SOUTH AFRICAN COVID-19 MODELLING CONSORTIUM

COVID-19 modelling update: Considerations for the third wave, including the impact of the Delta variant of concern

14 July 2021

Purpose

The purpose of this brief is to provide updated projections of the timing and size of the South African third wave of COVID-19 cases, taking into account both the impact of the Delta variant of concern and the progress of the SARS CoV-2 vaccination programme so far. We aim both to inform the public and to provide planning support, in particular to the National and Provincial Departments of Health and National Treasury.

Summary:

- **Nationally, total hospital admissions and deaths over the course of wave 3 are likely to be higher than in wave 1, while deaths (in-hospital and total) may be comparable to or exceed the values seen in wave 2.**
- Peak daily hospital admissions are projected to be similar to the second wave in most provinces under strong to moderate response scenarios.
- **Admissions in Gauteng are expected to peak by mid-July; admissions in Eastern Cape, KwaZulu-Natal, Limpopo, Mpumalanga, and Western Cape are expected to peak in mid-July to early August.**
- Cases and admissions are expected to reduce to low levels across all provinces by September 2021.
- **Uncertainty** with regards to seroprevalence data and distribution of variants between and within provinces **reduces the ability to produce robust projections in some provinces**, including projections of for the Free State, Northern Cape and North West provinces.
- Model projections will be updated rapidly as new data become available.
- Model scenarios depict waves of different sizes in each of the provinces as a result of different levels of non-pharmaceutical intervention (NPI) adherence and fatigue. **The increased transmissibility of the Delta variant places greater importance on strong NPI adherence** and vigilance.
- Even with continued NPI fatigue, **rapid vaccination** of the population provides a powerful tool to reduce severe illness and death.

Caveat

Due to the rapidly changing nature of the outbreak globally and in South Africa, our projections are updated regularly as new data become available and should be interpreted with caution. Changes in testing policy and hospitalisation criteria will impact the cases detected as well as the number of

hospital admissions and deaths that can be positively identified as associated with COVID-19. Likewise, the current social unrest could result in decreased testing, diagnosis, and access to care in the coming weeks, resulting in smaller numbers of admissions than projected. In addition saturation of hospital capacity, particularly during surges, could result in lower reported admissions than projected. Lastly, this version of the NCEM is a provincial-level model. District or sub-district level heterogeneity within provinces could result in longer, flatter provincial waves than projected.

Please direct all questions concerning this report to Dr Harry Moultrie, National Institute of Communicable Diseases (harrym@nicd.ac.za).

1. Factors influencing the shape of third wave

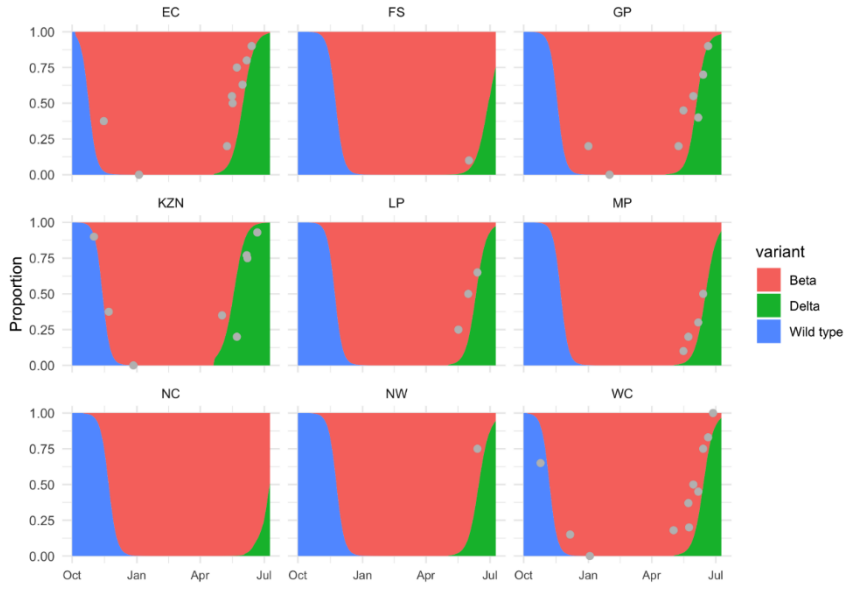
The updated model version continues to incorporate the impact of behaviour change, in particular reduced adherence to non-pharmaceutical interventions (NPIs), but has now been updated to also take into account the impact of the Delta variant of concern (VOC) as well as the ongoing COVID-19 vaccination roll-out. It has also been fitted to updated data regarding the seroprevalence of SARS-CoV-2 antibodies by province and age group.

Impact of Delta VOC

Genomic surveillance data suggests that the Delta variant is now the dominant SARS-CoV-2 variant in South Africa[1]. Preliminary estimates from genomic data and epidemiological studies suggest Delta may be 30-60% more transmissible than other variants of concern, including Beta[1]. Current sequencing data show that the Delta variant has already been detected in all nine provinces and is the dominant variant in EC, GP, KZN, LP, NW, WC[2]. Low sampling in MP, NC, NW and the FS however leads to increased uncertainty on the spread of Delta variant in these provinces.

Figure 1 shows how our model projections fit to the data on the prevalence of the wildtype virus and the Beta and Delta variants based on the sequencing data mentioned above.

Figure 1: Model predictions of distribution of infections by variant. Data from sequencing studies (via GISAID, www.gisaid.org) are represented by grey dots.



[1] https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2021.26.24.2100509
[2] https://www.nicd.ac.za/wp-content/uploads/2021/07/Update-of-SA-sequencing-data-from-GISAID-12-July-2021.pdf

Impact of vaccination

Vaccination against COVID-19 reduces a vaccinee's risk of developing severe and critical COVID-19. At baseline, the model takes into account the vaccination of mainly healthcare workers through the Sisonke Phase 3B trial, as well as mainly elderly people as part of the initial phase of the government vaccine roll-out. Forward projections incorporate the impact of the additional phases of the roll-out at the pace and uptake currently assumed by government planners. We will add additional scenarios varying these assumptions in a next set of analyses.

Impact of behaviour change

Behaviour change continues to be one of the main drivers of the timing and peak of the third wave. Factors that influence contact rates include holiday travel, large events such as religious and political gatherings, changes in adherence to NPIs such as mask wearing, and changes to government-imposed restriction levels. The projections presented below focus on the impact of behaviour change, acknowledging substantial uncertainty in the timing and the rate of change in both nationally directed and individual behaviour, in particular reduced NPI adherence due to fatigue. We show the results of five main scenarios that characterise the responses to resurgence along a spectrum of combined NPI adherence and government restrictions.

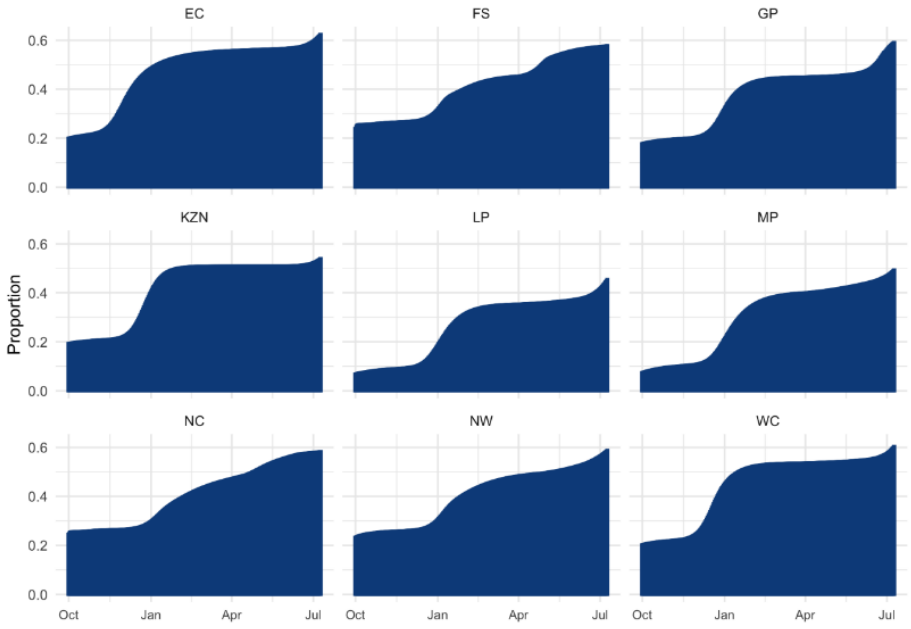
Impact of seroprevalence at the end of the second wave

A number of studies have estimated the seroprevalence of SARS-CoV-2, a measure of previous exposure to the virus, in South Africa between November 2020 and May 2021. These studies covered locales in all provinces based on different target populations, but none were representative across provinces or the South African age profile. Figure 2 shows the seroprevalence estimates incorporated in the model by province (Figure 2A) and age group (Figure 2B).

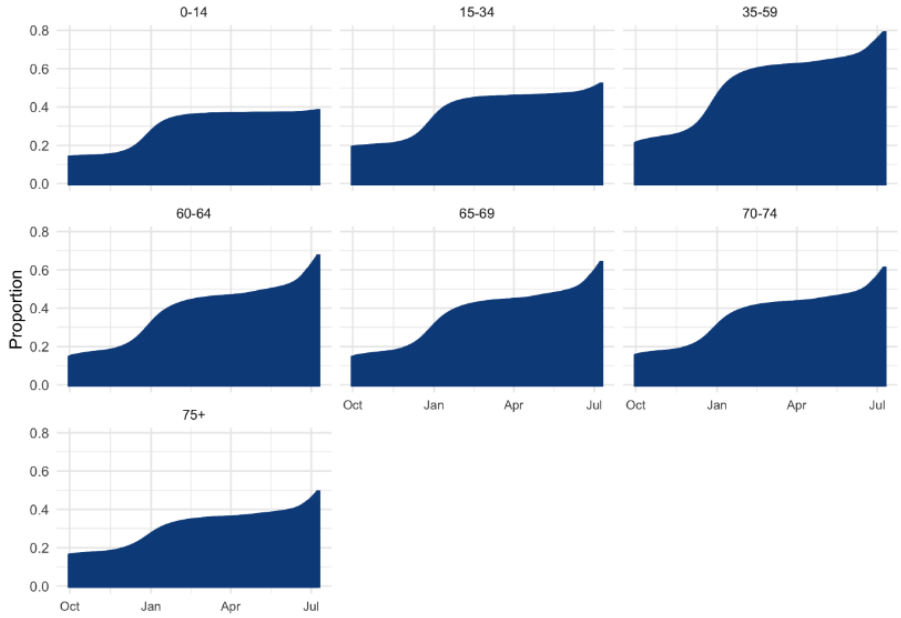
A clear upward trend is discernible, with most estimates from May 2021 arriving at values of 40% to 50% seroprevalence.

Figure 2: Model calibration of seroprevalence by (A) province and (B) age group.

(A)



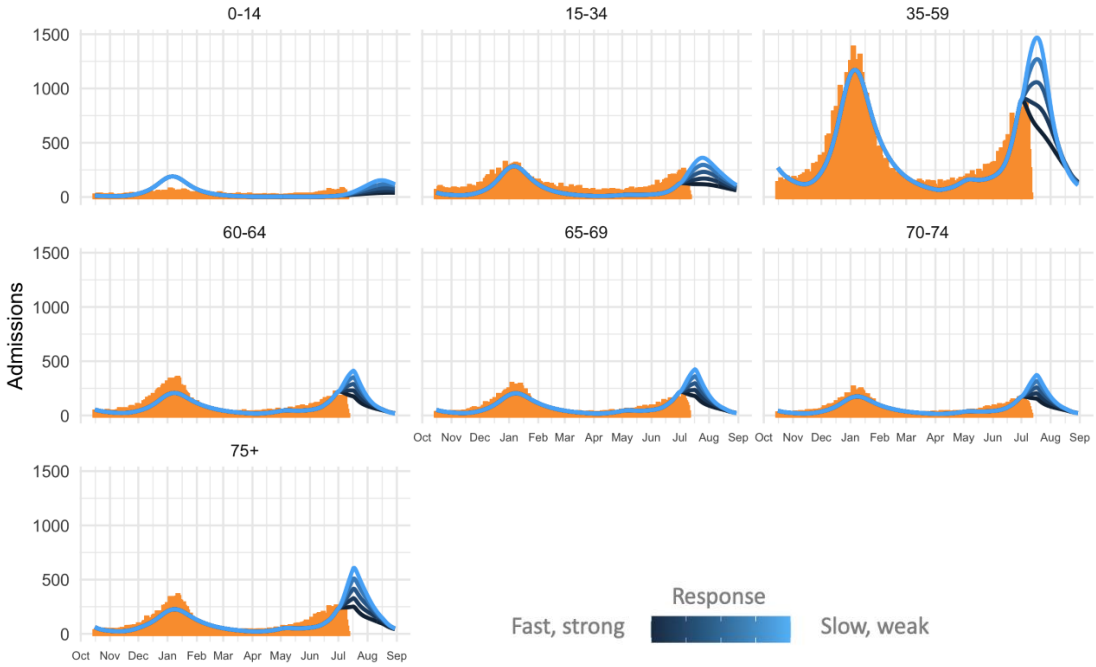
(B)



3. Simulating a potential third wave

With regards to hospital admissions for severe and critical cases, we expect the peak of the 3rd wave to be similar to or higher than that of the 2nd wave- except in the lowest age groups or in the most optimistic behavioural scenarios (Figure 3). A slow, weak behavioural response increases hospital admissions across most age groups. Across all scenarios, the 35-59 age group is still expected to generate the highest number of admissions.

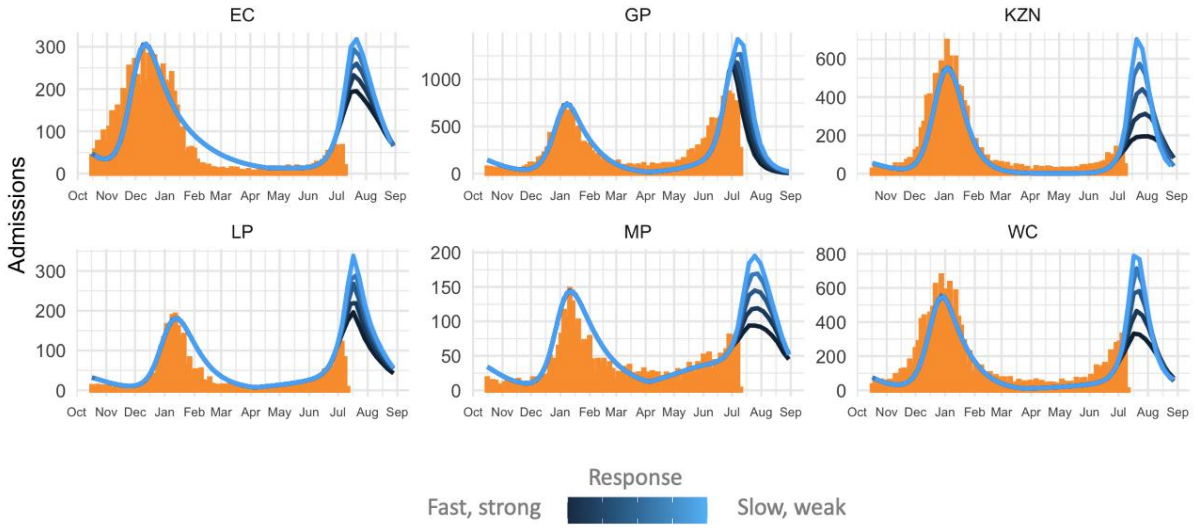
Figure 3: Third wave scenarios: Impact on hospital admissions, by age group (comparing 2nd and 3rd waves). Orange bars represent second wave data from DATCOV/NICD; blue curves represent model projections.



Our provincial projections (Figure 4) show substantial variation of the size of the third wave between provinces, reflective of the prevalence and dominance of the Delta variant, as well as different age distributions and prevalence of comorbidities. In all scenarios, Gauteng is projected to reach a peak that is higher than the second wave peak by mid-July. For Limpopo, all scenarios project a similar or higher peak in the third wave. For Mpumalanga and the Western Cape, only some scenarios project a higher wave than the second wave. For the Eastern Cape, all scenarios project waves at similar or lower levels compared to its second wave. For KwaZulu-Natal, only the most extreme "slow, weak response" scenario results in a third wave peak that is substantially higher than the second wave.

Considerable uncertainty in seroprevalence, variant distribution, and other underlying data have led to less well-calibrated scenarios for the Free State, Northern Cape and the North West province. Projections regarding these provinces will be shared once more sequencing data become available.

Figure 4: Third wave scenarios: Impact on hospital admissions, by province (comparing 2nd and 3rd waves). Orange bars represent second wave data from DATCOV/NICD; blue curves represent model projections. Projections for provinces not represented here (FS, NW, NC) will be provided in future updates, once additional data are available.



4. Estimating the timing of the peak of the third wave

Based on the above projections, we estimate the peak of the third wave to be as follows for the following provinces:

- **GP**: Early - mid July
- **EC, KZN, LP, WC, MP**: Mid July - early August

For the remaining provinces, the above-mentioned uncertainty with regards to the extent of spread of the Delta variant makes it impossible to confidently project the timing of the peak of the 3rd wave; these projections will be made available once new genomic data becomes available.

5. Quantifying the impact of a third wave

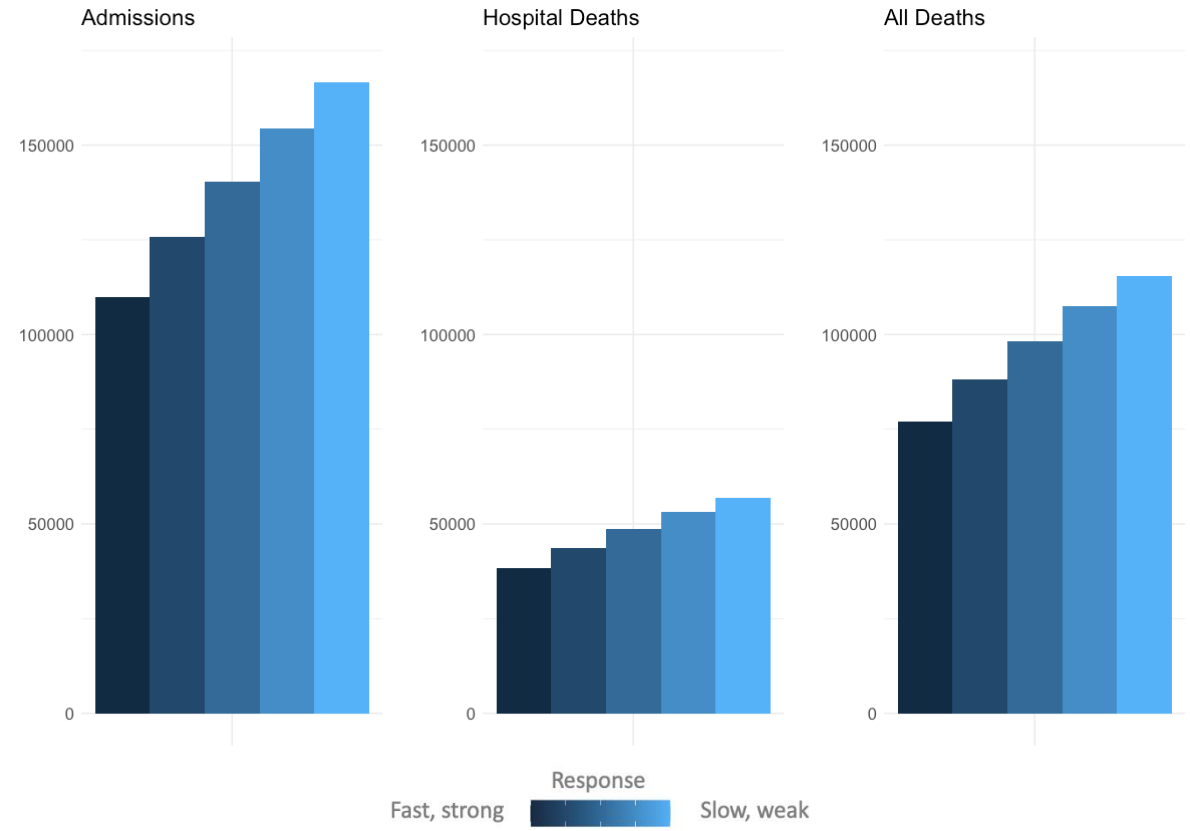
In summary, across all scenarios, we estimated the impact of the third wave to be higher than the first wave in terms of hospital admissions and deaths and comparable to higher than the second wave for in terms of deaths (Table 1). Importantly, there is large variation between the five behavioural scenarios (Figure 5), emphasising the impact that individual behaviour has on the size of the next peak.

Table 1: Impact of 1st, 2nd and 3rd waves on hospital admissions, hospital-based deaths, and total deaths (numbers rounded to the nearest 100)

			Wave 3***	
	Wave 1*	**Wave 2****	*Fast, strong response*	*Slow, weak response*
Hospital admissions	103,900	150,000	111,300	167,500
Hospital COVID-19 deaths	18,500	34,500	39,400	57,800
All COVID-19 deaths (in and out of hospital)	39,300+	80,300+	78,900	116,800

* 5 March 2020 – 30 September 2020 ** 1 October 2020 – 31 March 2021 *** 1 April 2021 – 31 August 2021
+ estimated as 85% of excess deaths[3]

Figure 5: Impact of the third wave on hospital admissions, hospital deaths and total deaths



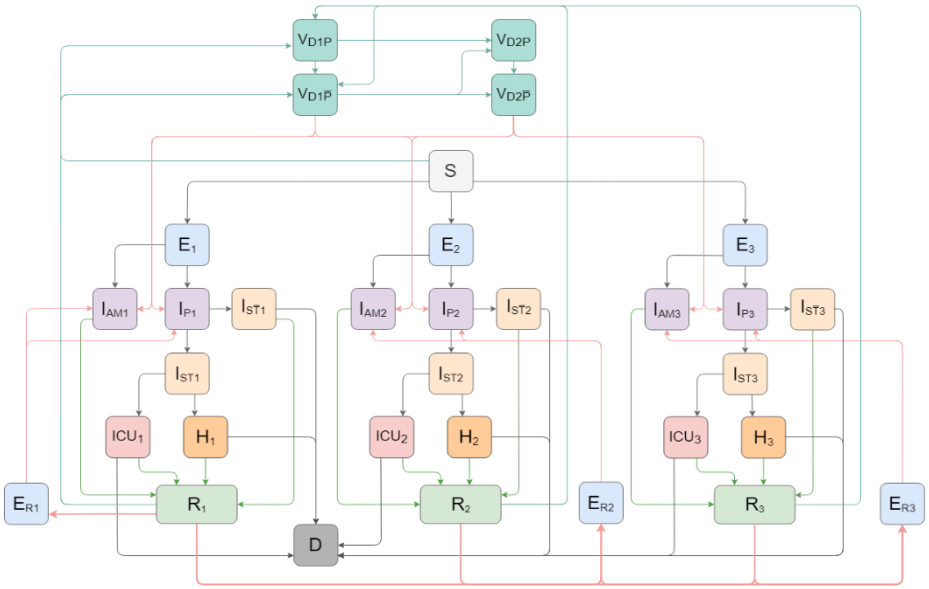
[3] Correlation Of Excess Natural Deaths With Other Measures Of The Covid-19 Pandemic in South Africa. Burden of Disease Research Unit, South African Medical Research Council (23 February 2021). https://www.samrc.ac.za/sites/default/files/files/2021-03-03/CorrelationExcessDeaths.pdf

Appendix

The National COVID-19 Epi Model (NCEM v5.2)

The National COVID-19 Epi Model (NCEM) is an epidemiological model that was developed by the South African COVID-19 Modelling Consortium. Since producing projections for the first wave of the South African epidemic in May 2020, the model has been adapted and updated several times as new data became available. The NCEM is a stochastic compartmental transmission model that estimates the total and reported incidence of COVID-19 cases, hospitalisations, and deaths in South Africa. The spatially-explicit model is calibrated to model the spread of infection in the 9 provinces of South Africa. The model follows a generalised Susceptible-Exposed-Infectious-Removed (SEIR) structure accounting for disease severity (asymptomatic, mild, severe and critical cases) and treatment pathways (outpatient services, inpatient non-ICU and ICU beds). Version 5.2 has been updated to incorporate additional features suitable to modelling vaccination and the Beta and Delta variants now prevalent in South Africa. This version of the NCEM is a stochastic, multi-strain, age-structured, compartmental model of COVID-19 (Figure A1).

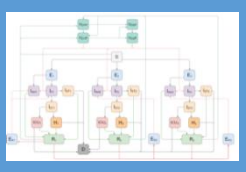
Figure A1: The National COVID-19 Epi Model v5.2



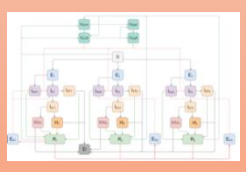
Model States

V_{D1P}	Vaccinated, Dose 1, Protected
$V_{D1\bar{P}}$	Vaccinated, Dose 1, Not protected
V_{D2P}	Vaccinated, Dose 2, Protected
$V_{D2\bar{P}}$	Vaccinated, Dose 2, Not protected
S	Susceptible
E	Exposed (not infectious)
E_R	Exposed, re-infected (not infectious)
I_{AM}	Infected, asymptomatic or mild
I_P	Infected, pre-symptomatic
$I_{S\bar{T}}$	Infected, severe, untreated
I_{ST}	Infected, severe, seeking treatment
H	Infected, severe, in general ward
ICU	Infected, critical, in ICU
R	Recovered
D	Died
SUBSCRIPTS	
1	Wild Type
2	Beta Variant
3	Delta Variant

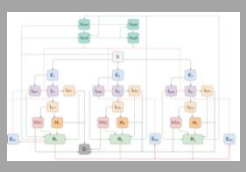
Health workforce



People with comorbidities



All other



Model Flows

ARROW COLOURS
Vaccination
Infection
Reinfection
Recovery
Death

The model's additional features include:

- **Age structure**: The population has been subdivided into age classes accounting for age-related differences in susceptibility to and severity of COVID-19 and to allow for age-related disease characteristics and age-targeted vaccination.
- **Multi-strain**: The wild type SARS-CoV-2 infection and the Beta and Delta variants dominating transmission in South Africa's second and third wave of infections respectively, have been incorporated. The structure assumes no co-infection but allows low levels of reinfection with new variants. Likewise, imperfect natural immunity allows reinfection with the same lineage, with a lower transmissibility.
- **Vaccination**: The model has been developed to account for vaccination of the susceptible and naturally immune populations with vaccines of 1 or 2 doses, allowing for vaccine waning, imperfect protection and the ability to protect against infection or disease.
- **Priority populations**: Age-stratified priority populations are defined as Healthcare Workers, Population with Comorbidities, and Everyone Else with the ability for future vaccine distribution to be tailored to these populations with respect to the type of vaccine, the timing of vaccination, and population age (Figure A2). The transmission characteristics of priority populations are also captured.

About the South African COVID-19 Modelling Consortium

The South African COVID-19 Modelling Consortium is a group of researchers from academic, non-profit, and government institutions across South Africa. The group is coordinated by the National Institute for Communicable Diseases, on behalf of the National Department of Health. The mandate of the group is to provide, assess and validate model projections to be used for planning purposes by the Government of South Africa. For more information, please contact Dr Harry Moultrie (harrym@nicd.ac.za).

Acknowledgements

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