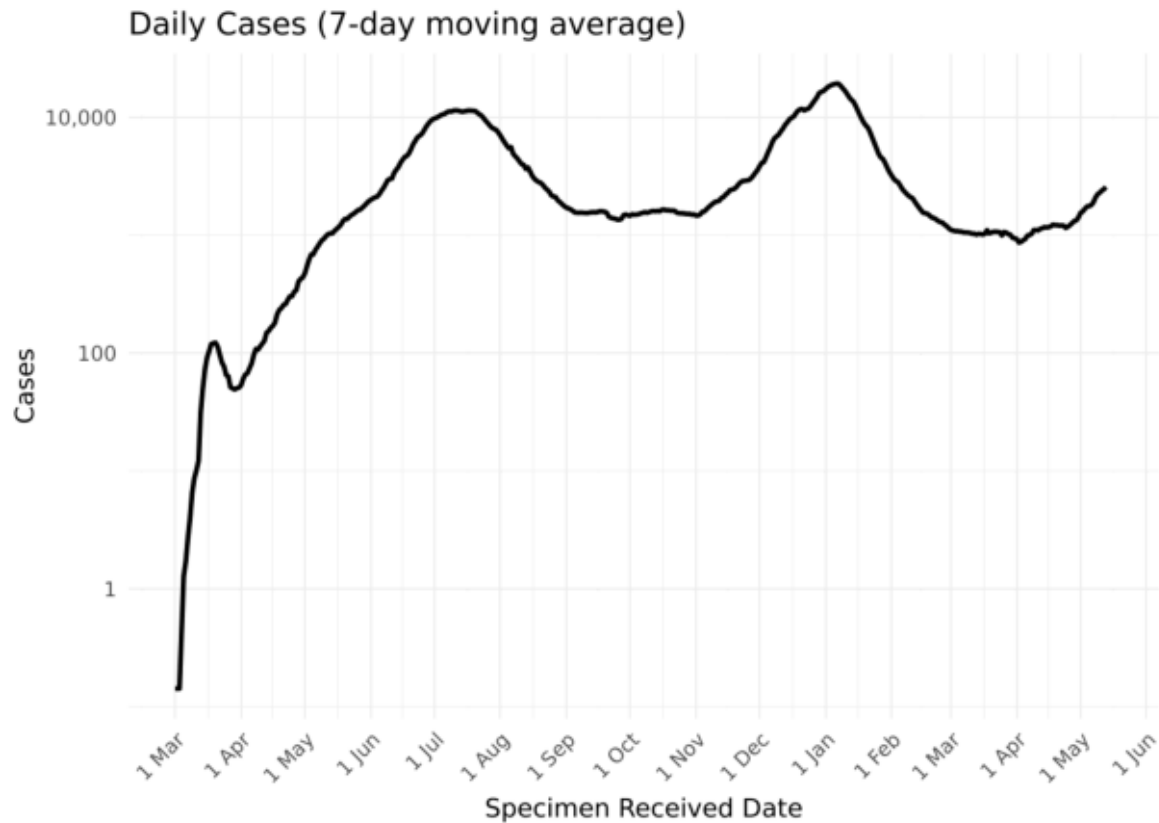


# Terminology

- Infections
- Cases
- Hospital Admissions
- Deaths
  - Reported COVID-19
  - Excess Deaths
- Attack Rate
- Infection Fatality Rate
- Reproduction Number (R)
  - Number of infections generated by a single infection
- R can be estimated using cases, admissions or deaths
  - Assumption that reporting is stable
  - Assuming hospitalisation rate is stable
  - Assuming IFR is stable



# Reproduction Number in South Africa

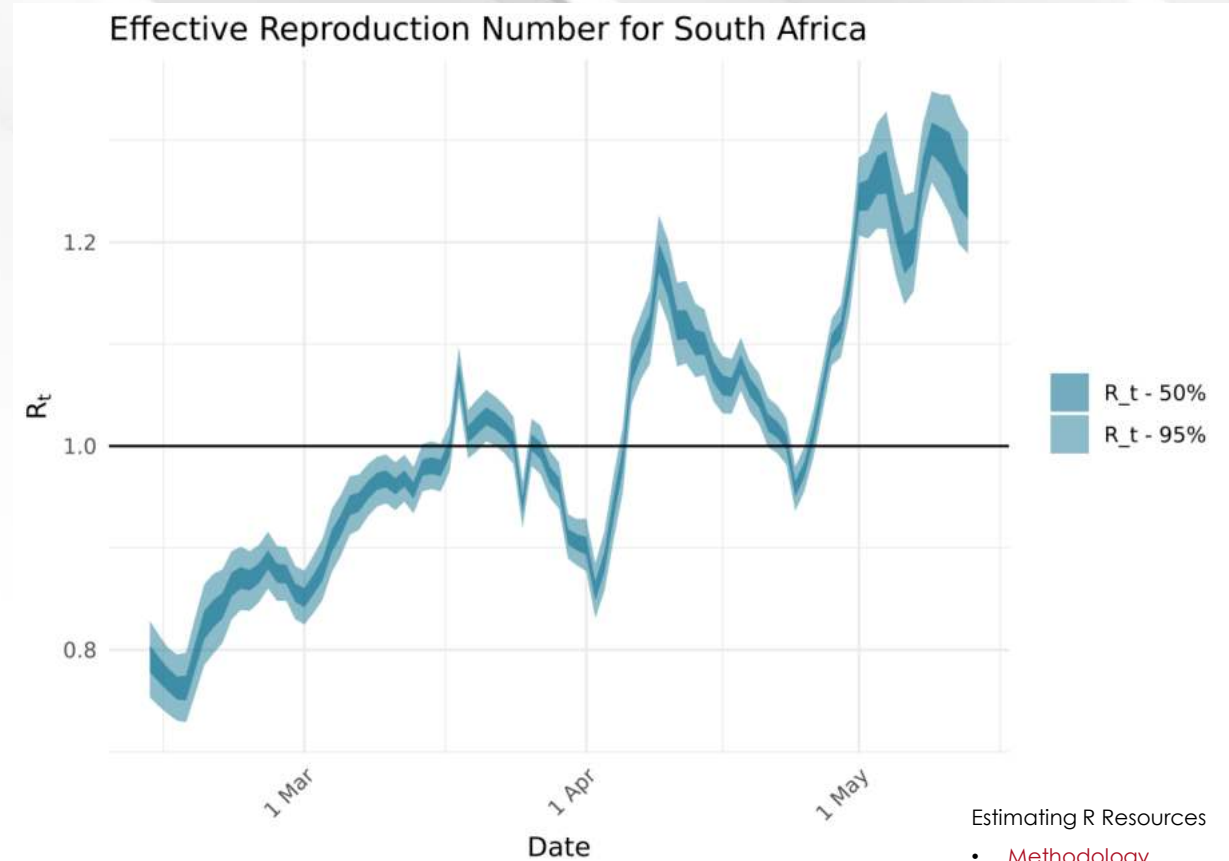
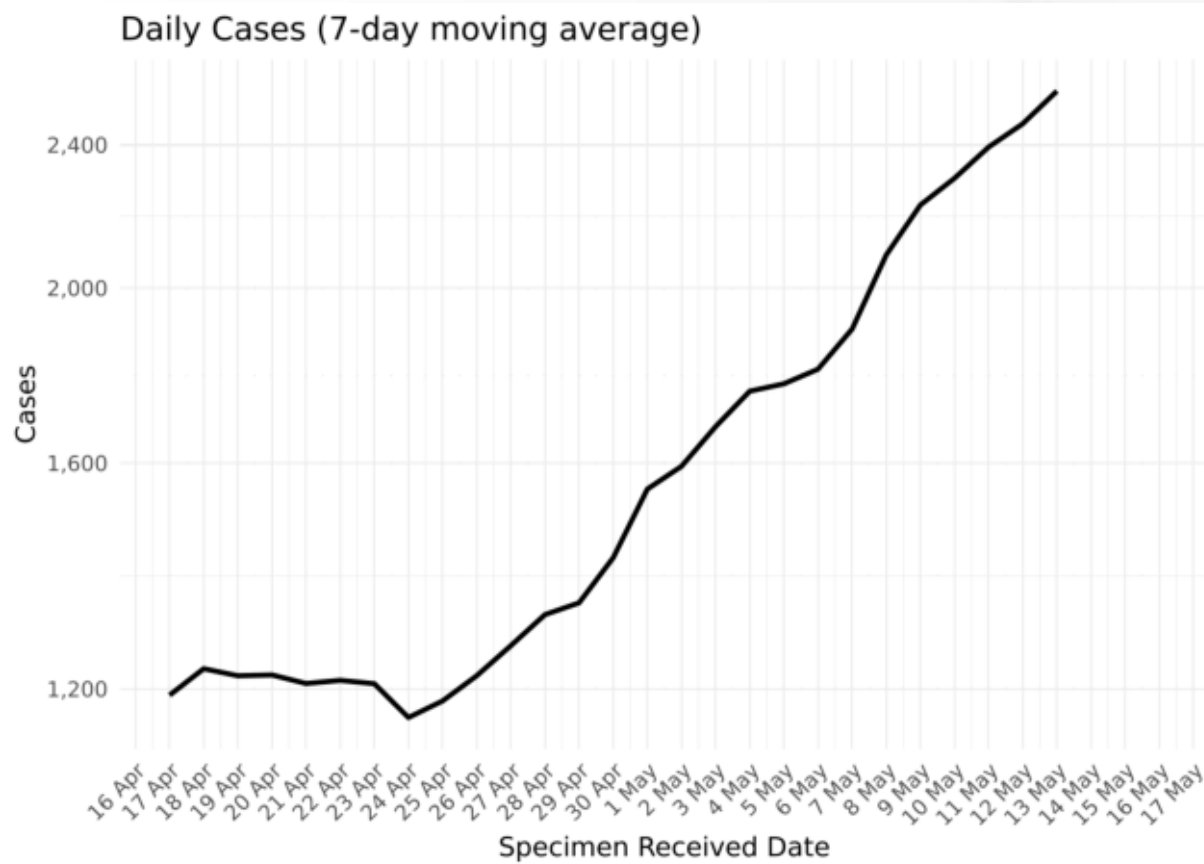


Estimating R Resources

- [Methodology](#)
- [Canada by Province](#)
- [Worldwide by Country](#)
- [South Africa by Province](#)
- [United Kingdom](#)



# Reproduction Number in South Africa

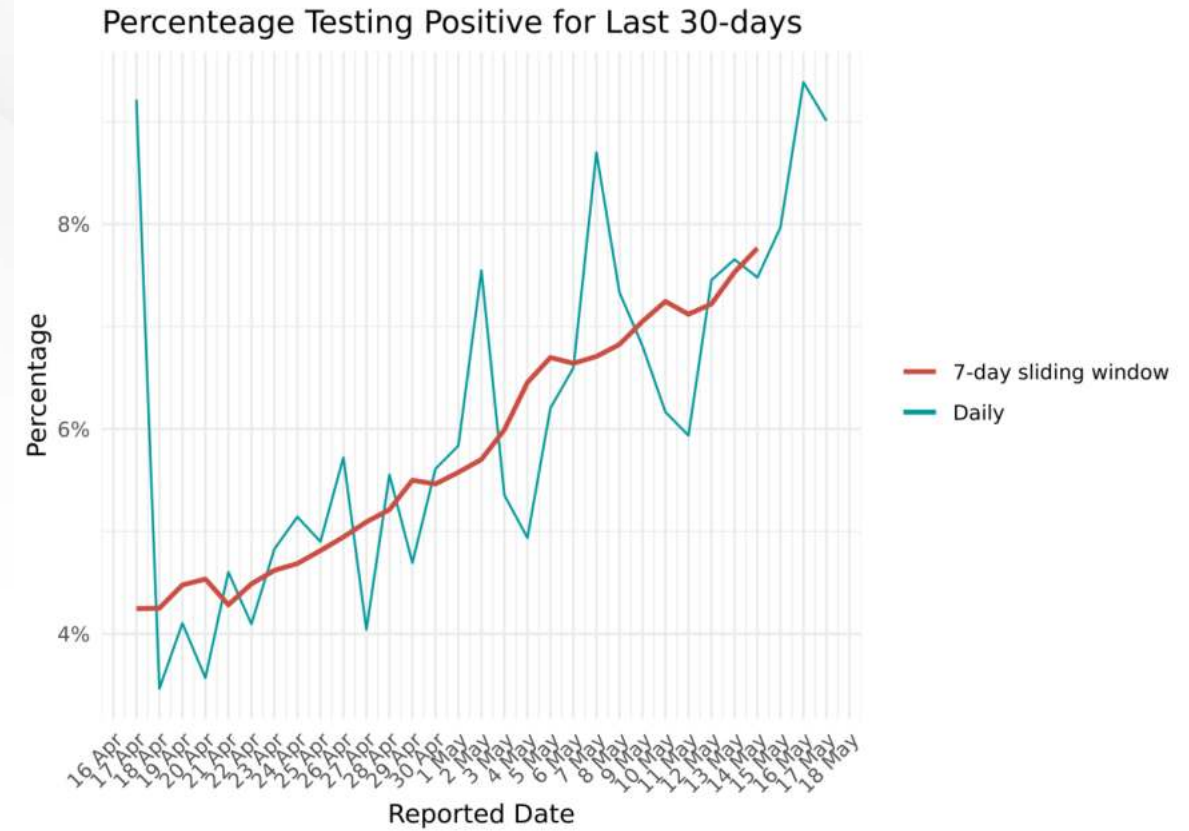
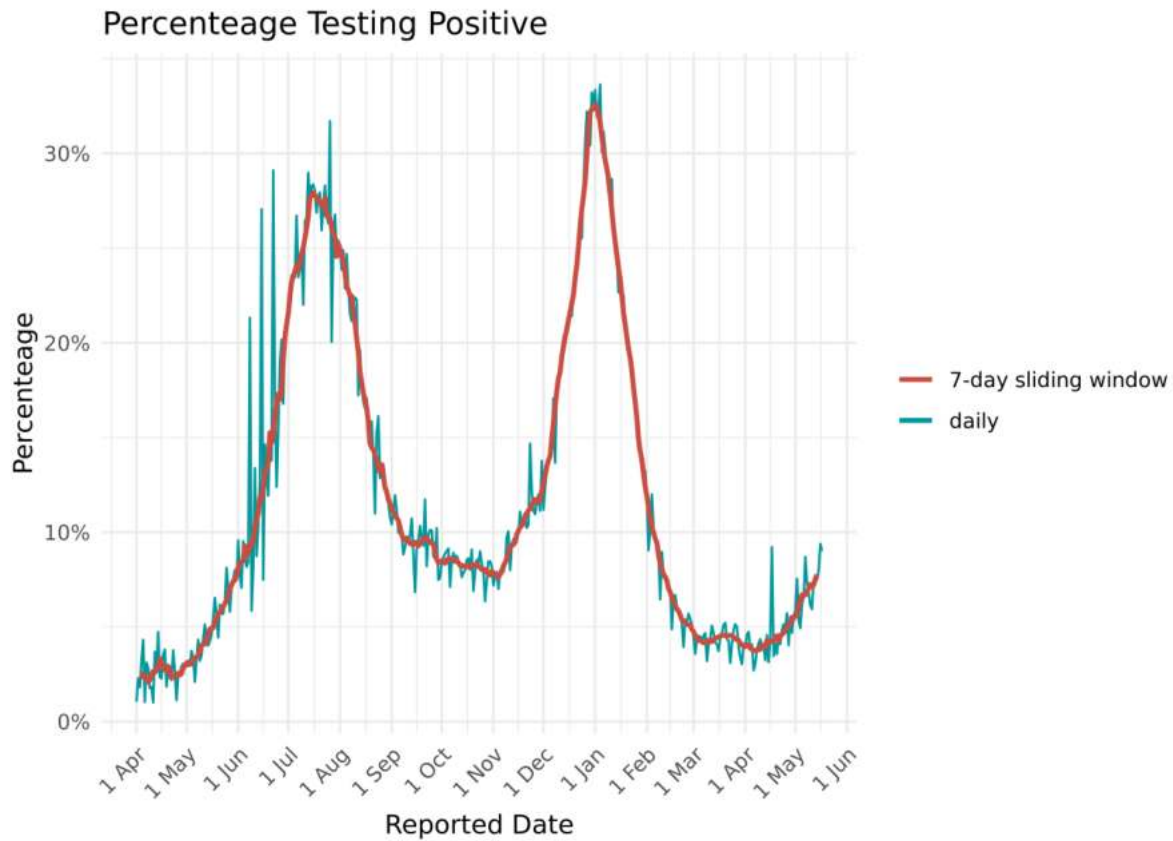


Estimating R Resources

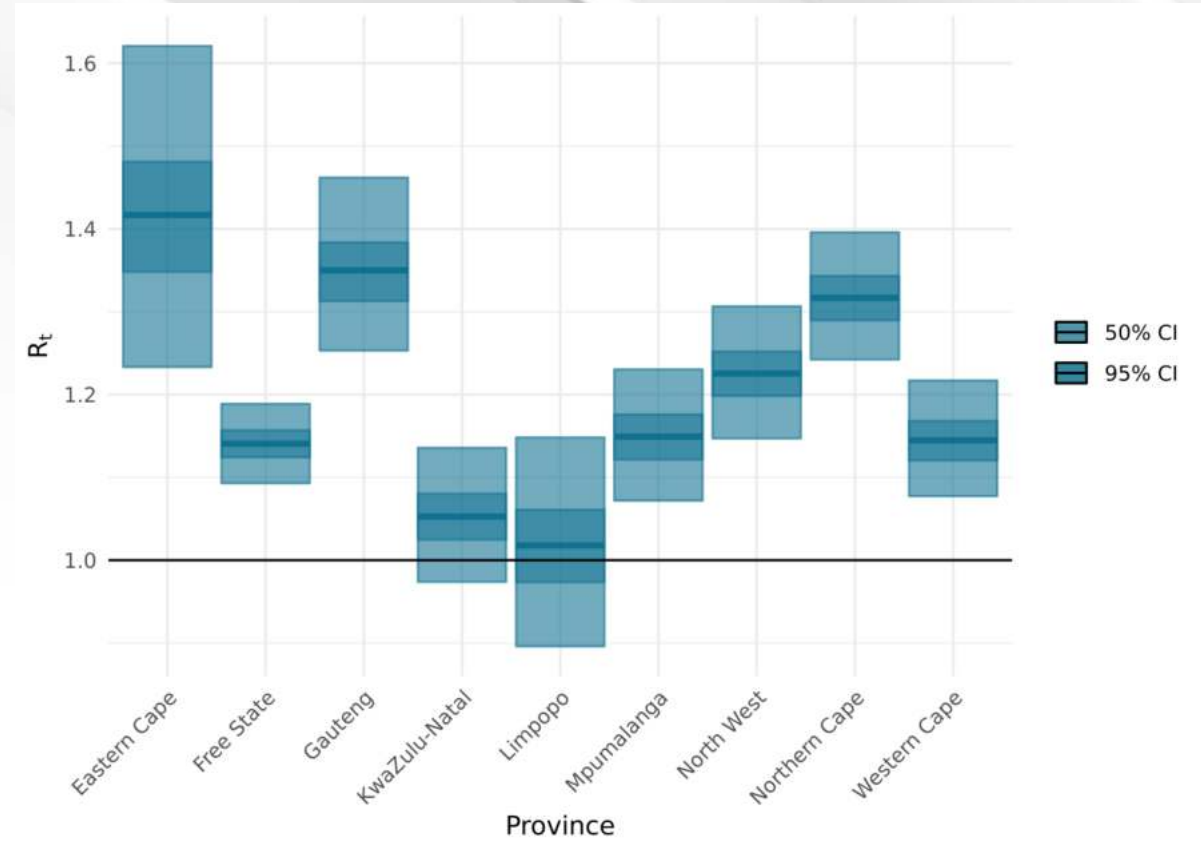
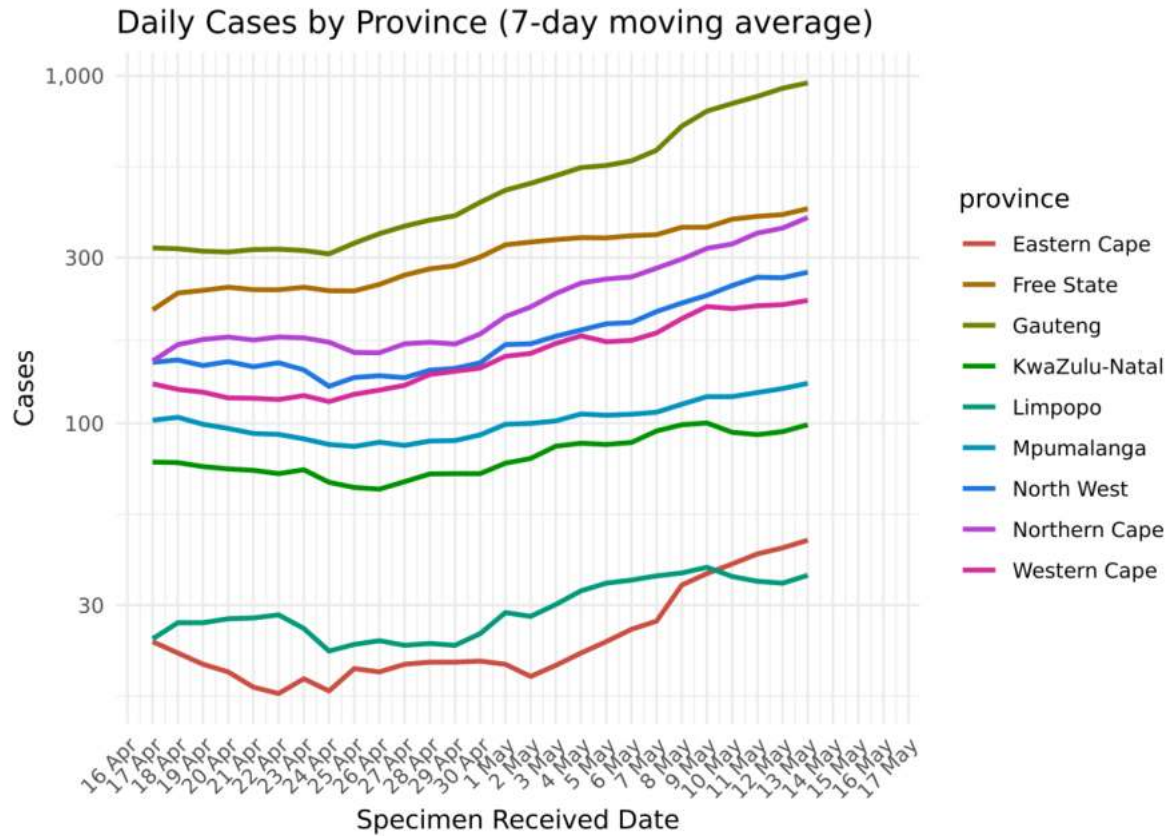
- [Methodology](#)
- [Canada by Province](#)
- [Worldwide by Country](#)
- [South Africa by Province](#)
- [United Kingdom](#)



# Percentage Testing Positive



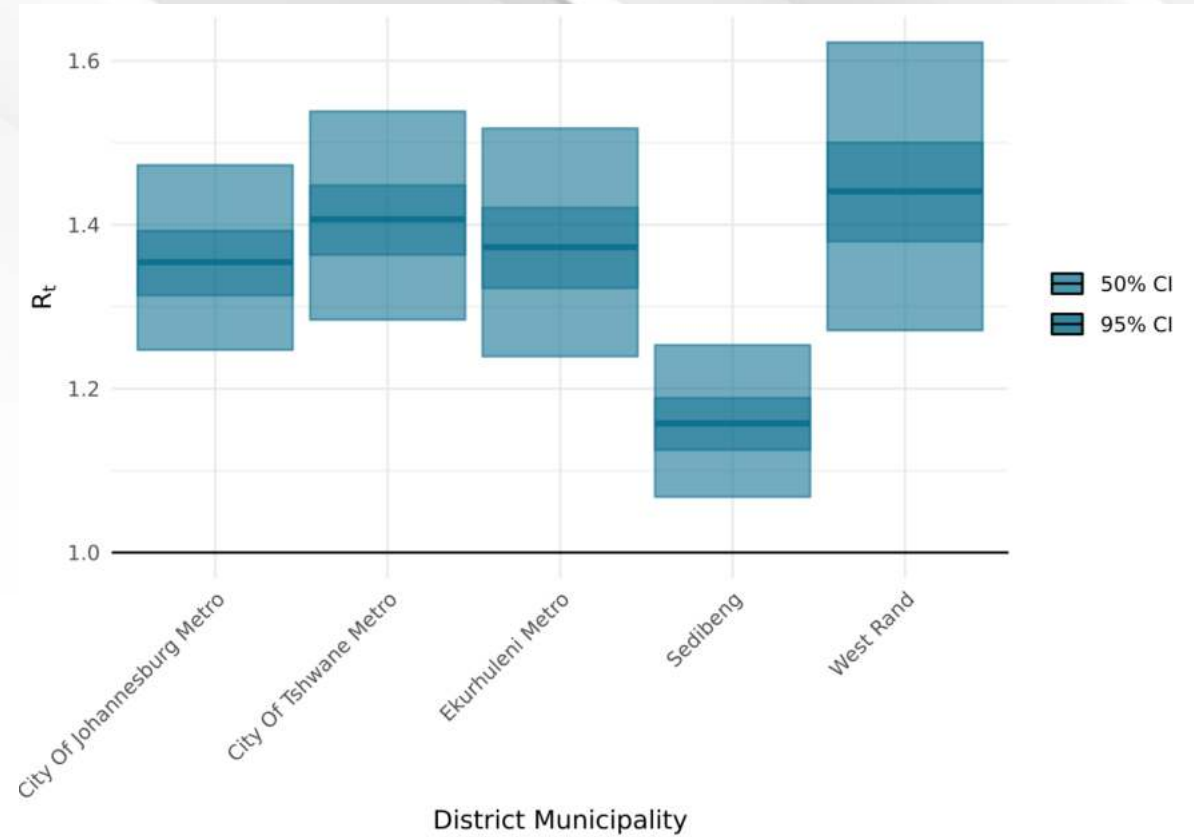
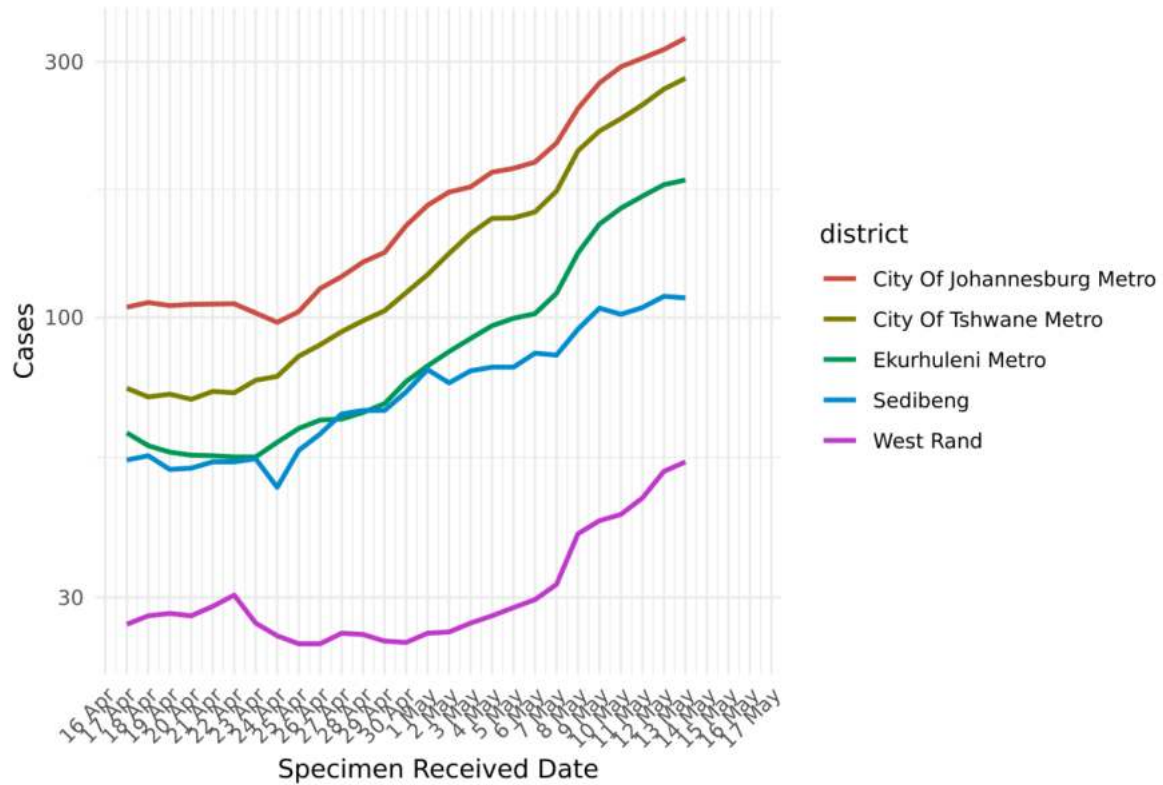
# Reproduction Number in South Africa





# Gauteng

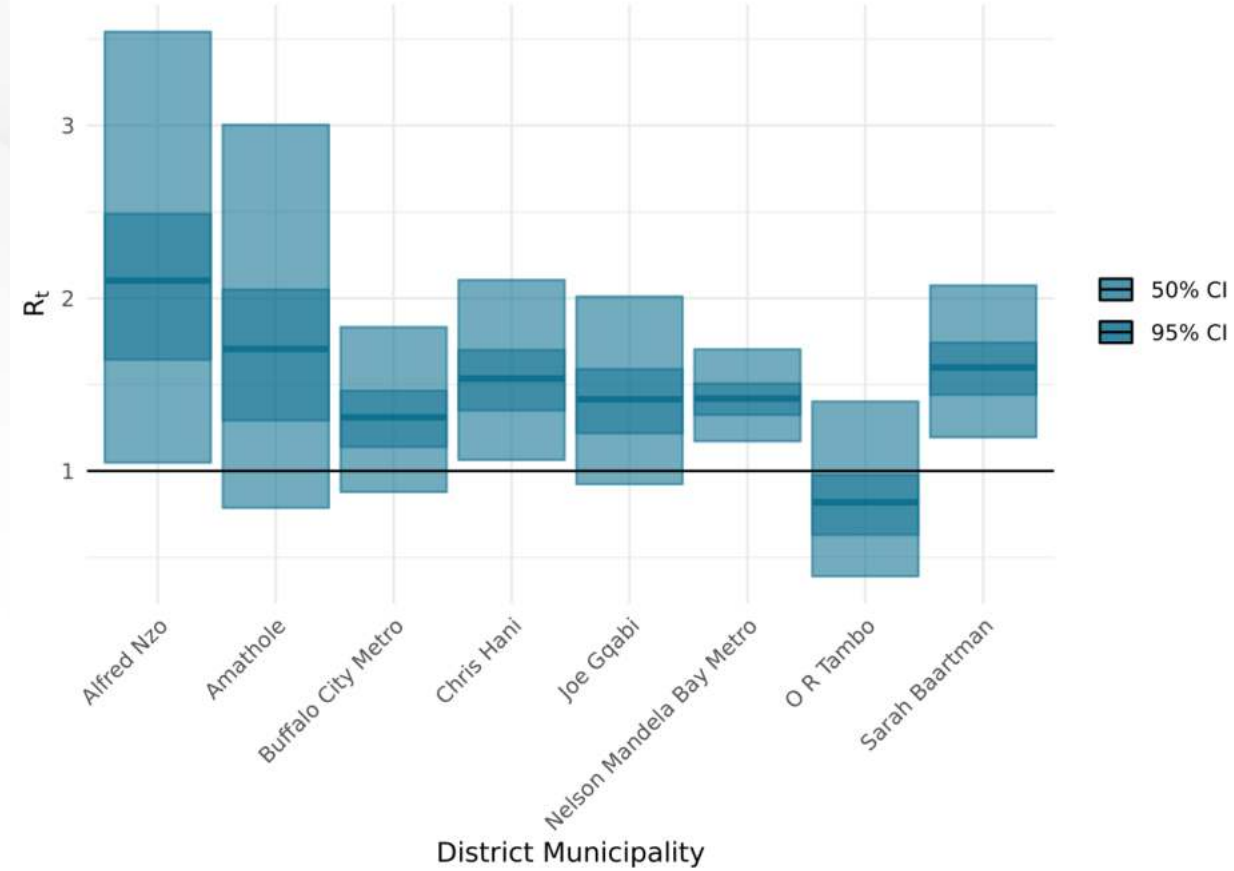
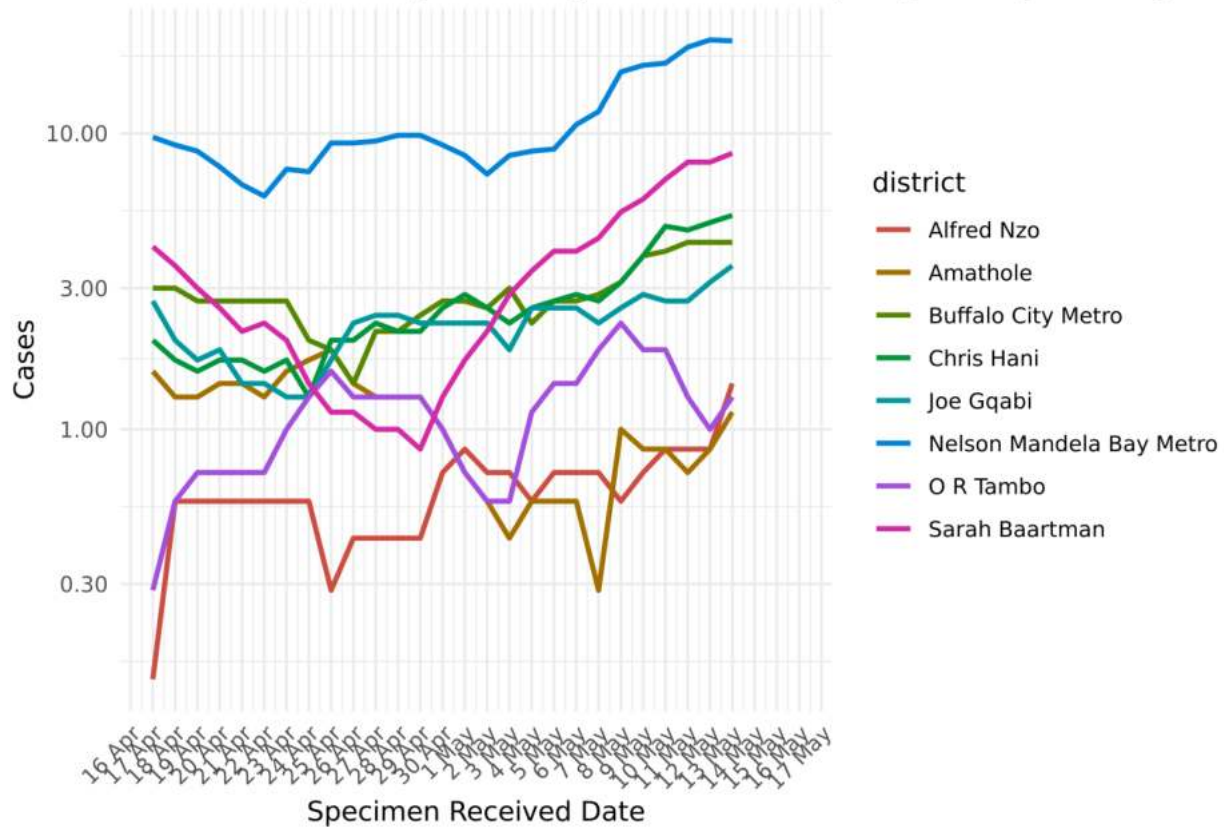
Gauteng Daily Cases by District Municipality (7-day moving average)





# Eastern Cape

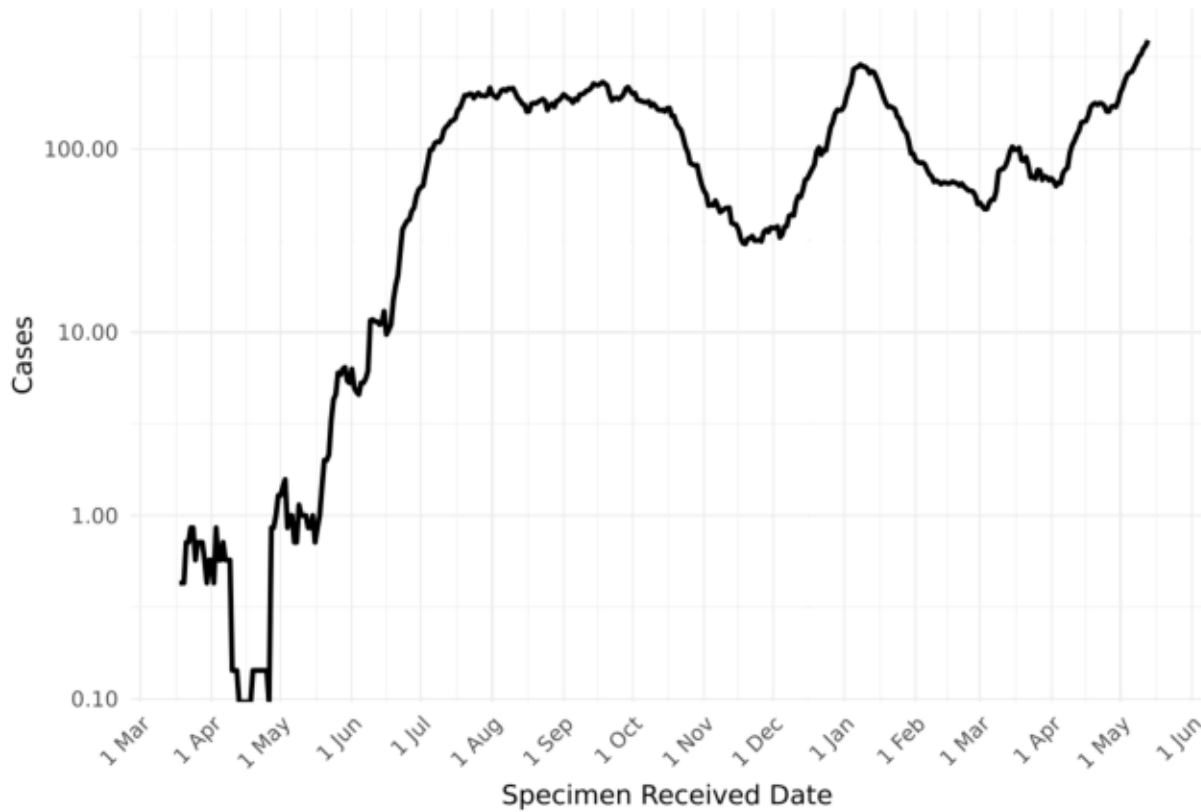
Eastern Cape Daily Cases by District Municipality (7-day moving average)



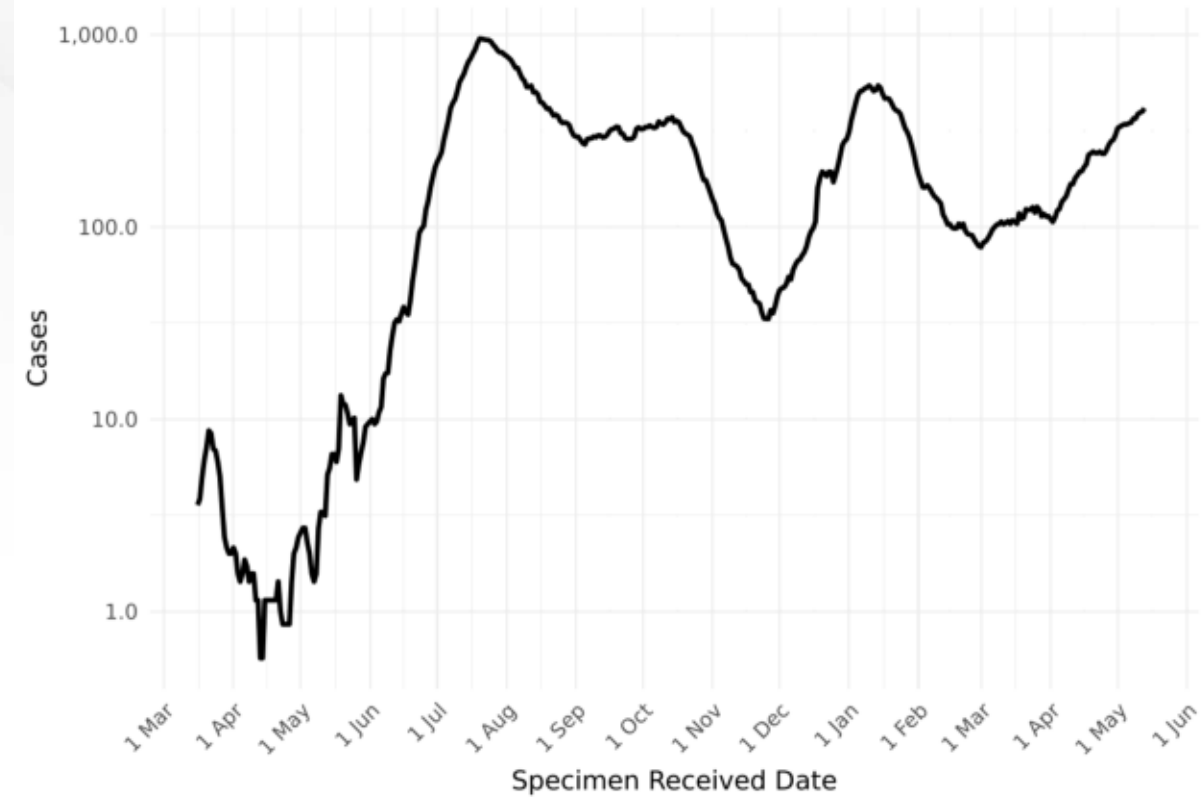


# 3<sup>rd</sup> Wave

Northern Cape Daily Cases (7-day moving average)



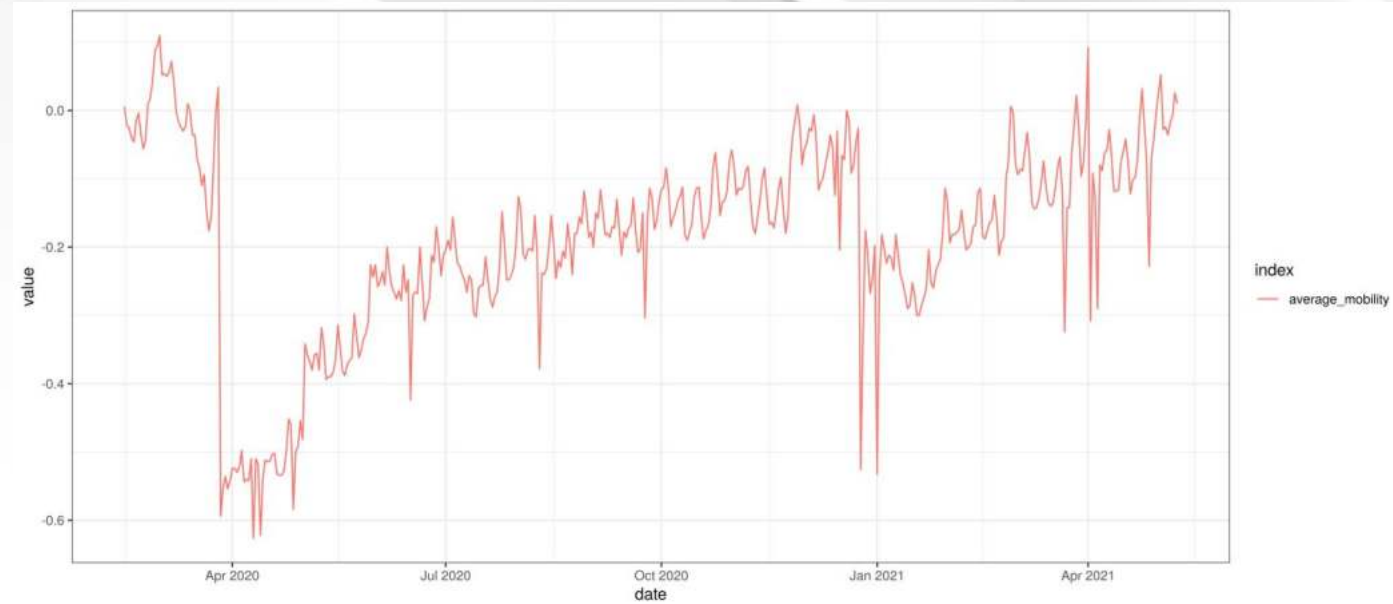
Free State Daily Cases (7-day moving average)





# Modelling

- Bayesian Hierarchical Model to calibrate model parameters based on observed death data and prior assumptions.
- Reproductive number is linked to mobility data as well as mask wearing laws
- Weekly AR(2) drift in reproduction number
- Reproductive number generates infections
- Population weighted IFRs to model deaths from infections
- Single combined model for all provinces
- Produces updated parameter estimates based on priors and data



## Models

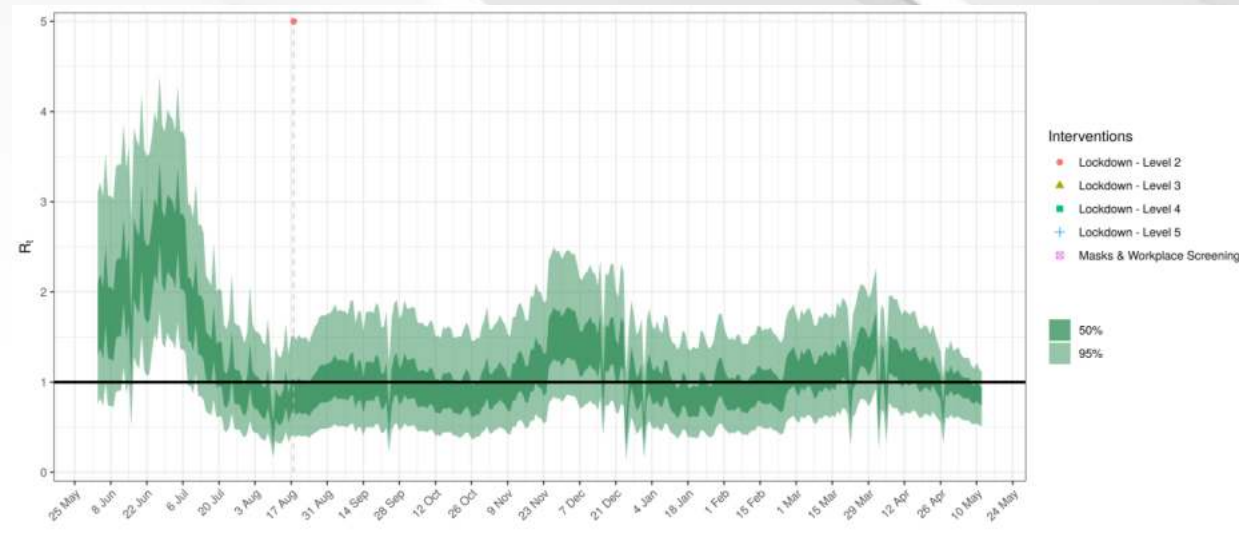
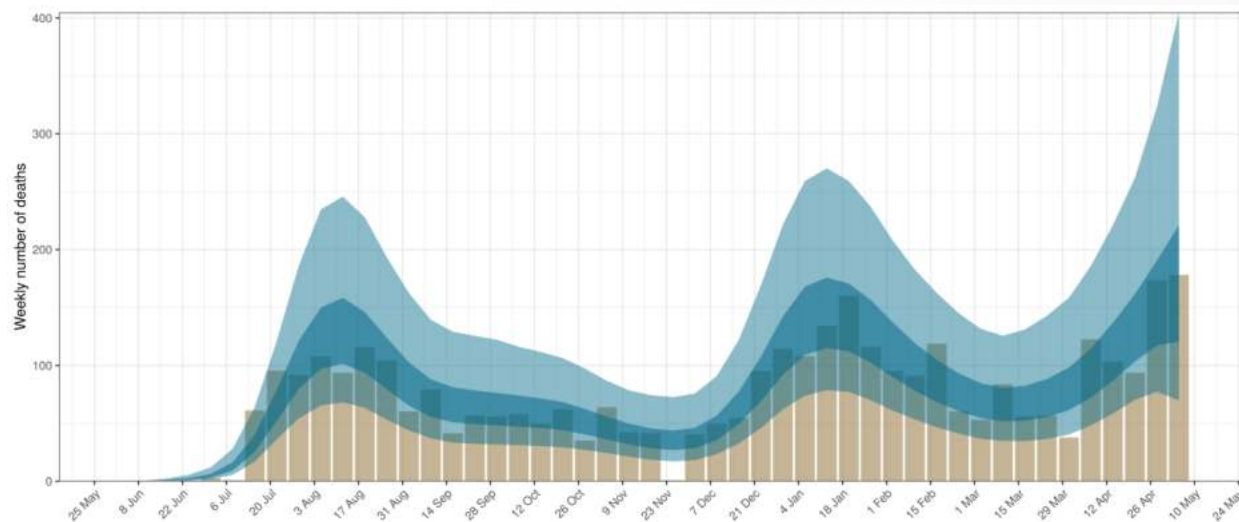
- [South Africa by Province](#)
- [Canada by Province](#)



# Northern Cape

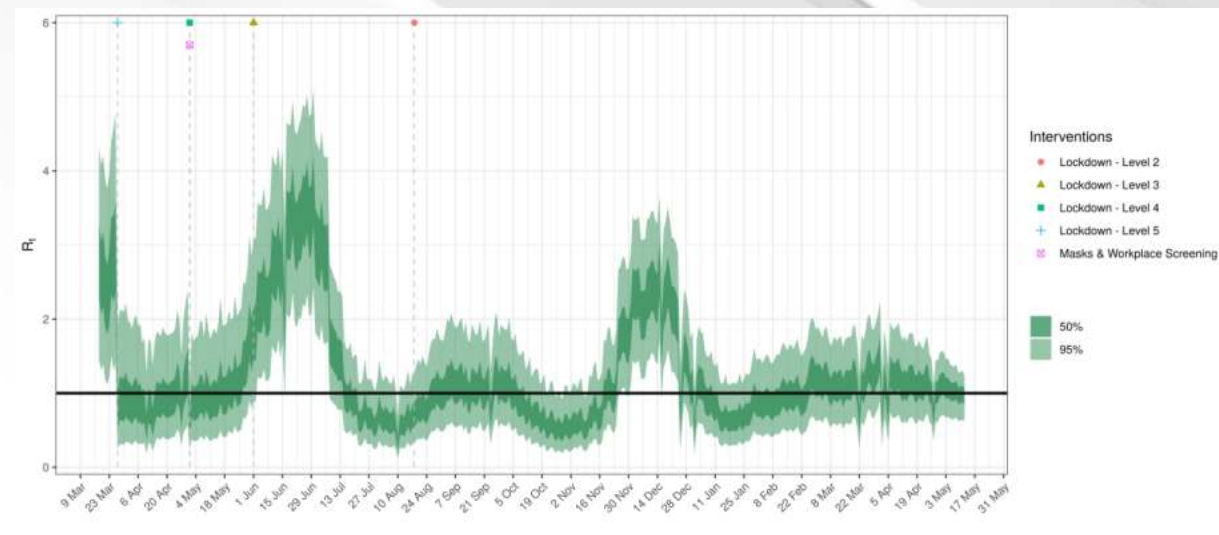
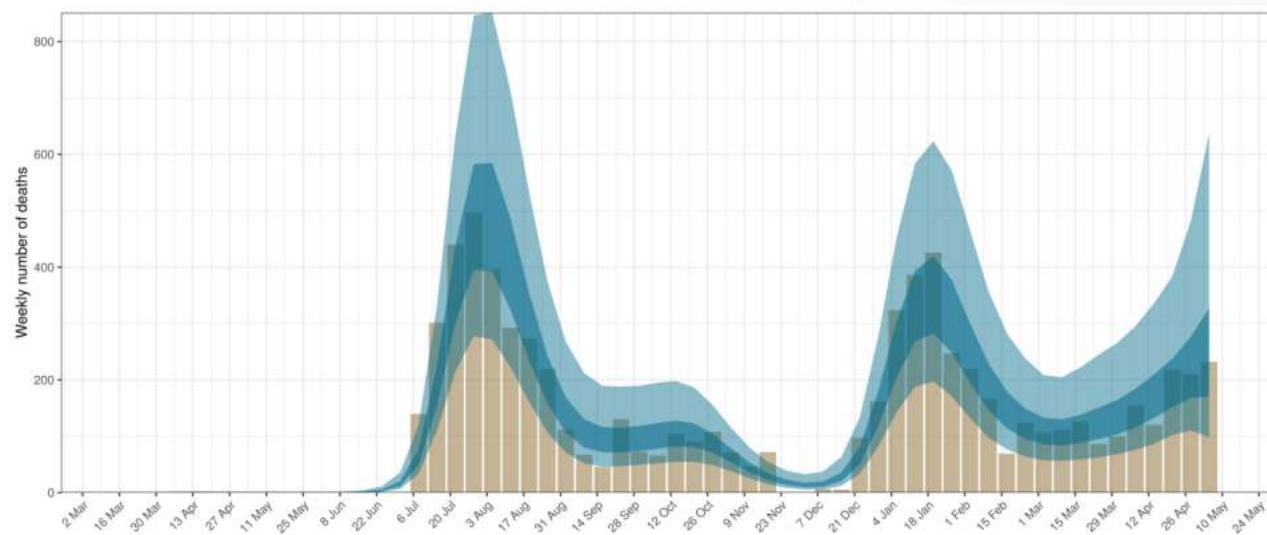
90% of excess deaths

Reproduction Number



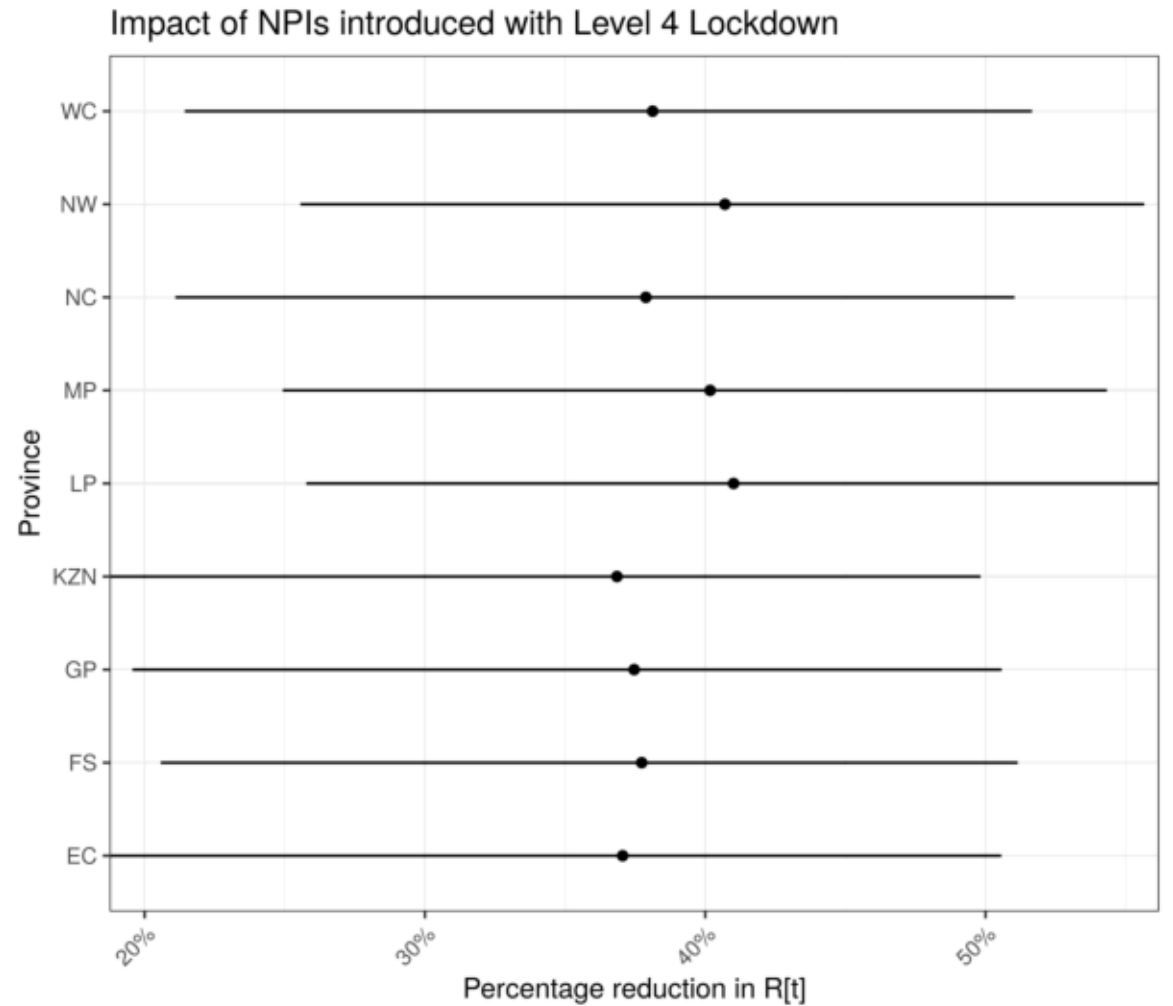
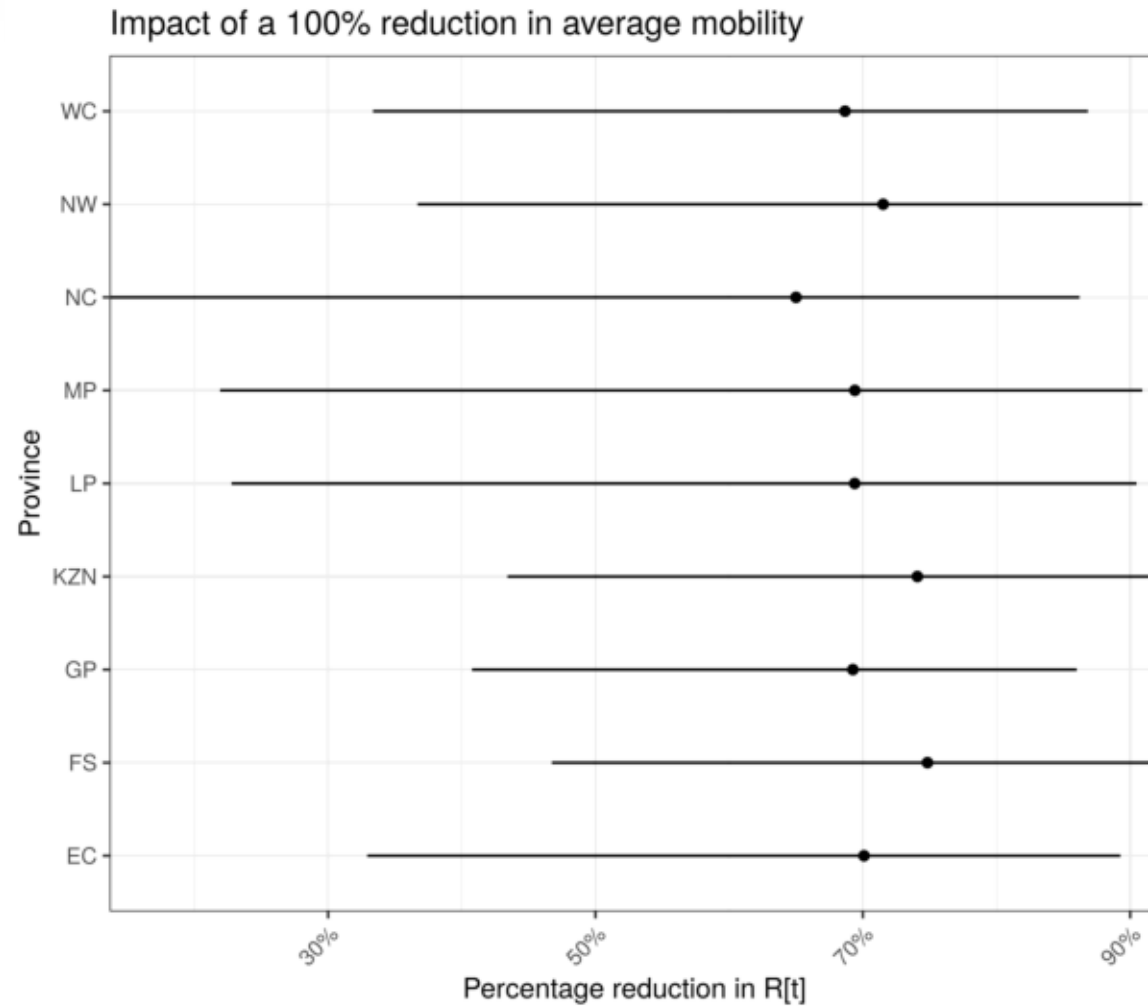
90% of excess deaths

Reproduction Number





# Parameters

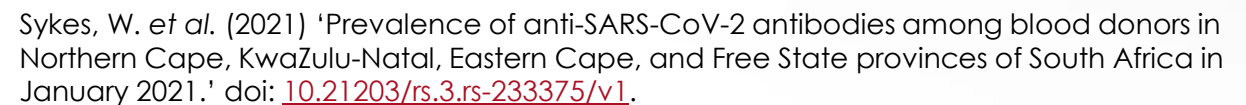




# Nowcast

Estimates at 12 May 2021

| Province            | Attack Rate                | Cumulative Deaths                  |
|---------------------|----------------------------|------------------------------------|
| EC                  | 66.7% [52.3%-78.7%]        | 29 419 [ 23 271 - 35 912]          |
| FS                  | 64.6% [46.5%-84.2%]        | 7 699 [ 5 923 - 9 783]             |
| GP                  | 51.0% [35.2%-70.0%]        | 25 692 [ 18 769 - 34 459]          |
| KZN                 | 66.8% [51.7%-79.5%]        | 31 330 [ 24 478 - 38 699]          |
| LP                  | 52.1% [34.9%-72.6%]        | 14 304 [ 10 048 - 19 761]          |
| MP                  | 60.5% [42.7%-78.2%]        | 10 659 [ 7 891 - 13 907]           |
| NC                  | 71.5% [52.5%-88.9%]        | 3 892 [ 3 019 - 4 884]             |
| NW                  | 40.5% [25.6%-65.4%]        | 5 810 [ 4 172 - 8 128]             |
| WC                  | 54.5% [39.1%-71.1%]        | 15 896 [ 11 918 - 20 624]          |
| <b>South Africa</b> | <b>57.5% [50.7%-64.8%]</b> | <b>144 702 [129 841 - 160 783]</b> |





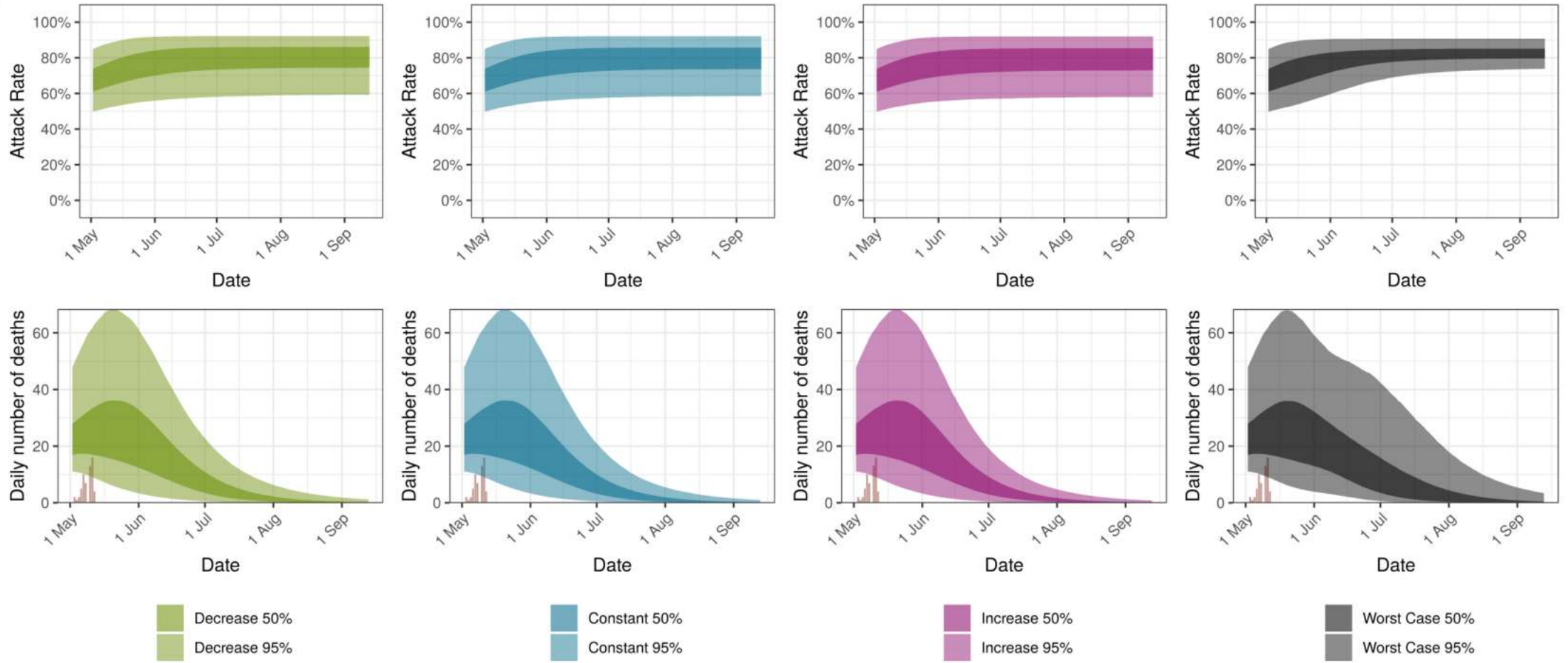
# “Worst Case” – 30 September 2021

Assuming return to “normal”, but impact from variants or change in IFR

| Province            | Attack Rate                | Deaths                           | Peak Daily Deaths | Peak Date         |
|---------------------|----------------------------|----------------------------------|-------------------|-------------------|
| EC                  | 73.6% [64.3%-83.2%]        | 32 501 [ 26 521- 40 320]         | 291               | 2020-12-31        |
| FS                  | 82.5% [74.2%-90.0%]        | 11 294 [ 8 819- 14 009]          | 74                | 2020-08-04        |
| GP                  | 84.2% [73.6%-91.6%]        | 45 168 [ 33 578- 56 870]         | 325               | 2020-07-19        |
| KZN                 | 74.9% [65.9%-83.7%]        | 35 524 [ 28 801- 43 957]         | 487               | 2021-01-11        |
| LP                  | 81.1% [66.1%-90.4%]        | 22 956 [ 16 202- 29 770]         | 266               | 2021-01-19        |
| MP                  | 78.6% [67.6%-88.2%]        | 14 356 [ 10 889- 18 486]         | 160               | 2021-01-19        |
| NC                  | 82.4% [74.0%-90.8%]        | 5 225 [ 4 166- 6 401]            | 28                | 2021-05-18        |
| NW                  | 89.0% [81.2%-94.0%]        | 15 249 [ 11 615- 18 778]         | 196               | 2021-06-25        |
| WC                  | 79.7% [66.2%-89.2%]        | 23 659 [ 17 355- 30 415]         | 200               | 2021-01-07        |
| <b>South Africa</b> | <b>80.1% [75.7%-83.8%]</b> | <b>205 932 [186 478-225 972]</b> | <b>1 680</b>      | <b>2021-01-14</b> |
| <b>No change</b>    | <b>66.5% [57.0%-75.6%]</b> | <b>172 446 [149 618-196 602]</b> | <b>1 680</b>      | <b>2021-01-14</b> |

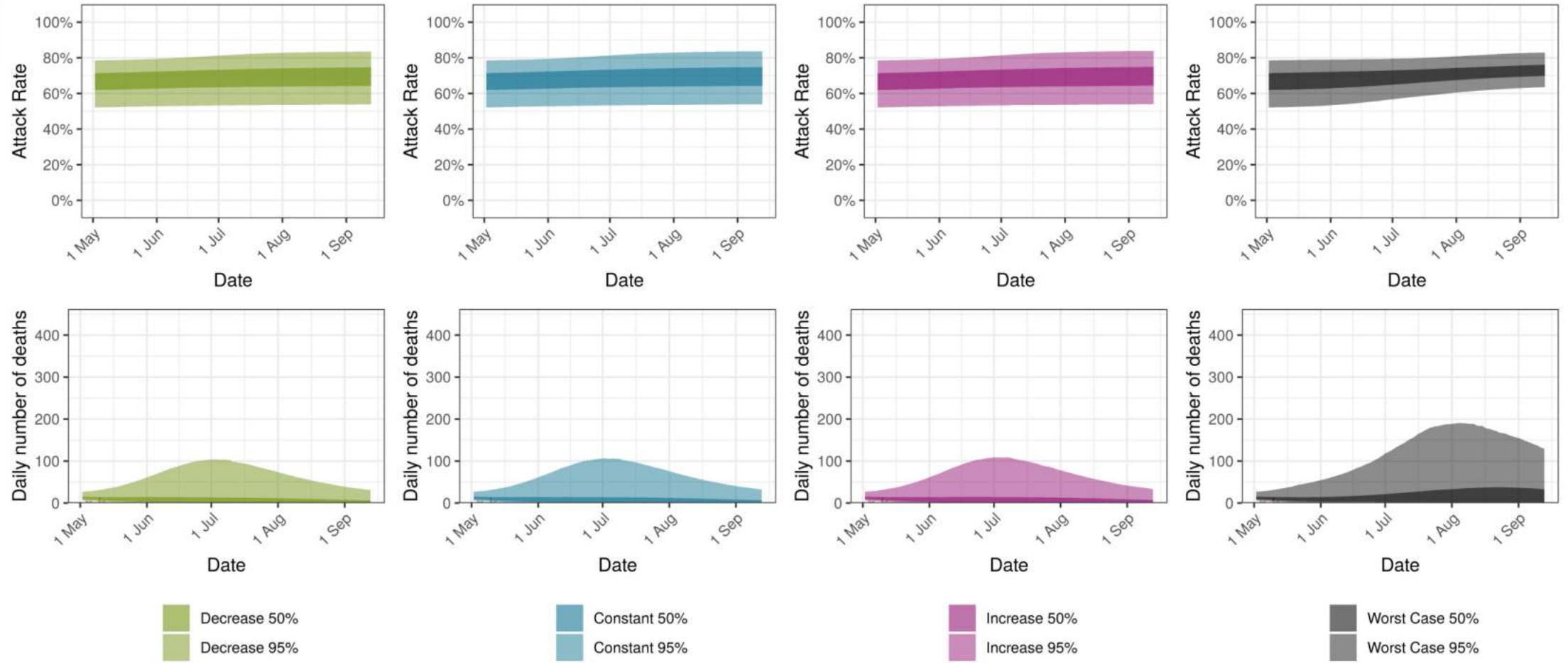


# Northern Cape



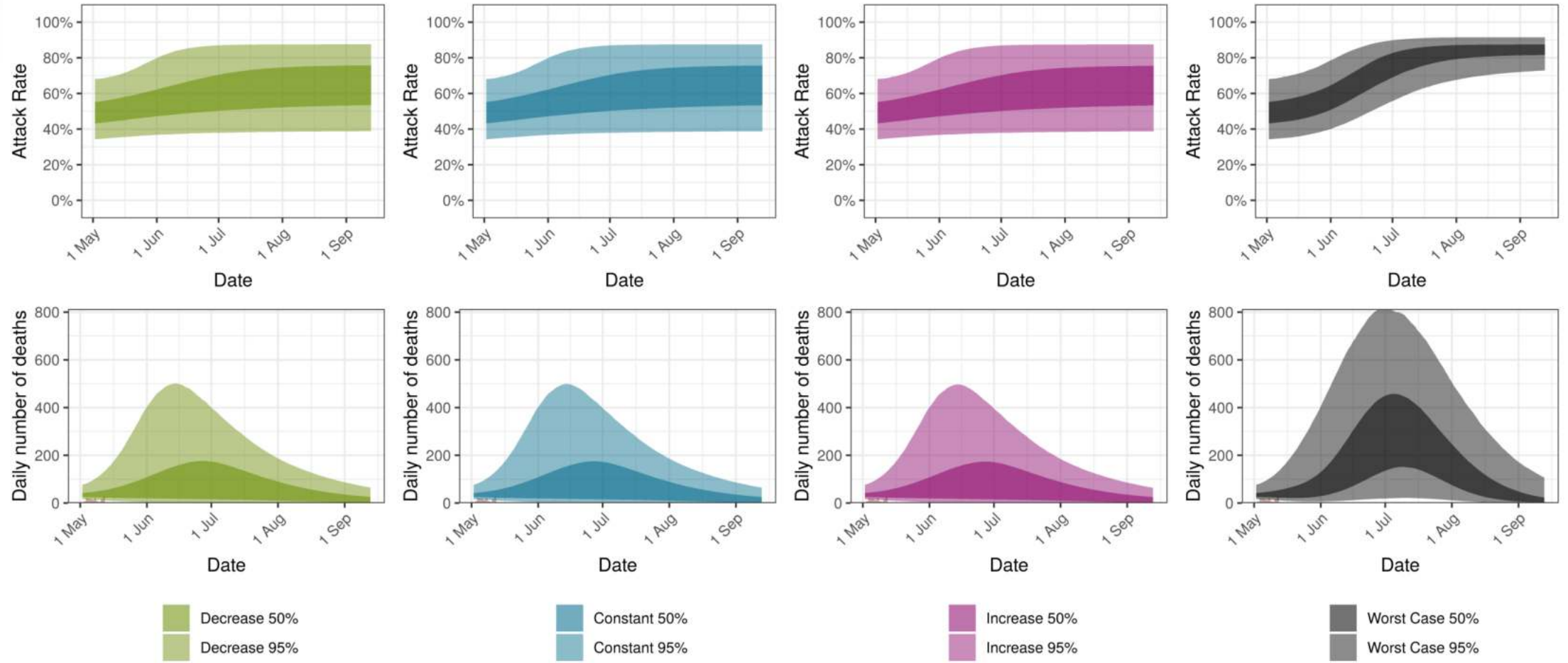


# Eastern Cape



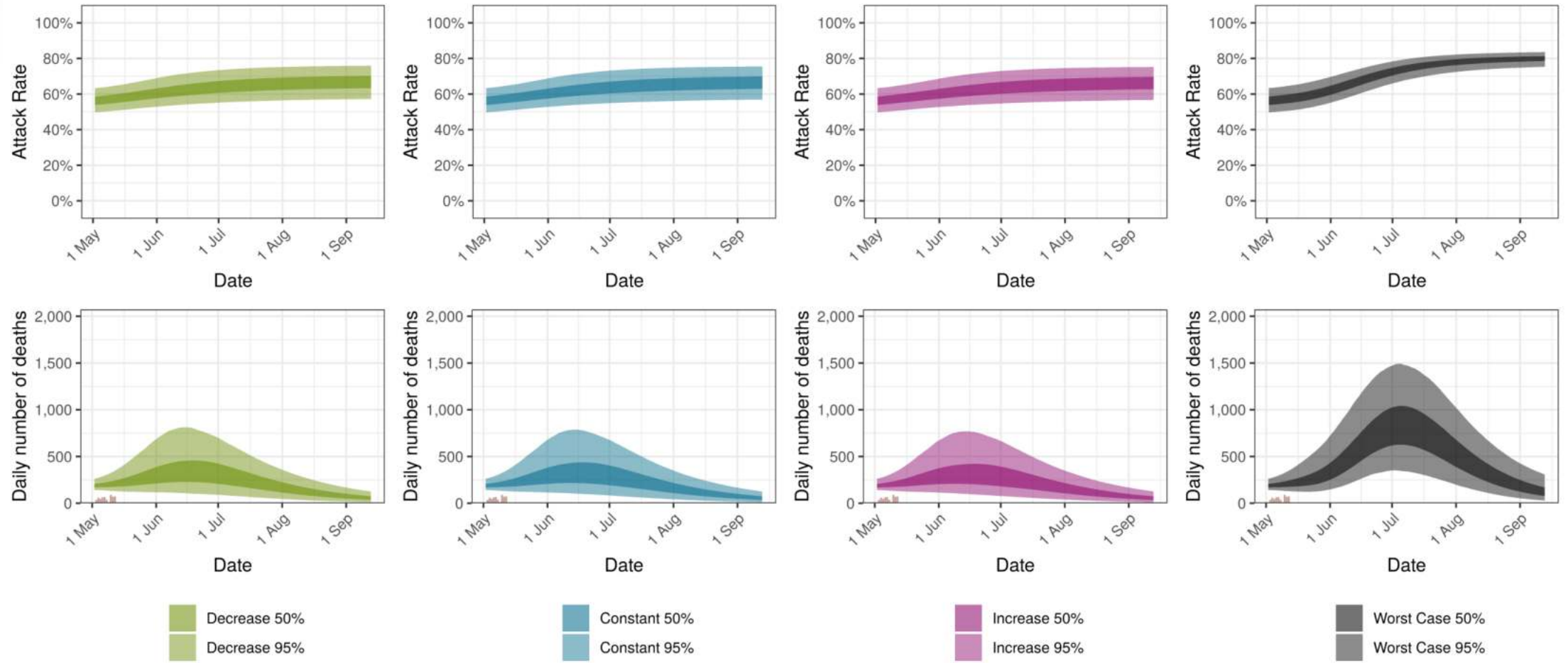


# Projections - Gauteng





# Projections – South Africa





# Population Immunity Reading

Aschwanden, C. (2021) 'Five reasons why COVID herd immunity is probably impossible', *Nature*, 591 (7851), pp. 520–522. doi: [10.1038/d41586-021-00728-2](https://doi.org/10.1038/d41586-021-00728-2).

Sridhar, D. and Gurdasani, D. (2021) 'Herd immunity by infection is not an option', *Science*, 371 (6526), pp. 230–231. doi: [10.1126/science.abf7921](https://doi.org/10.1126/science.abf7921).

Meyerowitz-Katz, G. (2021) *We may never achieve long-term global herd immunity for COVID. But if we're all vaccinated, we'll be safe from the worst*, *The Conversation*. Available at: <http://theconversation.com/we-may-never-achieve-long-term-global-herd-immunity-for-covid-but-if-were-all-vaccinated-well-be-safe-from-the-worst-159821> (Accessed: 16 May 2021).



# Population Immunity

## Herd Immunity Threshold (HIT)

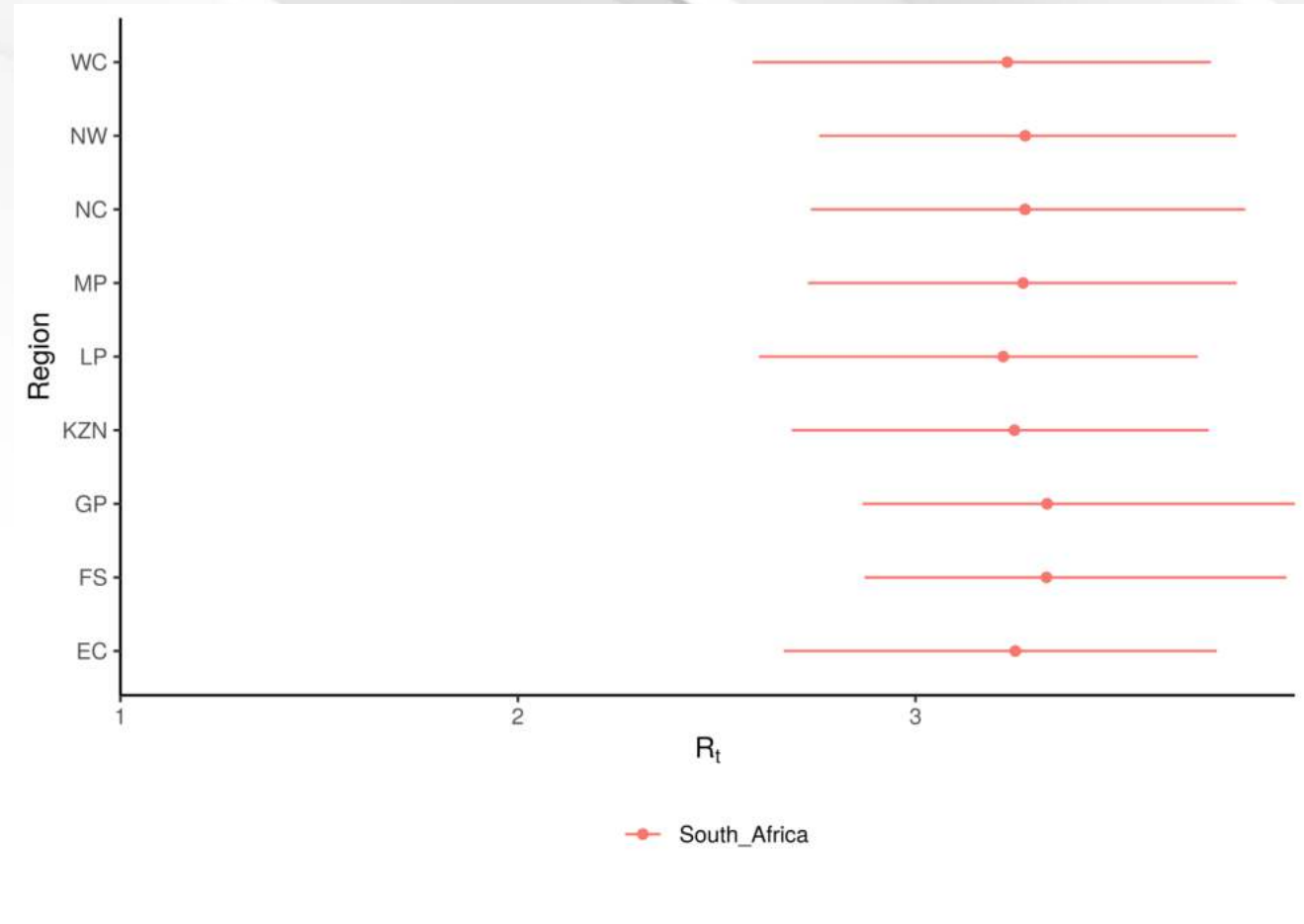
- Proportion of population that need to be infected for the disease to reach a steady state in the absence of interventions  
 $= 1 - 1/R_0$
- When  $R_t = 1$  without intervention
- Infections continue
  - **Overshoot**

| $R_0$ | Herd Immunity Threshold |
|-------|-------------------------|
| 2.0   | 50%                     |
| 2.5   | 60%                     |
| 3.0   | 67%                     |
| 3.5   | 71%                     |
| 4.0   | 75%                     |



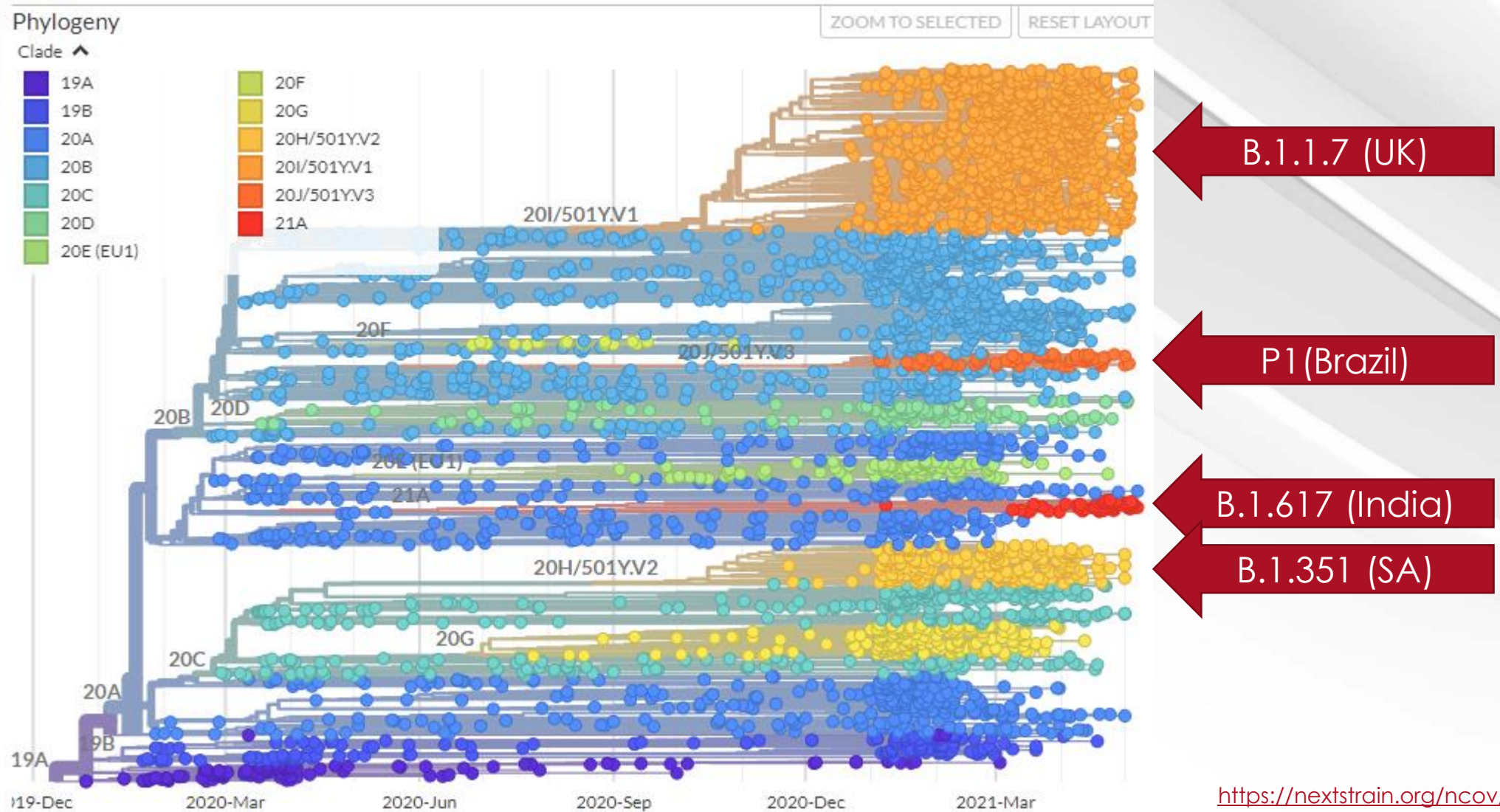
# What is $R_0$ ?

- What is it in South Africa?
- Modelling mainly based on prior assumption
- How has  $R_0$  changed?
  - We could have changed
    - May have changed due to “permanent” changes in behaviour?
  - Changes to the virus





# SARS-CoV-2 “family tree”





# Impact of variants

- Transmission (Increased  $R_0$ ?)
- Reinfection
- Effectiveness of vaccines reduced
- Severity of disease
- Infection Fatality Rate

Model does not allow for the impact of variants on

- $R_0$
- IFR
- Reinfection



# What is the attack rate?

## Modelling

- Work backwards from deaths
- What infections would have generated deaths
- Infection Fatality Rate is key

## Seroprevalence

- How representative are these?
- Blood donors?
- HIV/diabetic blood samples?
- Households?
- Assay accuracy?

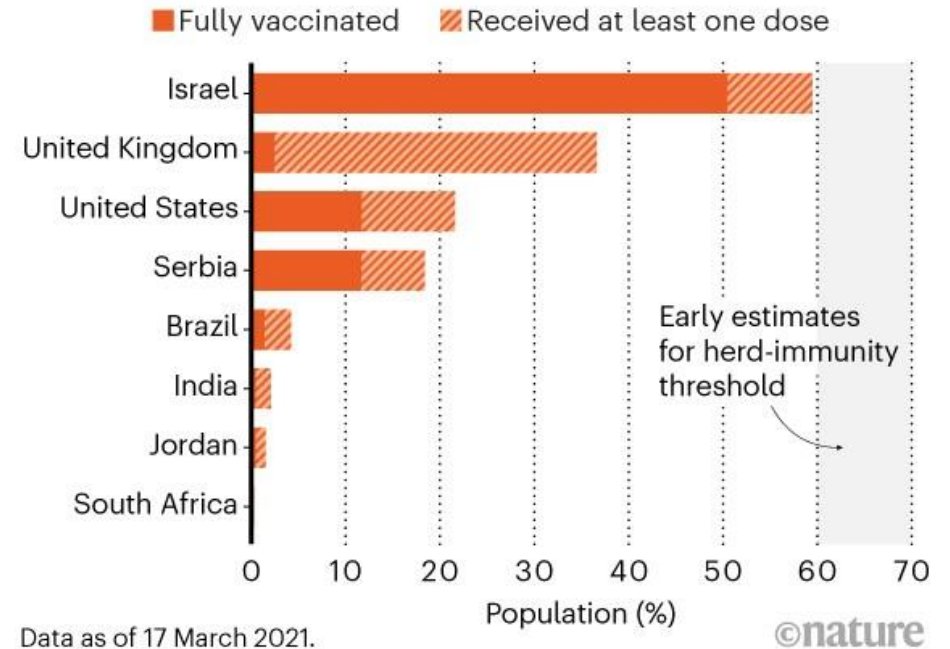


# Immunity & Vaccines

- Immunity (through infection) is not uniform
- Vaccine roll-out is uneven
  - Between countries
  - Within countries
- How fast does immunity wane?

## DISPARITIES IN DISTRIBUTION

The worldwide roll-out of COVID-19 vaccinations is uneven, as shown by this selection of countries. Even as some nations approach a theoretical threshold for herd immunity, quashing the spread of the virus will prove difficult.

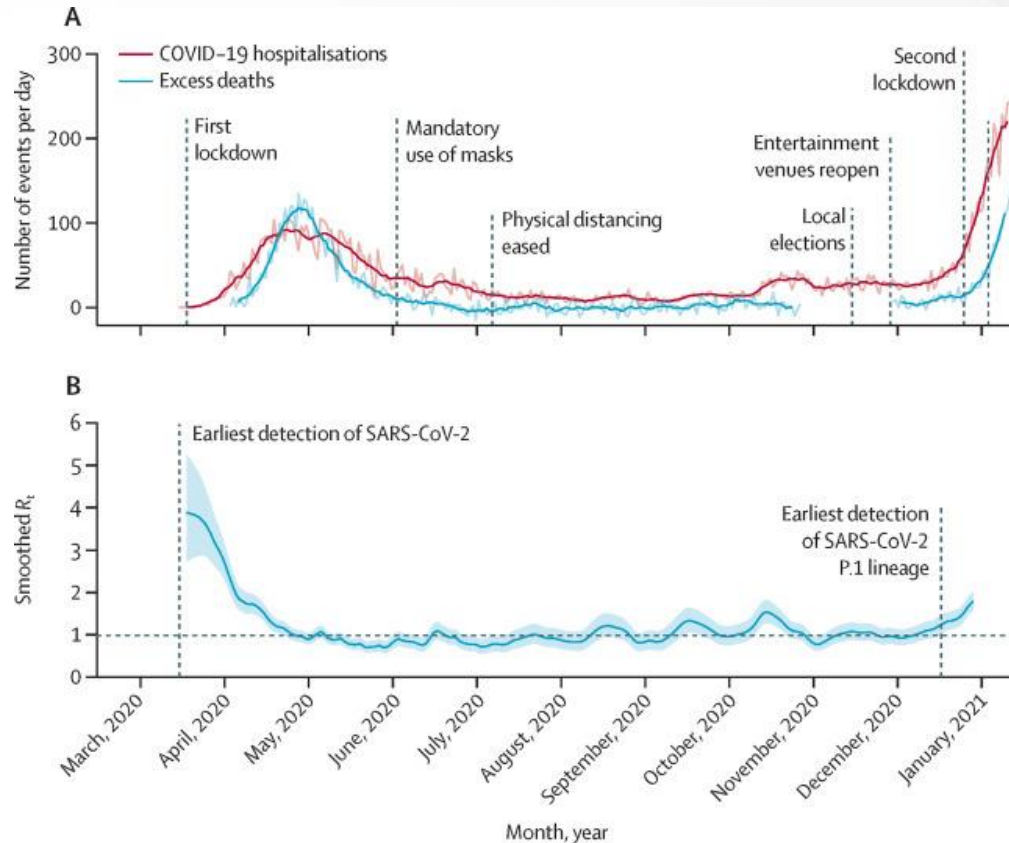


Aschwanden, C. (2021) 'Five reasons why COVID herd immunity is probably impossible', *Nature*, 591(7851), pp. 520–522. doi: [10.1038/d41586-021-00728-2](https://doi.org/10.1038/d41586-021-00728-2).



# Manaus, Brazil

## Second wave despite 76% of blood donors positive



- Why?

- Over-estimated sero-prevalence
- Waning immunity
- Variants evading immunity
- Variants that are more transmissible

Sabino, E. C. *et al.* (2021) 'Resurgence of COVID-19 in Manaus, Brazil, despite high seroprevalence', *The Lancet*, 397(10273), pp. 452–455. doi: [10.1016/S0140-6736\(21\)00183-5](https://doi.org/10.1016/S0140-6736(21)00183-5).



# Looking Back

Mortality – Country Results (Source: Imperial College London Report 12)

|                     | Unmitigated    | Mitigation     |                | Suppression   |               |
|---------------------|----------------|----------------|----------------|---------------|---------------|
|                     |                | High           | Low            | High          | Low           |
| <b>South Africa</b> |                |                |                |               |               |
| Population          | 59 308 690     | 59 308 690     | 59 308 690     | 59 308 690    | 59 308 690    |
| Infections          | 52 669 882     | 35 977 239     | 35 976 825     | 22 629 957    | 3 961 213     |
| <b>Deaths</b>       | <b>216 064</b> | <b>145 536</b> | <b>125 010</b> | <b>90 469</b> | <b>15 438</b> |
| Hospitalised        | 1 398 489      | 973 006        | 914 191        | 613 931       | 106 575       |
| Critical Care       | 286 429        | 192 965        | 165 794        | 260 261       | 30 600        |
| <b>Attack Rate</b>  | 89%            | 61%            | 61%            | 38%           | 7%            |
| <b>IFR</b>          | 0.4%           | 0.4%           | 0.3%           | 0.4%          | 0.4%          |
| <b>Hospital %</b>   | 3%             | 3%             | 3%             | 3%            | 3%            |
| <b>Critical %</b>   | 20%            | 20%            | 18%            | 42%           | 29%           |



# Learnings – Impact of uncertainty

## Tail risk of contagious diseases

*By analyzing data for pandemic outbreaks spanning over the past 2500 years, we show that the related distribution of fatalities is strongly fat-tailed, suggesting a tail risk that is unfortunately largely ignored in common epidemiological models...*

*We argue that our findings have significant implications, including on the extent to which compartmental epidemiological models and similar approaches can be relied upon for making policy decisions.*

Cirillo, P. and Taleb, N. N. (2020) 'Tail risk of contagious diseases', *Nature Physics*, 16(6), pp. 606–613. doi: [10.1038/s41567-020-0921-x](https://doi.org/10.1038/s41567-020-0921-x).

## On single point forecasts

- Tail wags the dog
- More data does not help
  - Do not need more evidence
  - Evidence is in the tail
- Science is about understanding
- Science is not about safety
- Decision making in the face of uncertainty

Taleb, N. N., Bar-Yam, Y. and Cirillo, P. (2020) 'On Single Point Forecasts for Fat-Tailed Variables', *arXiv:2007.16096 [physics, q-fin, stat]*. Available at: <http://arxiv.org/abs/2007.16096> (Accessed: 26 October 2020).



# Conclusions

- We are entering the third wave
- Models says it won't be as bad
- Depends on Population Immunity
- Which depends on IFR and other factors
- Seems likely that COVID-19 will become endemic
- Lessons
  - Identify experts
  - Uncertainty
  - Contribute & engage



# Keeping up with COVID-19

## What's next and what have we learnt?

Louis Rossouw

