Foresight 2020
05.10.20

connecting
the dots.

foresight
dialogues 2020

Connecting the dots

**Adaptive Disease Modelling
for COVID-19 decision-making
in South Africa**

Dr Sheetal Silal

Modelling and Simulation Hub, Africa (MASHA)
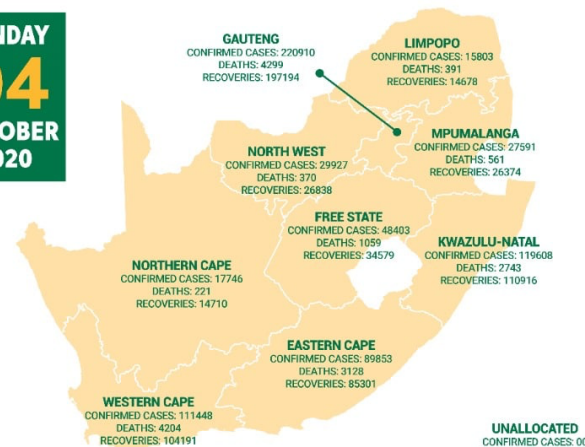
University of Cape Town

foresight
dialogues 2020

South African COVID-19 Modelling Consortium (SACMC)

- Group of researchers from academic, non-profit, and government institutions across South Africa

- Epi and Econ models developed by MASHA, SACEMA and HE2RO in conjunction with the NICD

- Extensive and ongoing input from clinicians, virologists, intensivists and epidemiologists to refine key model assumptions and parameters

- Purpose: support govt planning

COVID-19 STATISTICS IN SA

4 269 626	681 289	614 781	16 976	1 573
TESTS CONDUCTED	POSITIVE CASES IDENTIFIED	TOTAL RECOVERIES	TOTAL DEATHS	NEW CASES

SUNDAY 04 OCTOBER 2020

GAUTENG
CONFIRMED CASES: 220910
DEATHS: 4299
RECOVERIES: 197194

LIMPOPO
CONFIRMED CASES: 15803
DEATHS: 391
RECOVERIES: 14678

NORTH WEST
CONFIRMED CASES: 29927
DEATHS: 370
RECOVERIES: 26838

MPUMALANGA
CONFIRMED CASES: 27591
DEATHS: 561
RECOVERIES: 26374

FREE STATE
CONFIRMED CASES: 48403
DEATHS: 1059
RECOVERIES: 34579

KWAZULU-NATAL
CONFIRMED CASES: 119608
DEATHS: 2743
RECOVERIES: 110916

NORTHERN CAPE
CONFIRMED CASES: 17746
DEATHS: 221
RECOVERIES: 14710

EASTERN CAPE
CONFIRMED CASES: 89853
DEATHS: 3128
RECOVERIES: 85301

WESTERN CAPE
CONFIRMED CASES: 111448
DEATHS: 4204
RECOVERIES: 104191

UNALLOCATED
CONFIRMED CASES: 00

Learn more to Be READY for #COVID19:
www.sacoronavirus.co.za

Covid-19 public hotline: 0800 029 999
WhatsApp 'Hi' to 0600 123 456

DOWNLOAD the **COVID Alert SA** app

The COVID Alert SA app can notify you if you have been exposed to another app user with coronavirus. Download it now to protect yourself and others

App Store

Google Play

health
Department:
Health
REPUBLIC OF SOUTH AFRICA

Who are disease modellers?

Who are disease modellers?

Mathematics · Biology · Statistics · Computer Science · Economics · Public Health System

Model multiple diseases · Falciparum Malaria · Pertussis · Hepatitis A · Vivax Malaria
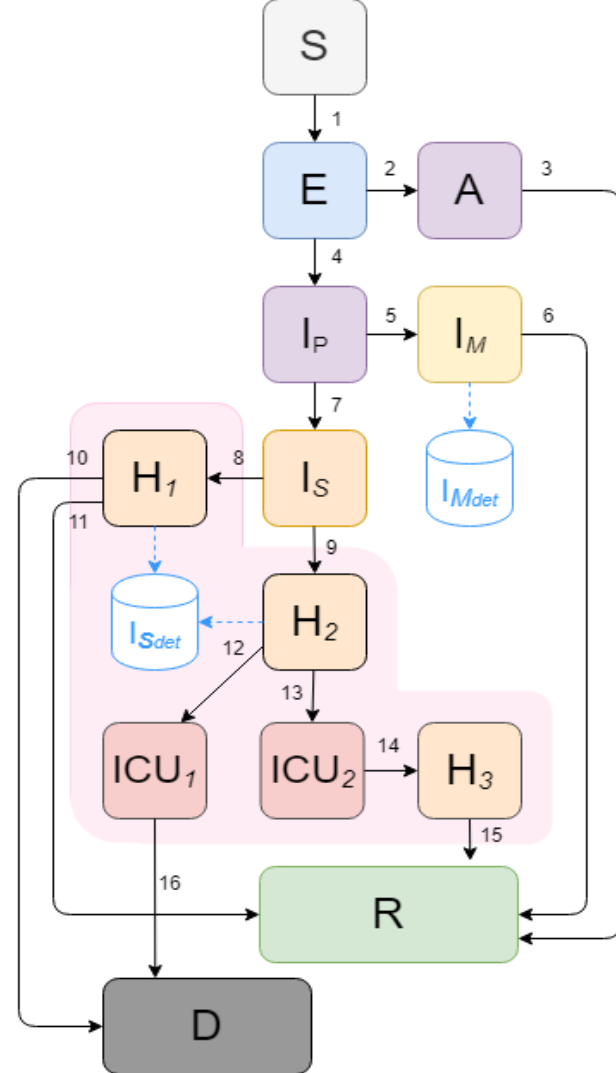
Adaptive modelling for COVID-19 in South Africa

NCEM model structure (v1)

Modelling Method?

- Statistical prediction
- Compartmental models
- Metapopulation models
- Agent-based models

Modelling in Context

- Absence of local level data
- Not yet possible to estimate impact of lockdown
- Models project estimated need for services
  - Utilisation of services is likely to be lower
  - Criteria for entry into hospital (general and ICU) likely to be stricter
- Behavioural changes in response to the epidemic unaccounted for
- Long run expectation of epidemic assumed to be the same across country (after accounting for population/age distribution)
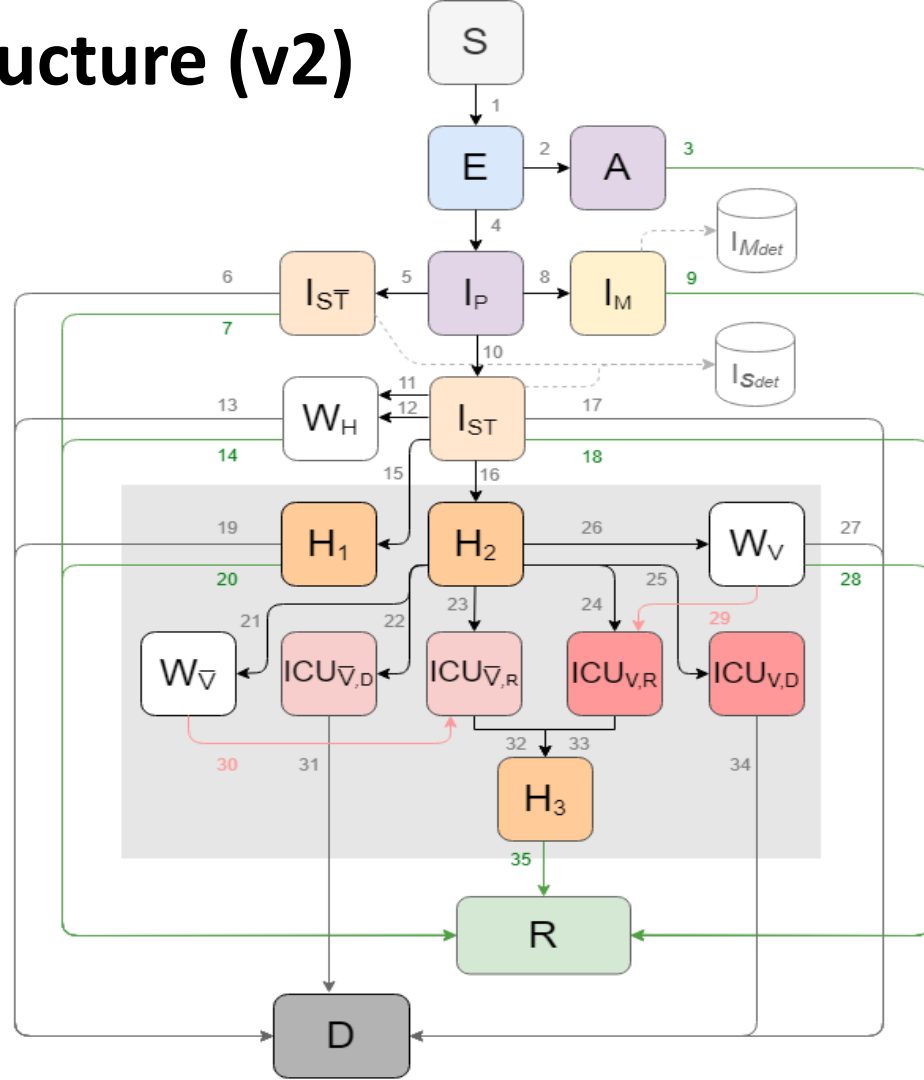- Budgets calculated before anything known on cost/resources needed
- UNCERTAINTY

NCEM model structure (v2)

Model States

|	
S	Susceptible
E	Exposed (not infectious)
A	Infected, asymptomatic (A)
I_P	Infected, pre-symptomatic (Ip)
I_M	Infected, mild
$I_{S\overline{T}}$	Infected, severe, untreated
I_{ST}	Infected, severe, seeking treatment
W_H	Infected, severe, waiting for hospital bed
Hospitalised	Infected, severe, general ward (H_1)
	Infected, severe, general ward pre-ICU (H_2)
	Infected, critical, waiting for ICU, no ventilation ($W_{\overline{V}}$)
	Infected, critical, in ICU, not ventilated, non-survivor ($ICU_{\overline{V},D}$)
	Infected, critical, in ICU, not ventilated, survivor ($ICU_{\overline{V},R}$)
	Infected, critical, waiting for ICU & ventilation (W_V)
	Infected, critical, in ICU, ventilated, survivor ($ICU_{V,R}$)
	Infected, critical, in ICU, ventilated, non-survivor ($ICU_{V,D}$)
	Infected, severe, general ward post-ICU (H_3)
R	Removed (recovered)
D	Died
I_{Mdet}	Detection of mild cases (laboratory confirmed)
I_{Sdet}	Detection of severe cases (laboratory confirmed)

Model Flows

1. Force of infection
2. Latent period (until asymptomatic infectiousness)
3. Recovery: duration of asymptomatic infectiousness)
4. Latent period (until symptomatic infectiousness)
5. Development of severe symptoms, does not seek treatment
6. Death of severe, untreated case
7. Recovery: duration of severe case's infectiousness
8. Development of mild symptoms
9. Recovery: duration of mild case's infectiousness
10. Development of severe symptoms, seeks treatment
11. Severe case waiting for a hospital bed (if bed capacity reached)
12. Critical case waiting for a hospital bed (if bed capacity reached)
13. Death while waiting for hospital bed (excess mortality)
14. Recovery while waiting for hospital bed
15. Severe case admitted to hospital
16. Critical case admitted to hospital (pre-ICU progression)
17. Death of severe case while seeking treatment
18. Recovery of severe case while seeking treatment
19. Death of severe case in general hospital bed
20. Recovery of severe case in general hospital bed
21. Critical case in hospital, waiting for ICU admission (no ventilation)
22. Progression to ICU admission (no ventilation), non-survivor
23. Progression to ICU admission (no ventilation), survivor
24. Progression to ICU admission (with ventilation), survivor
25. Progression to ICU admission (with ventilation), non-survivor
26. Critical case in hospital, waiting for ICU admission (ventilation)
27. Death of critical case while awaiting ICU & ventilation
28. Recovery of critical case while awaiting ICU & ventilation
29. Waiting critical case needing ventilation admitted to ICU
30. Waiting critical case not needing ventilation admitted to ICU
31. Death of critical case from ICU (not ventilated)
32. Critical case discharged from ICU (non-ventilated) to general ward
33. Critical case discharged from ICU (ventilated) to general ward
34. Death of critical case from ICU (ventilated)
35. Recovery of critical case (discharged from hospital)

Source: NICD COVID-19 Surveillance Reports
https://www.nicd.ac.za/diseases-a-z-index/covid-19/surveillance-reports/

NCEM Model Structure (v3)

- Preparation of DATCOV and NICD surveillance data

- Analysis of mobility data from different sources

- Revision of Bed Availability
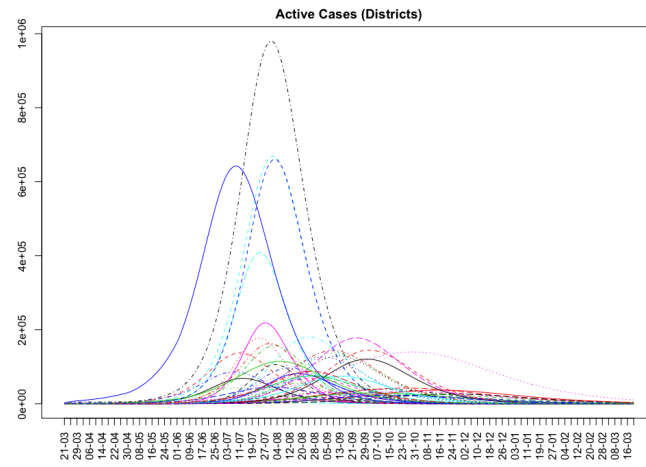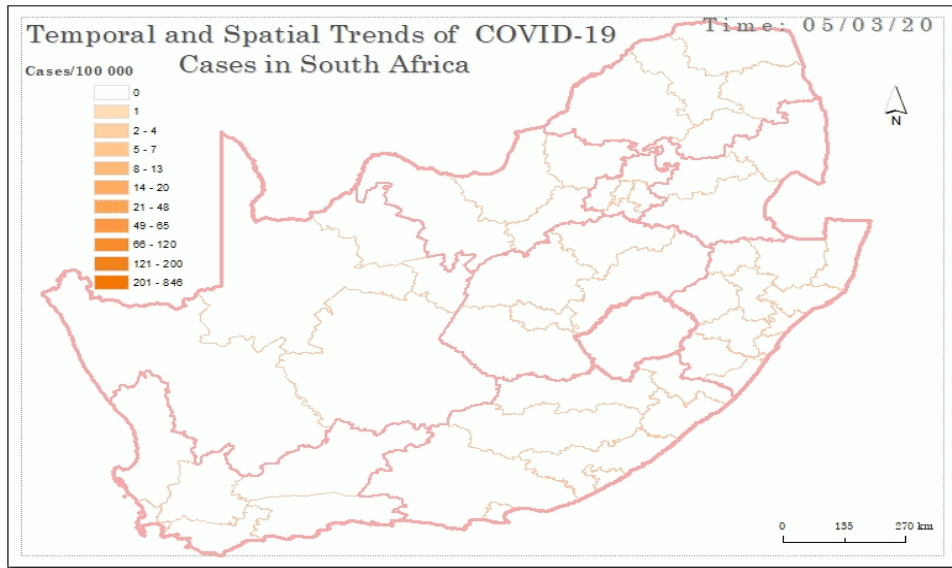
Source: SA COVID-19 Modelling Consortium (Preliminary output)

Stakeholders

- NDOH Ministerial Advisory Committee
- Facility preparedness and expansion
- Staff required at facilities
- Ventilators
- Oxygen planning team
- Drug quantities
- Number of diagnostic test kits and testing algorithms
- Isolation facilities
- Number and placement of mortuary containers
- National and provincial treasuries: *Covid-19 health budget*
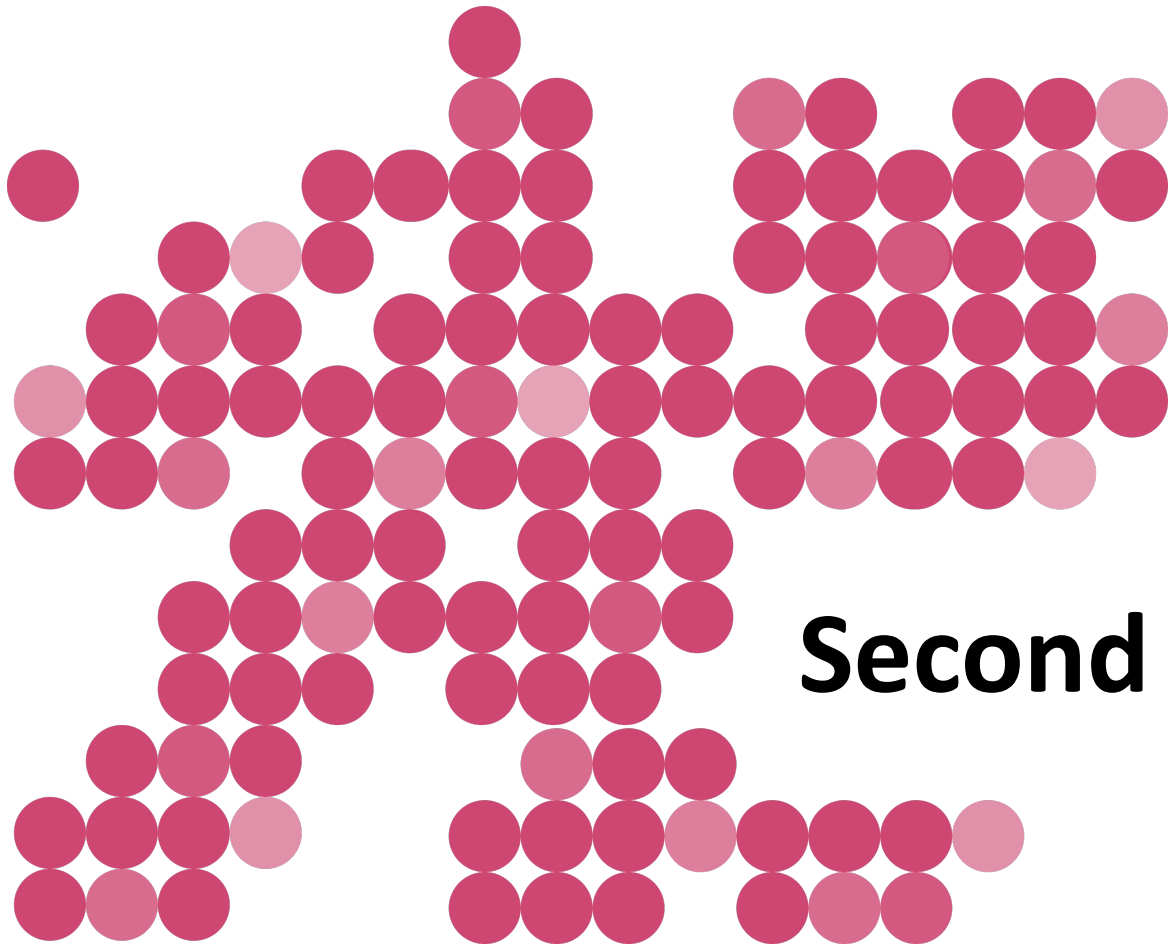
Second Wave

• Will it really be a second wave?

- Second Wave
- Resurgence
- Uptick
- Upswing
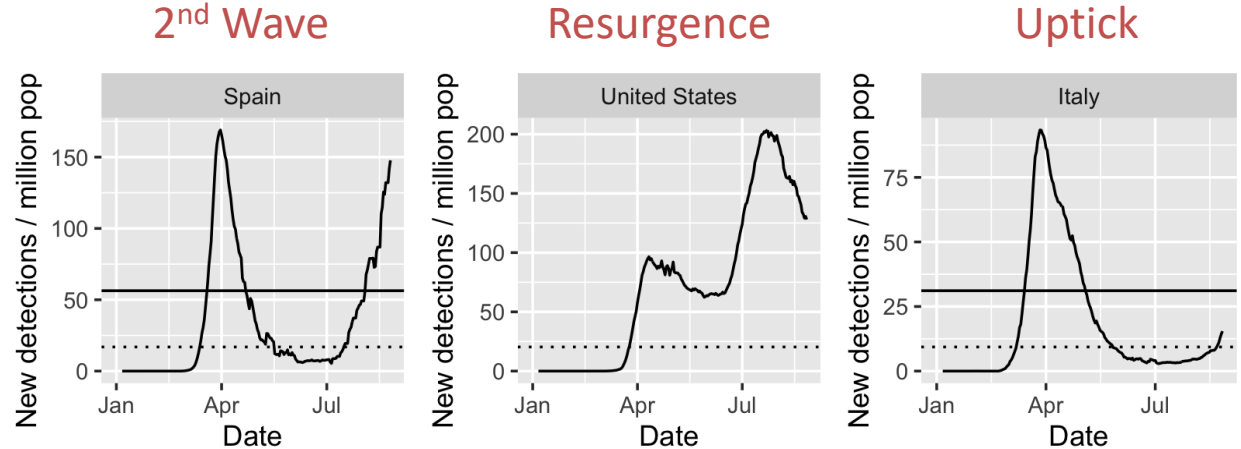
https://covid.ourworldindata.org/data/owid-covid-data.csv [2020-08-30]

Vaccine & Therapeutics

Treatment & Cure

- No cure yet.
- No fully licensed treatments. FDA granted emergency authorization to Remdesivir & Cytosorb
- Promising evidence:
  - Remdesivir (antiviral) for reducing hospital stay duration (possibly mortality)
  - Dexamethasone (steroid) for reducing mortality in ventilated & oxygenated patients

Vaccination

- **R&D:** over 140 teams with 231 candidates in development
- **Timeline:** aiming for a licensed vaccine by end-2020 to mid-2021
- **Distribution:** likely to be challenges with production constraints, hoarding and roll-out

590+
Drug development programs in planning stages[1]

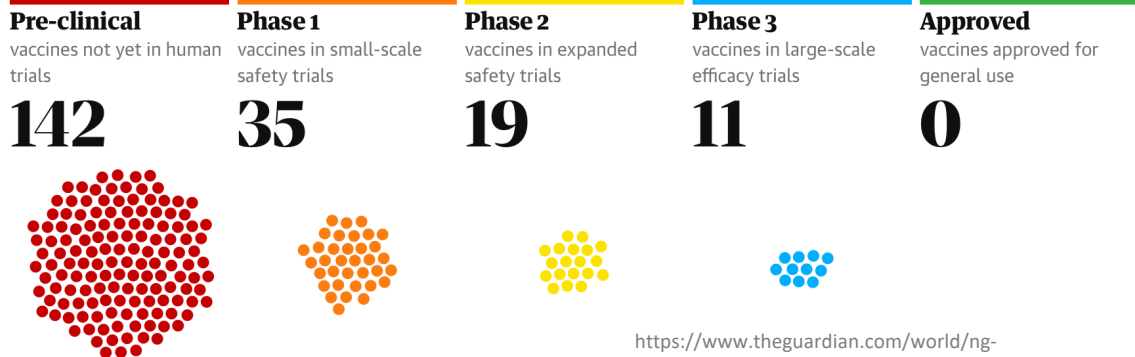**310+**
Trials reviewed by FDA[2]

5
COVID 19 treatments currently authorized for Emergency Use[3]

0
Treatments currently approved by FDA for use in COVID-19

https://www.fda.gov/drugs/coronavirus-covid-19-drugs/coronavirus-treatment-acceleration-program-ctap

Pre-clinical	Phase 1	Phase 2	Phase 3	Approved
vaccines not yet in human trials	vaccines in small-scale safety trials	vaccines in expanded safety trials	vaccines in large-scale efficacy trials	vaccines approved for general use
142	35	19	11	0

Source: WHO. Last updated 30 Sep

https://www.theguardian.com/world/ng-interactive/2020/oct/02/covid-vaccine-tracker-when-will-a-coronavirus-vaccine-be-ready

Immunity Dynamics

- A lot of uncertainty (and a lot of research underway):

- Antibodies, T-cells and memory cells detected during and post-infection

- **Major question:** What is the duration and strength of protective immunity?

- **Implications for vaccine development:** Uncertain what level of immune response is needed to protect against the virus, which is crucial for evaluating vaccine efficacy.

- **Life-long immunity:** Possible that neither a vaccine nor infection will produce life-long immunity (similar to influenza).

Scenario A: Short duration of immunity (40 weeks)

Expect: Annual epidemics with smaller peaks than the initial epidemic

COVID-19 becomes a regular occurence

Adapted from Kissler et al. 2020 Science
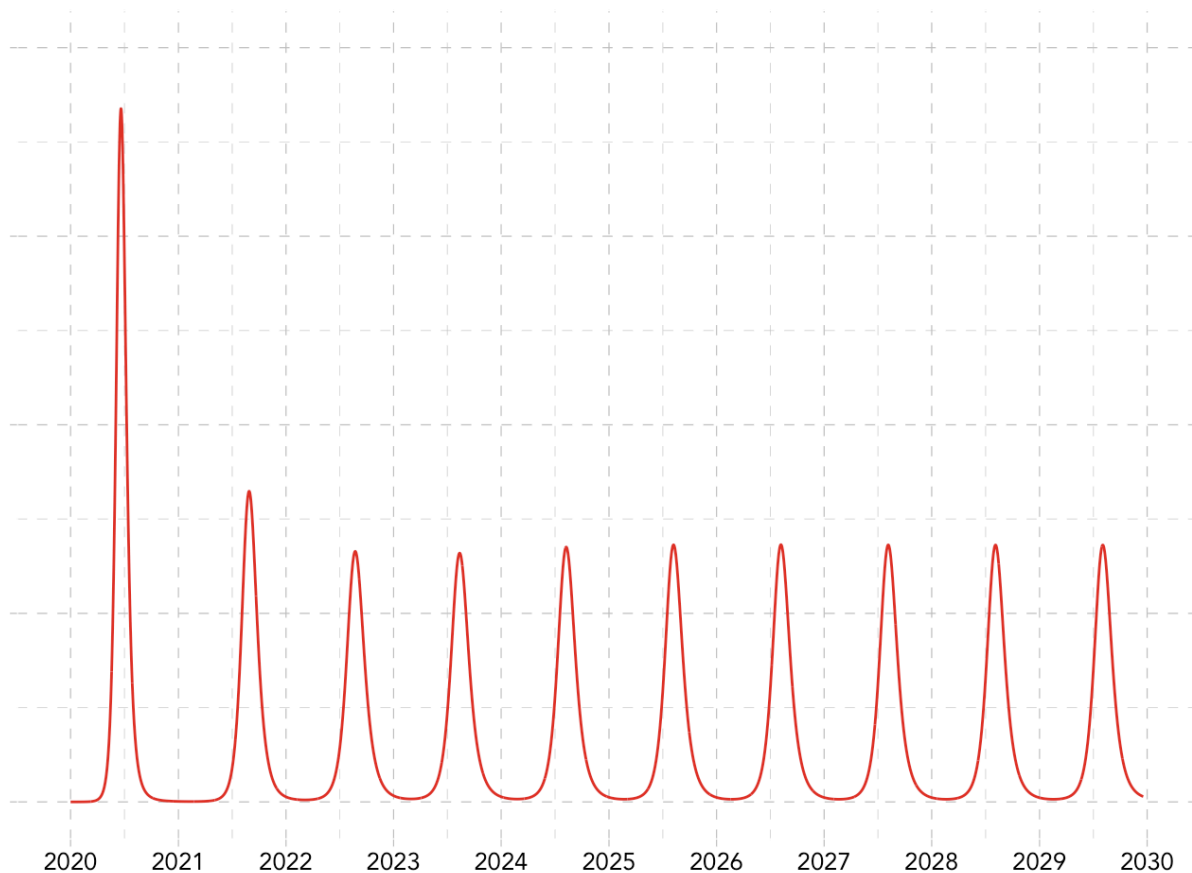
Scenario B: Longer duration of immunity (2 years)

Expect: Two-year gap before the next epidemic (2023) followed by epidemics every 2 years with substantially smaller peaks than the initial epidemic.

Adapted from Kissler et al. 2020 Science
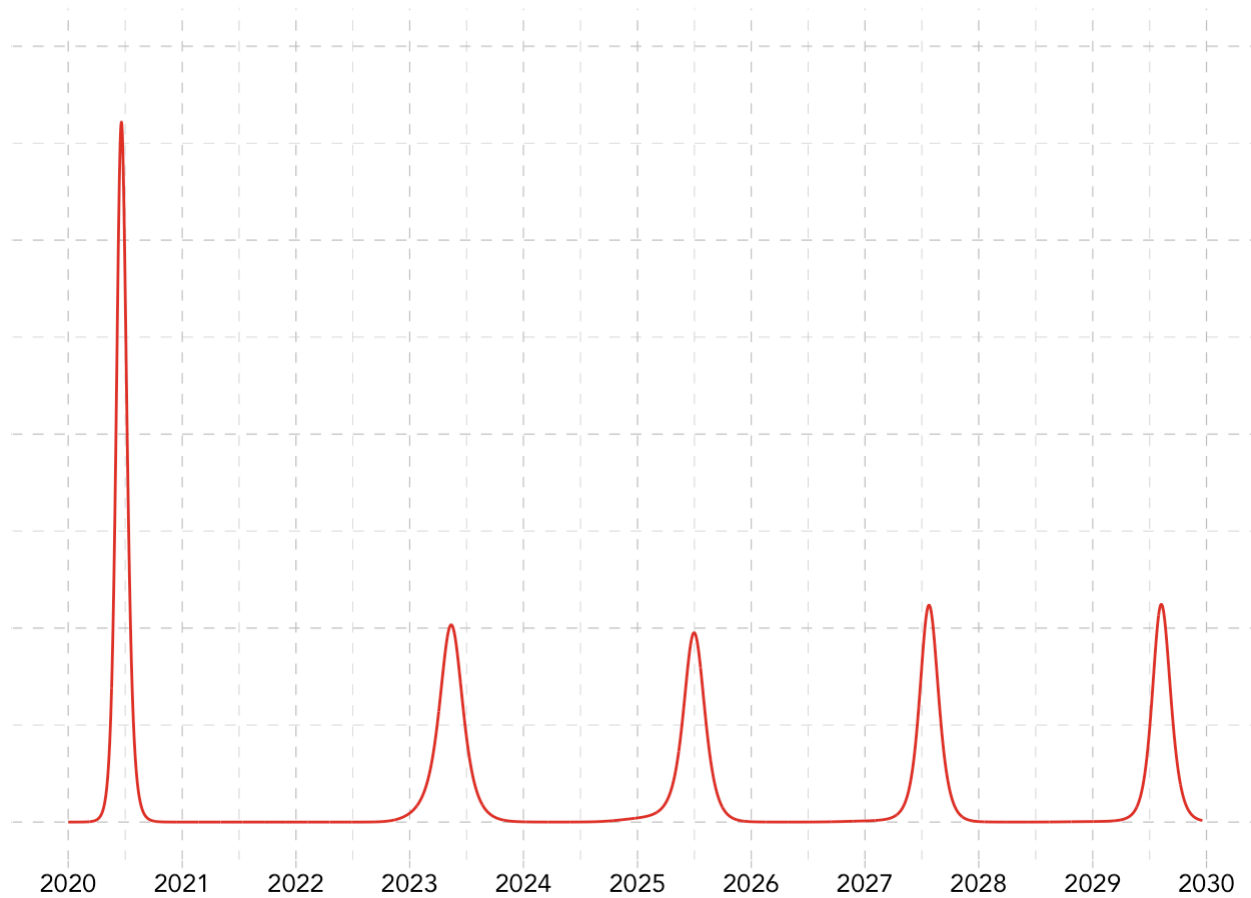
Scenario C: Longer duration immunity (2 years) with reduced disease upon reinfection

Expect: COVID-19 becomes a regular occurrence BUT severity of disease (burden on hospitals) decreases

Adapted from Kissler et al. 2020 Science
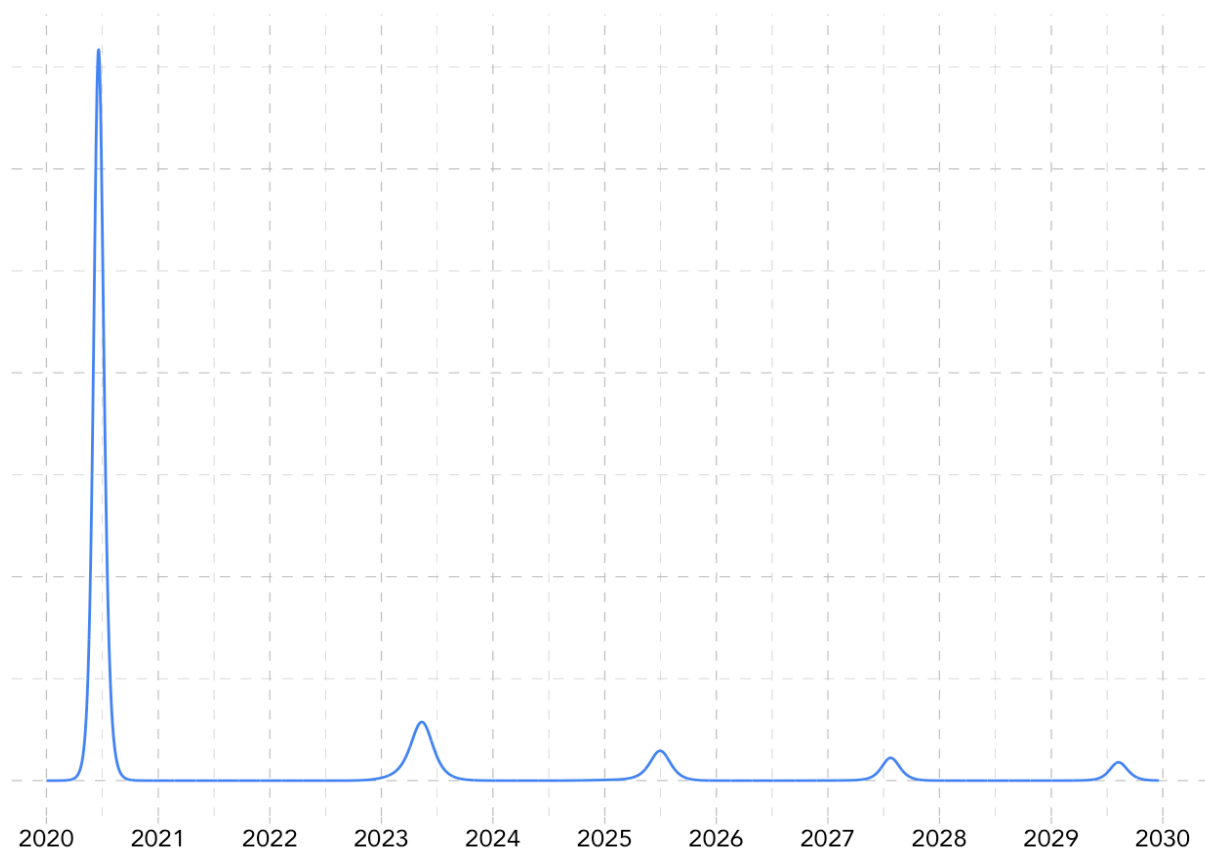
Scenario D: Weak cross immunity with long duration of immunity (2 years)

Some protection from seasonal coronaviruses (orange).

Expect: Two-year gap before the next COVID epidemic (red) followed by small but <u>variable</u> epidemics every one to two years.
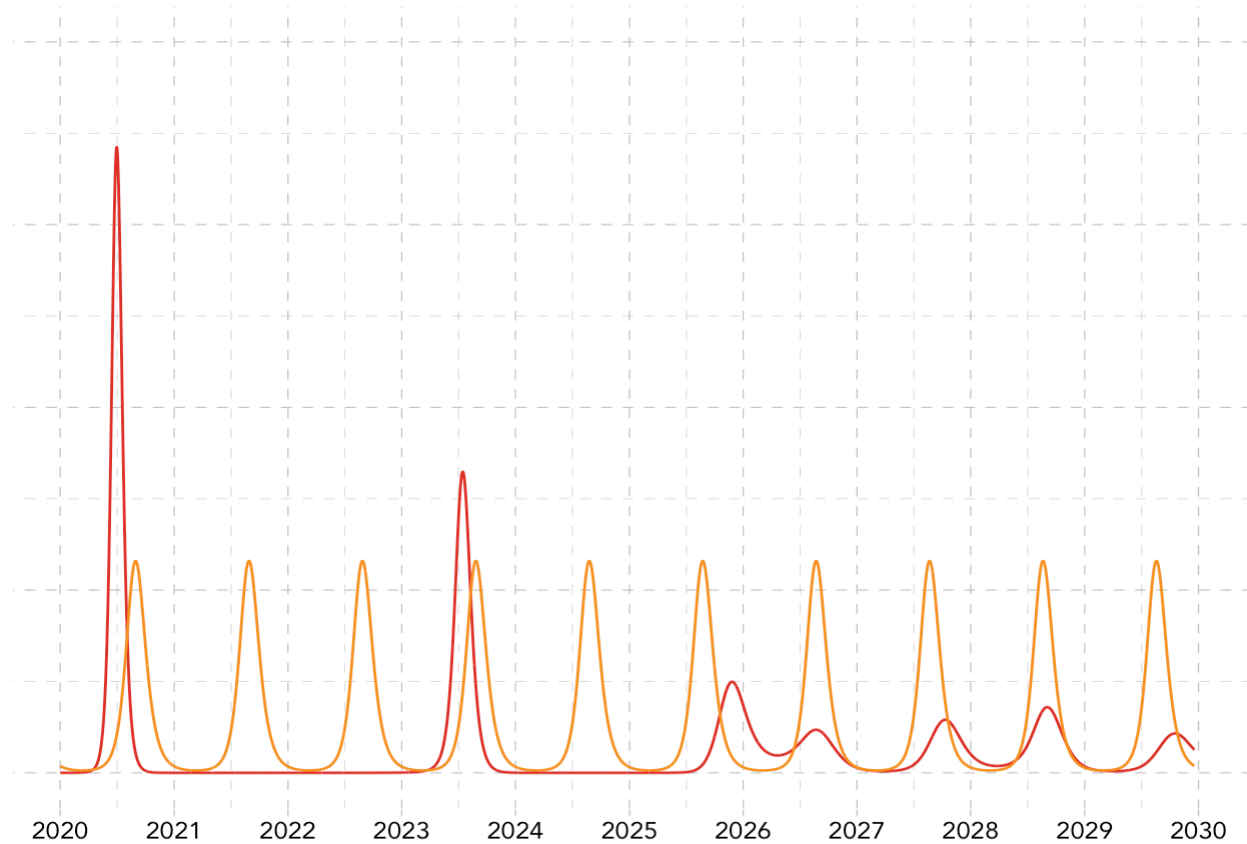
Long term considerations

foresight
dialogues 2020

Future Outlook

- Invest in data for decision support
  - Cluster surveillance, Pandemic preparedness, Linked data systems
- Hospital Preparedness
  - Fungibility of wards, Healthcare Workers, Fully Equipped beds, Emergency services
- Procurement flexibility
- Improved National and Provincial coordination

- Vaccine Allocation and Implementation
- Planning for the 2nd Wave