Open-source modelling tools to support policy decision-making throughout the COVID-19 post-pandemic phase.

Study investigators

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Overview

Study 1 (~Feb 2021)

Vaccinating Australia: How long will it take?

Study 2 (~April 2021)

Modelling vaccination capacity at mass vaccination hubs and GP clinics

Study 3 (~July 2021)

Modelling outbreaks against the backdrop of vaccine rollout and border openings

AS SEEN BY USERS OF ...

Artwork by @allison_horst

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dplyr : go wrangling

Artwork by @allison_horst

Artwork by @allison_horst

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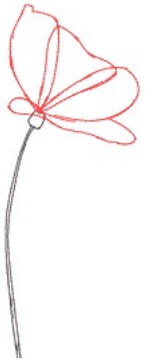
From github.com



Artwork Alex Grigg via GIPHY

Study 1

Vaccinating Australia: How long will it take

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Vaccinating Australia: How long will it take?

Mark Hanly [a,*], Timothy Churches [b], Oisín Fitzgerald [a], C. Raina MacIntyre [c], Louisa Jorm [a]

[a] Centre for Big Data Research in Health, UNSW Sydney, Australia
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https://doi.org/10.1016/j.vaccine.2021.07.006

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Vaccinating Australia: How long will it take?

Australia's vaccine arrangements (February 2021)

Name	Type	Doses (millions)	Schedule	Status as at 1st March, 2021
Pfizer/BioNTech	mRNA vaccine	20	2 doses, 21 days apart	Provisionally approved by the Therapeutic Goods Administration
University of Oxford/AstraZeneca	Viral vector vaccine	54	2 doses, 84 days apart	Provisionally approved by the Therapeutic Goods Administration
Novavax	Protein vaccine	51	2 doses, 21 days apart	Phase 3 clinical trials
COVAX Facility	Assorted	25	Assorted	Nine candidate vaccines in various clinical trial stages

Vaccinating Australia: How long will it take?

Australia's vaccination program phases (February 2021)

Phase	Description	Size
1a	Quarantine & border workers | Frontline health care workers | Aged care and disability care staff & residents	678,000
1b	Elderly adults aged 70 years and over | Other health care workers | Aboriginal and Torres Strait Islander people aged 55 years and over | Younger adults with an underlying medical condition | Critical and high-risk workers	6,139,000
2a	Adults aged 50 years and over | Aboriginal and Torres Strait Islander people aged 18-54 | Other critical and high-risk worker	6,117,000
2b	Balance of adult population	6,643,000
3	<18 if recommended	5,670,000

Vaccinating Australia: How long will it take?

> ***We aim to have the country vaccinated before the end of October***
>
> – Greg Hunt, Jan 31

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Vaccinating Australia: How long will it take?

Projection scenarios

Scenario	Doses per day	Schedule	Hesitancy
1	80,000	3 to 4 weeks	7%
2	80,000	3 to 4 weeks	13%
3	80,000	12 to 13 weeks	7%
4	80,000	12 to 13 weeks	13%
5	200,000	3 to 4 weeks	7%
6	200,000	3 to 4 weeks	13%
7	200,000	12 to 13 weeks	7%
8	200,000	12 to 13 weeks	13%

Vaccinating Australia: How long will it take?

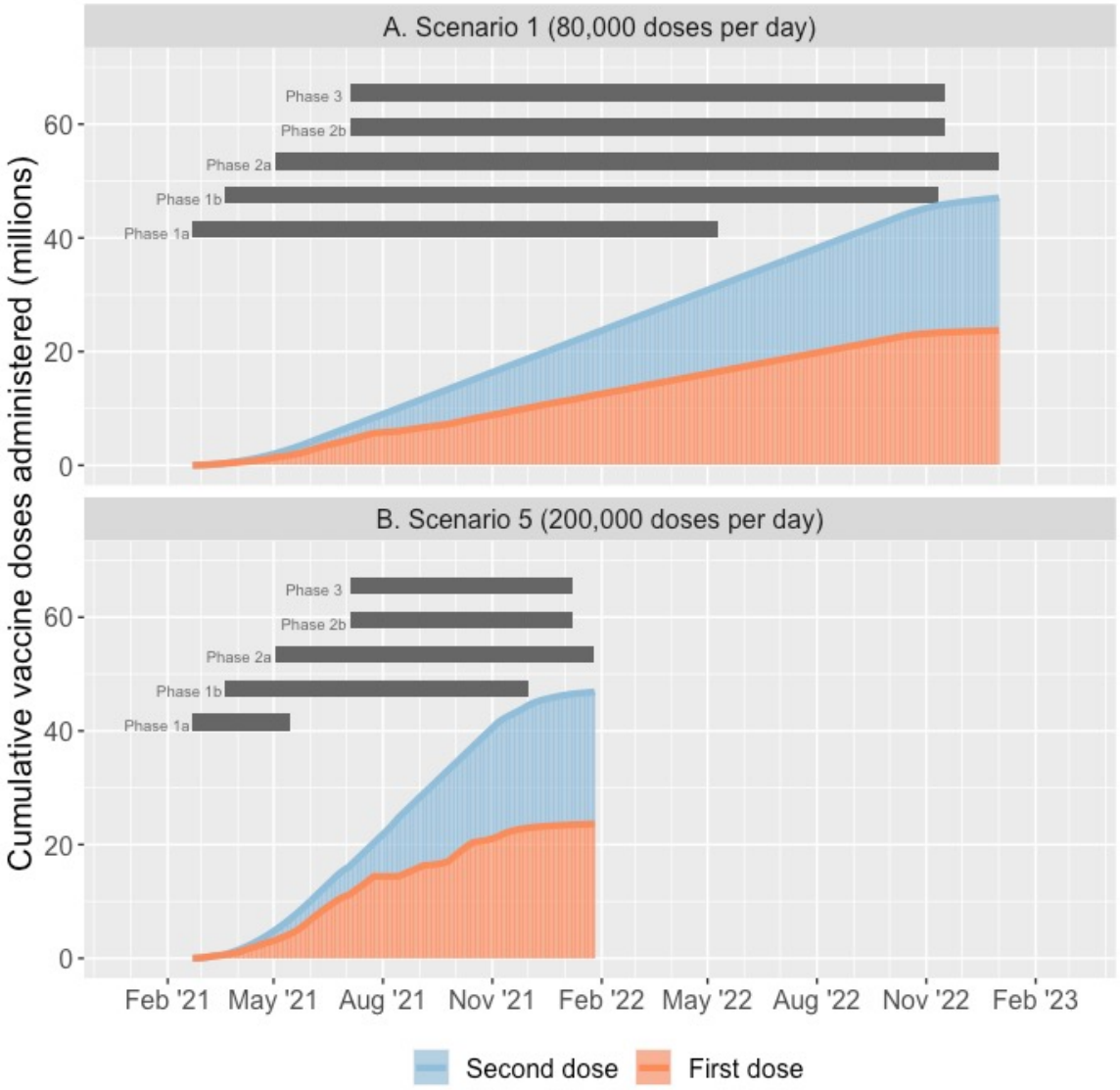

Figure 1.

Projected cumulative vaccine doses over time

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Vaccinating Australia: How long will it take?

```
# summarise key dates
dfDates <- dfPhases %>%
    group_by(scenario, date, phase) %>%
    summarise(n = sum(n)) %>%
    arrange(scenario, phase, date) %>%
    group_by(scenario, phase) %>%
    mutate(doseCuml = cumsum(n),
           popSize = case_when(
                    phase == '1a' ~ pop[1],
                    phase == '1b' ~ pop[2],
                    phase == '2a' ~ pop[3],
                    phase == '2b' ~ pop[4],
                    phase == '3' ~ pop[5]),
           pctDone = case_when(
               doseCuml >= popSize*2*0.90 ~ 'd',
               doseCuml >= popSize*2*0.80 ~ 'c',
               doseCuml >= popSize*2*0.70 ~ 'b',
               doseCuml < popSize*2*0.70 ~ 'a')
           ) %>%
    group_by(scenario, phase, pctDone) %>%
    filter(n > 0) %>%
    summarise(start = min(date), end = max(date)) %>%
    arrange(scenario, phase, pctDone)
```

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Vaccinating Australia: How long will it take?

Opensource code hosted on GitHub

- Collaboration
- Transparency
- Reproducibility
- Public-facing web presence

github.com/CBDRH/vaccinatingAustralia

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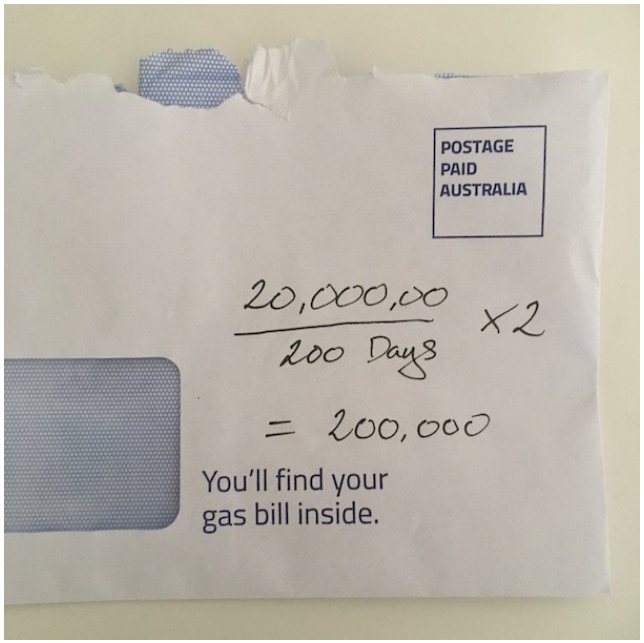
Vaccinating Australia: How long will it take?

Simple analysis | Important message



Politician's language (Reassuring, vague)

We aim to have the country vaccinated before the end of October

– Greg Hunt, Jan 31

Policy language (Specific, actionable target)

Australia must vaccinate 200,000 adults a day to meet October target

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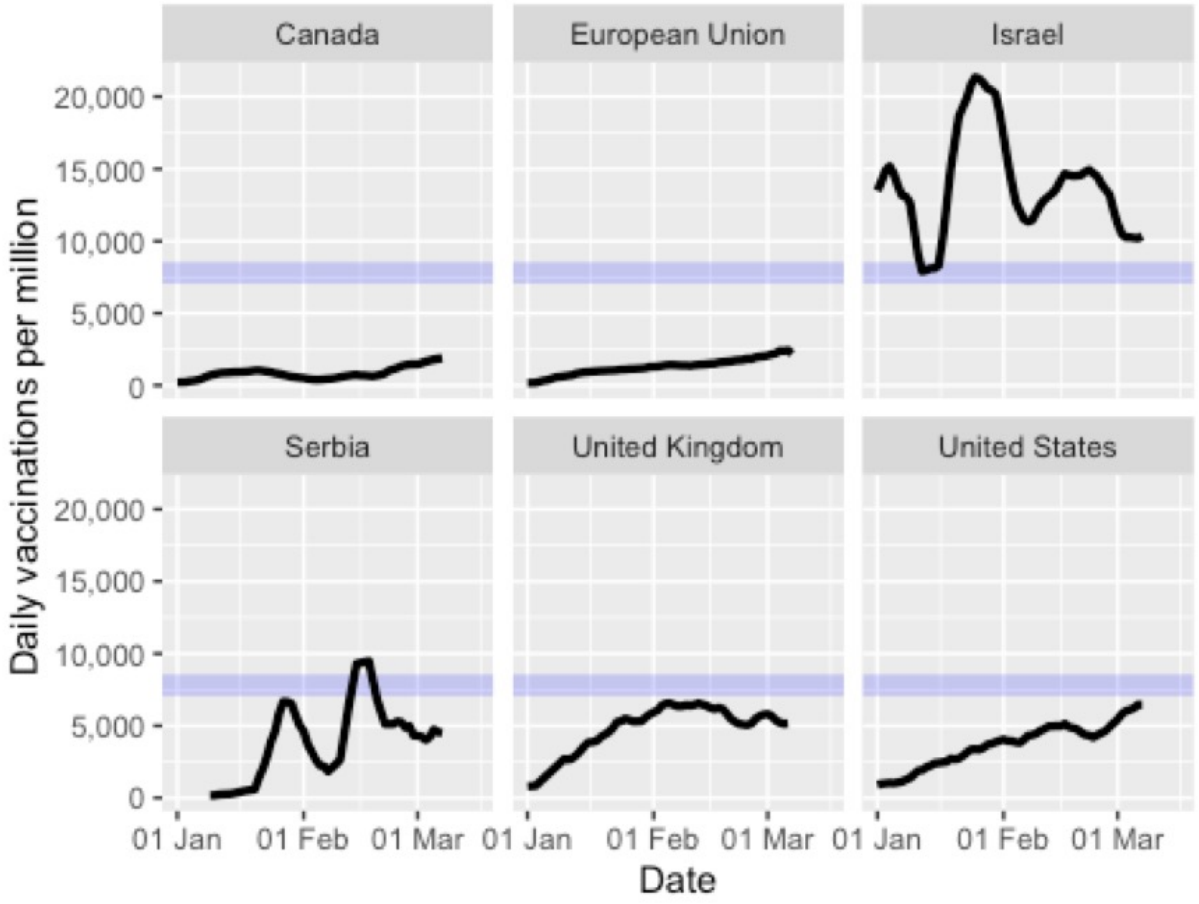
Vaccinating Australia: How long will it take?

Projected cumulative vaccine doses over time



Data source: ourworldindata.org

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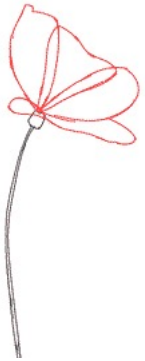
Vaccinating Australia: How long will it take?

- How do we administer ~200,000 doses per day?
- Government originally set out to recruit 1,000 GP clinics
- $\frac{200{,}000}{1{,}000} = 200$
- There are ~7,000 GP clinics in Australia
- $\frac{200{,}000}{7{,}000} \approx 29$
- We will need mass vaccination hubs!
- How doses can you administer a day in a mass vaccination hub?
- How many vaccinators do he have?
- We need a model!



Artwork Alex Grigg via GIPHY

Study 2

Modelling vaccination capacity

MODELLING VACCINATION CAPACITY AT MASS VACCINATION HUBS AND GENERAL PRACTICE CLINICS

A PREPRINT

Mark Hanly
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Ingham Institute for Applied Medical Research

https://doi.org/10.1101/2021.04.07.21255067

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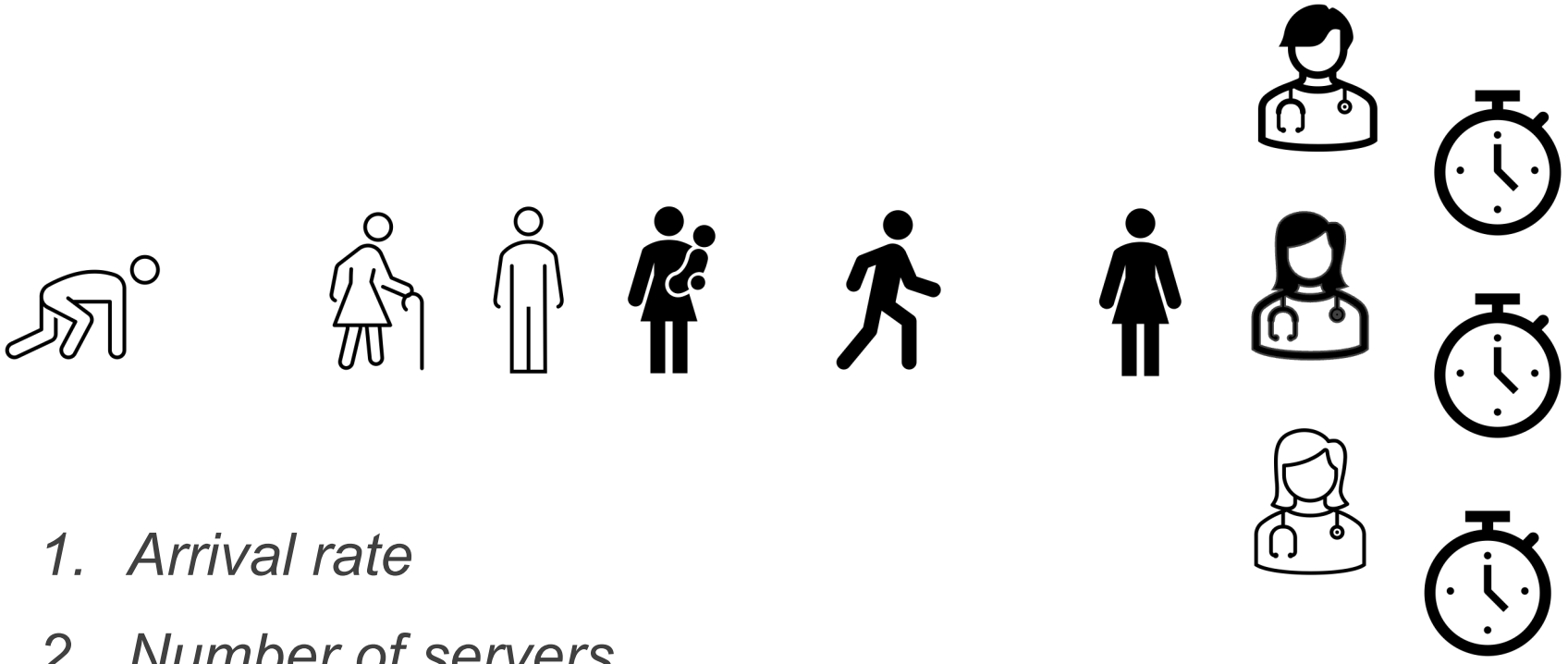
Modelling vaccination capacity

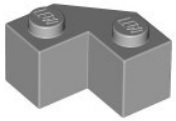
Queue Dynamics



1. *Arrival rate*
2. *Number of servers*
3. *Service time*

Modelling vaccination capacity

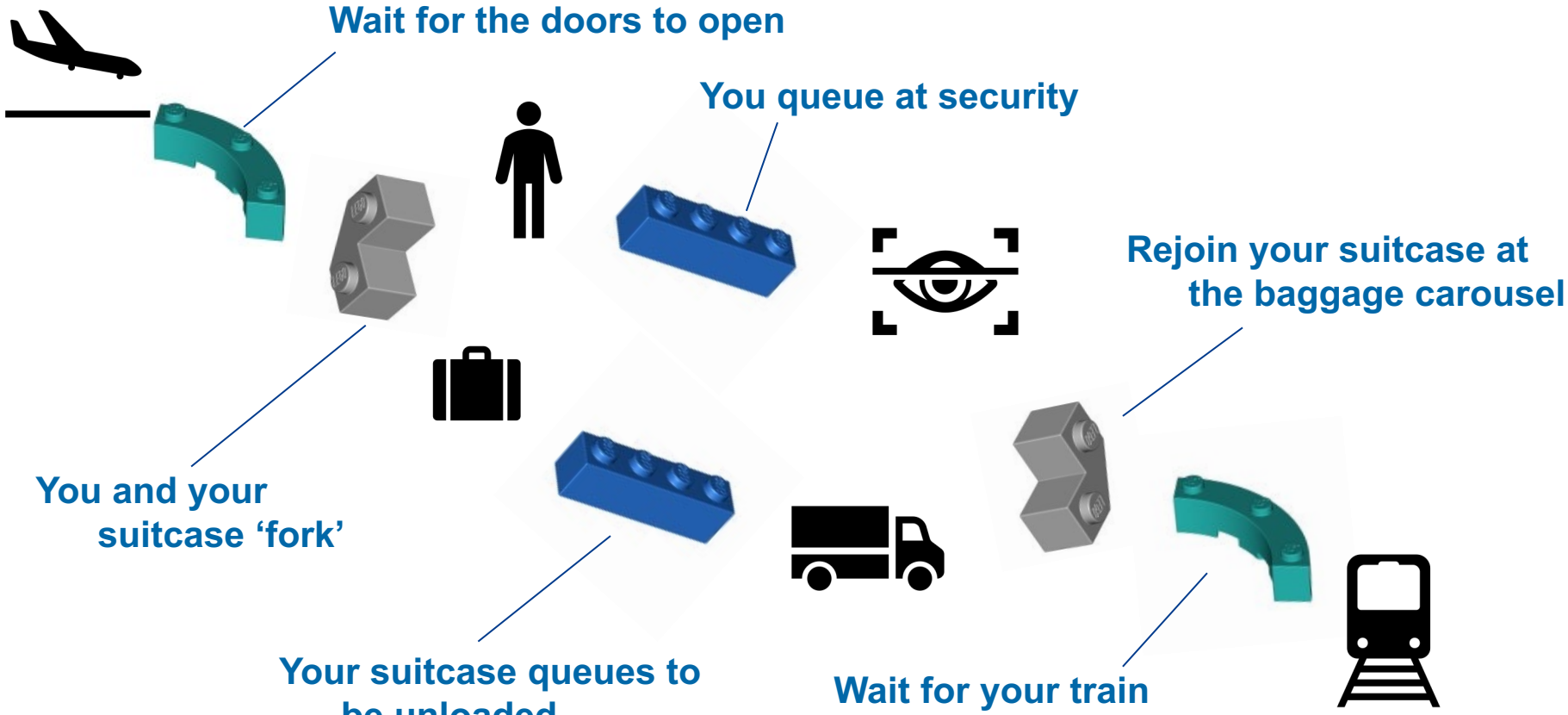
Queue Networks

1. Queue step 
2. Wait step 
3. Fork/join step 

Implemented in the R package **queuecomputer**

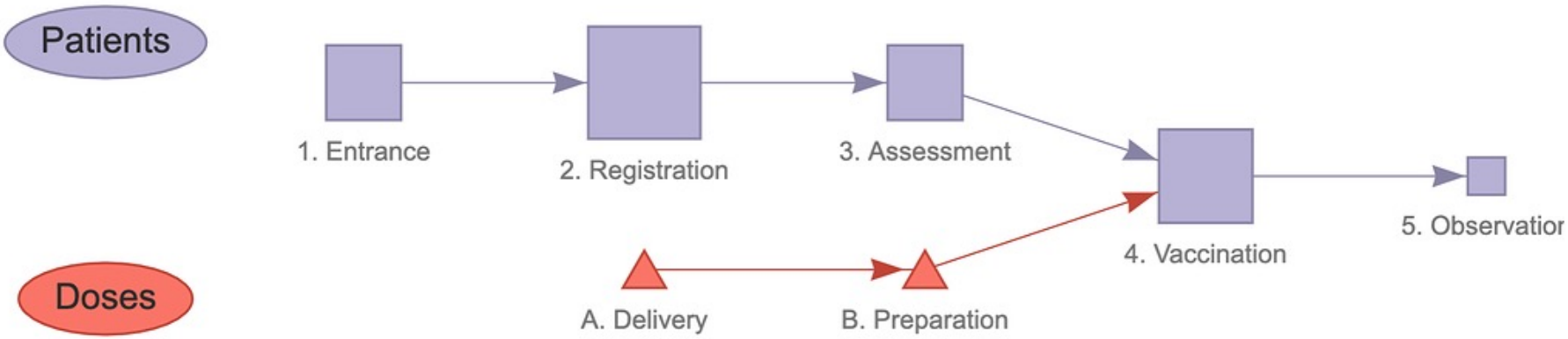
Modelling vaccination capacity

Arriving at an airport



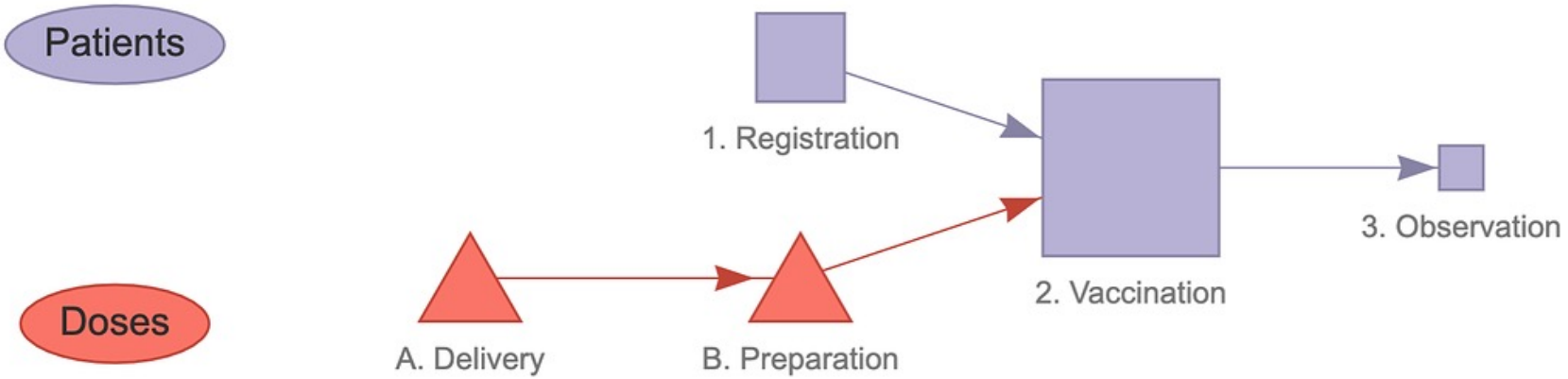
Modelling vaccination capacity

Mass vaccination hub



Modelling vaccination capacity

GP clinic



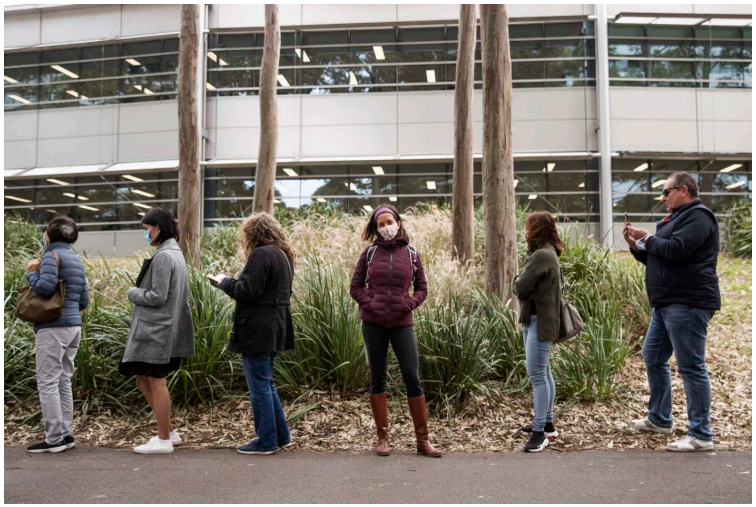
Modelling vaccination capacity

Model inputs

Arrival rate

Number of servers

Service time



Model outputs

Daily throughput

Total service time

Staff utilisation

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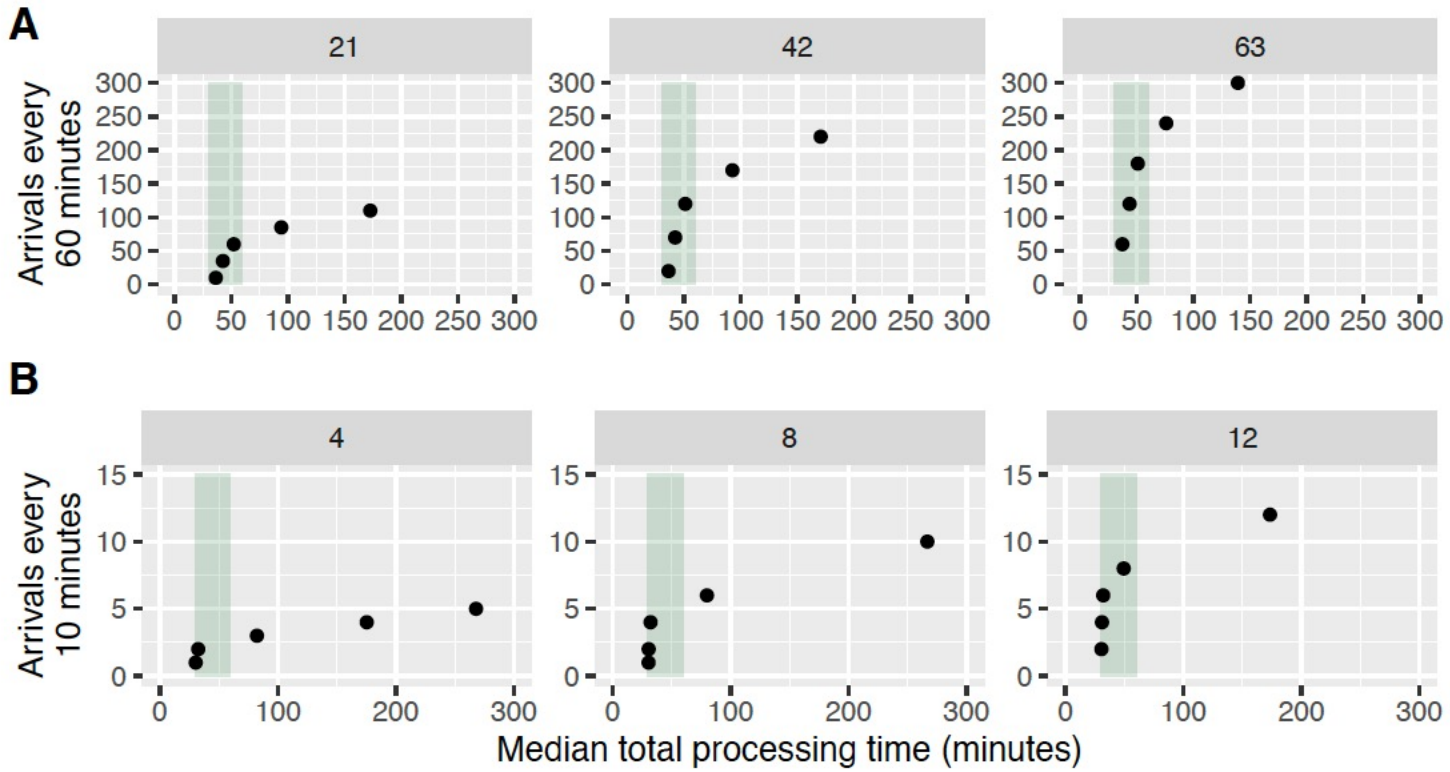
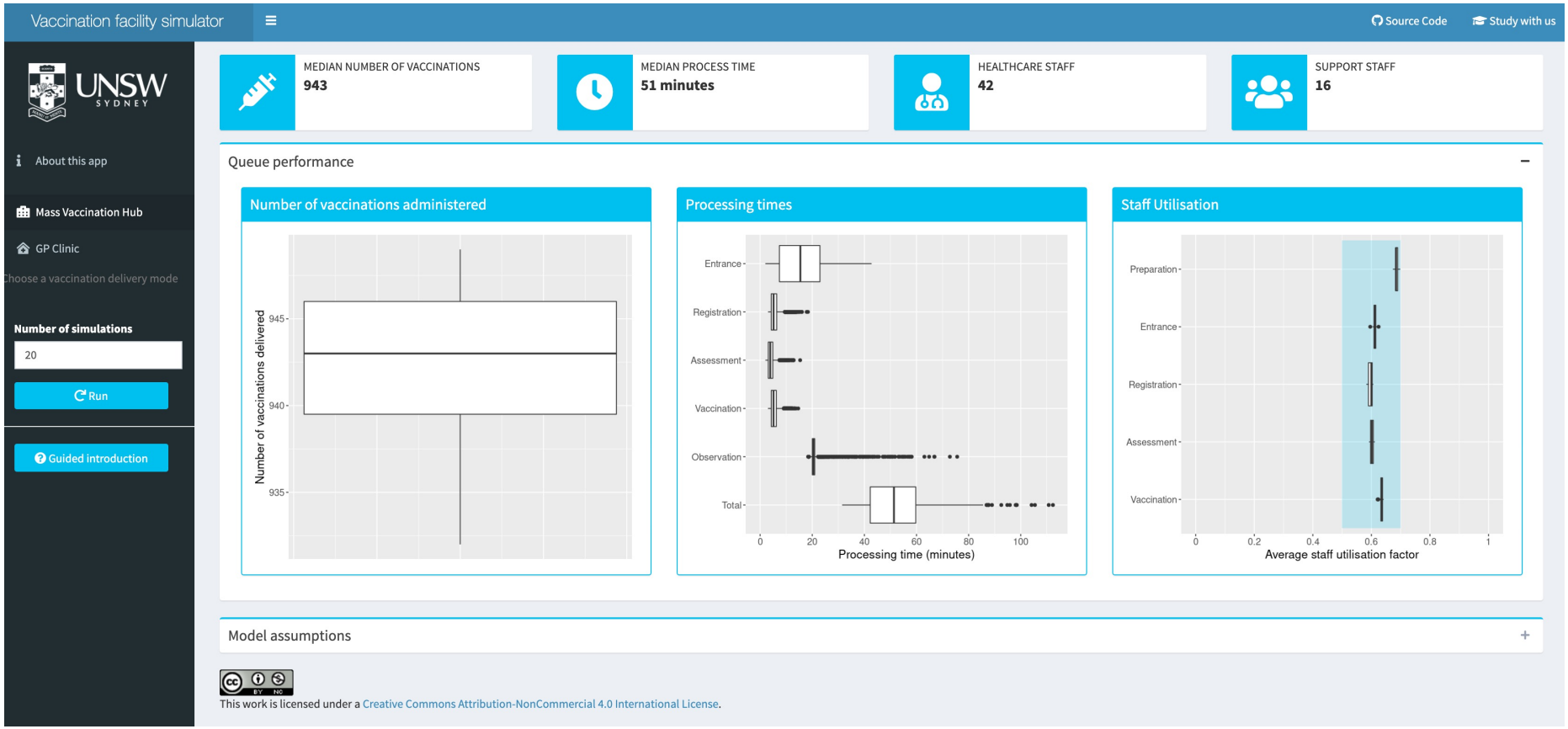
Modelling vaccination capacity

Total service time as arrivals increase



Modelling vaccination capacity

Model implemented in Shiny with a graphical user interface



cbdrh.shinyapps.io/queueSim

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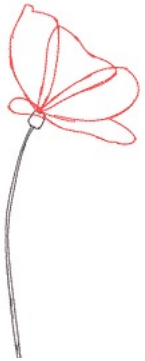
Modelling vaccination capacity

Summary of findings

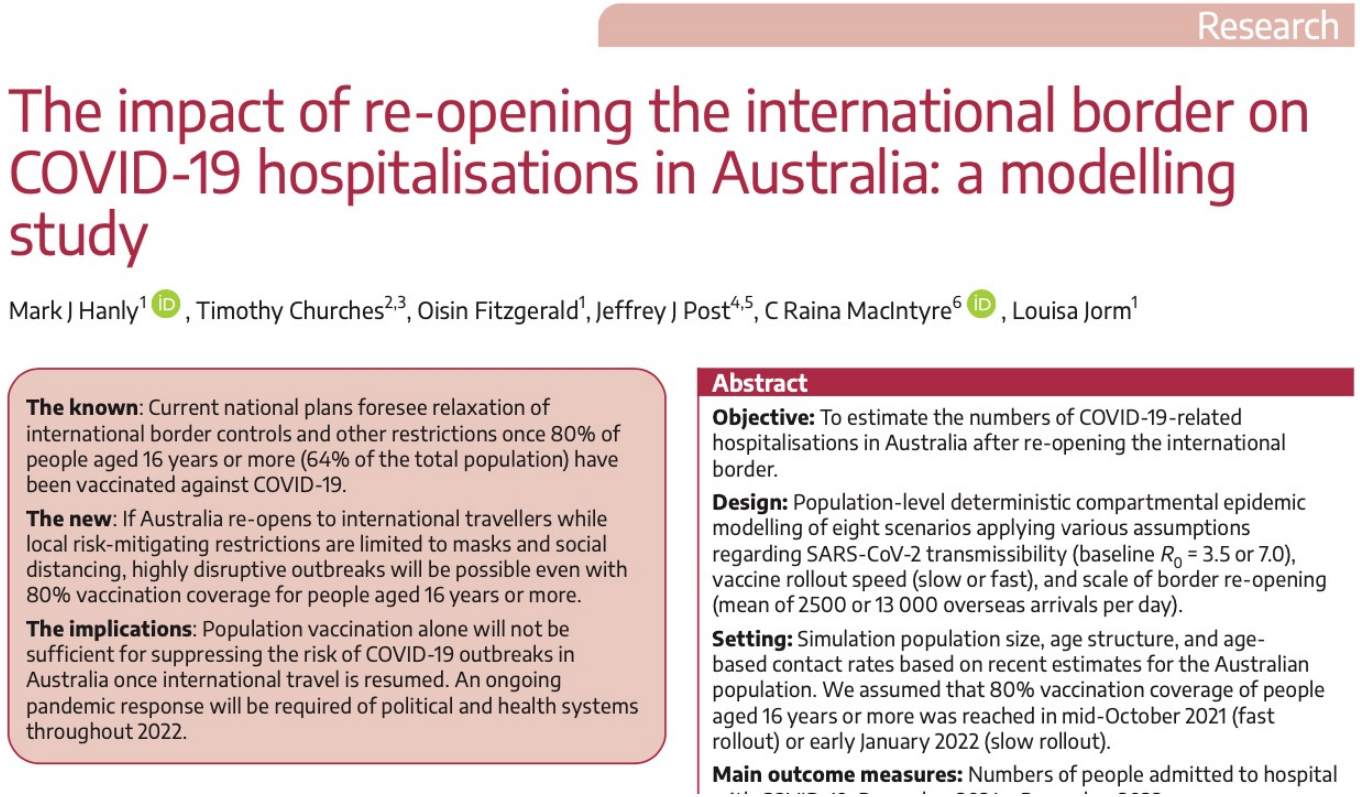
- A small GP clinic (4 staff) could administer 100 vaccinations in an 8-hour clinic
- A large hub (60-65 staff) could administer 1,400 vaccinations in an 8-hour clinic
- Vaccination capacity scales linearly with staffing capacity, keeping queue performance constant
- Large hubs and small clinics equal in terms of doses per staff member (but other economies of scale are likely)
- Larger hubs are better able to scale up performance and more robust to shocks



Artwork Alex Grigg via GIPHY

Study 3

Modelling COVID-19 hospitalisations



Research

The impact of re-opening the international border on COVID-19 hospitalisations in Australia: a modelling study

Mark J Hanly[1], Timothy Churches[2,3], Oisin Fitzgerald[1], Jeffrey J Post[4,5], C Raina MacIntyre[6], Louisa Jorm[1]

The known: Current national plans foresee relaxation of international border controls and other restrictions once 80% of people aged 16 years or more (64% of the total population) have been vaccinated against COVID-19.

The new: If Australia re-opens to international travellers while local risk-mitigating restrictions are limited to masks and social distancing, highly disruptive outbreaks will be possible even with 80% vaccination coverage for people aged 16 years or more.

The implications: Population vaccination alone will not be sufficient for suppressing the risk of COVID-19 outbreaks in Australia once international travel is resumed. An ongoing pandemic response will be required of political and health systems throughout 2022.

Abstract

Objective: To estimate the numbers of COVID-19-related hospitalisations in Australia after re-opening the international border.

Design: Population-level deterministic compartmental epidemic modelling of eight scenarios applying various assumptions regarding SARS-CoV-2 transmissibility (baseline R_0 = 3.5 or 7.0), vaccine rollout speed (slow or fast), and scale of border re-opening (mean of 2500 or 13 000 overseas arrivals per day).

Setting: Simulation population size, age structure, and age-based contact rates based on recent estimates for the Australian population. We assumed that 80% vaccination coverage of people aged 16 years or more was reached in mid-October 2021 (fast rollout) or early January 2022 (slow rollout).

Main outcome measures: Numbers of people admitted to hospital

10.5694/mja2.51291

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Modelling COVID-19 Hospitalisations

Age-structured, deterministic SEIR compartment model

Modelling COVID-19 Hospitalisations

Model parameters

Domain	Parameterisation
Population	Size | Age distribution | Daily contacts
Infection dynamics	R0 | Latent period (days) | Infectious period (days)
Interventions	Reduce daily contacts | Reduce transmission probability at each contact
Vaccination program	Available doses | Vaccine effectiveness | Vaccine hesitancy
New cases	Daily arrivals | False negative pre-flight tests | Risk of hotel quarantine escape

Modelling COVID-19 Hospitalisations

The COVOID Model

Image source: Author supplied

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Modelling COVID-19 Hospitalisations

Model scenarios

Scenario	Reproduction number (R_0)	Daily overseas arrivals from Dec 2021	Vaccine rollout	Adult vaccine coverage Dec 2021
1	3.5	2,500	Slow	71%
2	3.5	2,500	Fast	91%
3	3.5	13,000	Slow	71%
4	3.5	13,000	Fast	91%
5	7.0	2,500	Slow	71%
6	7.0	2,500	Fast	91%
7	7.0	13,000	Slow	71%
8	7.0	13,000	Fast	91%

Modelling COVID-19 Hospitalisations

Estimated numbers of COVID-19-related hospitalisations

Low R_0

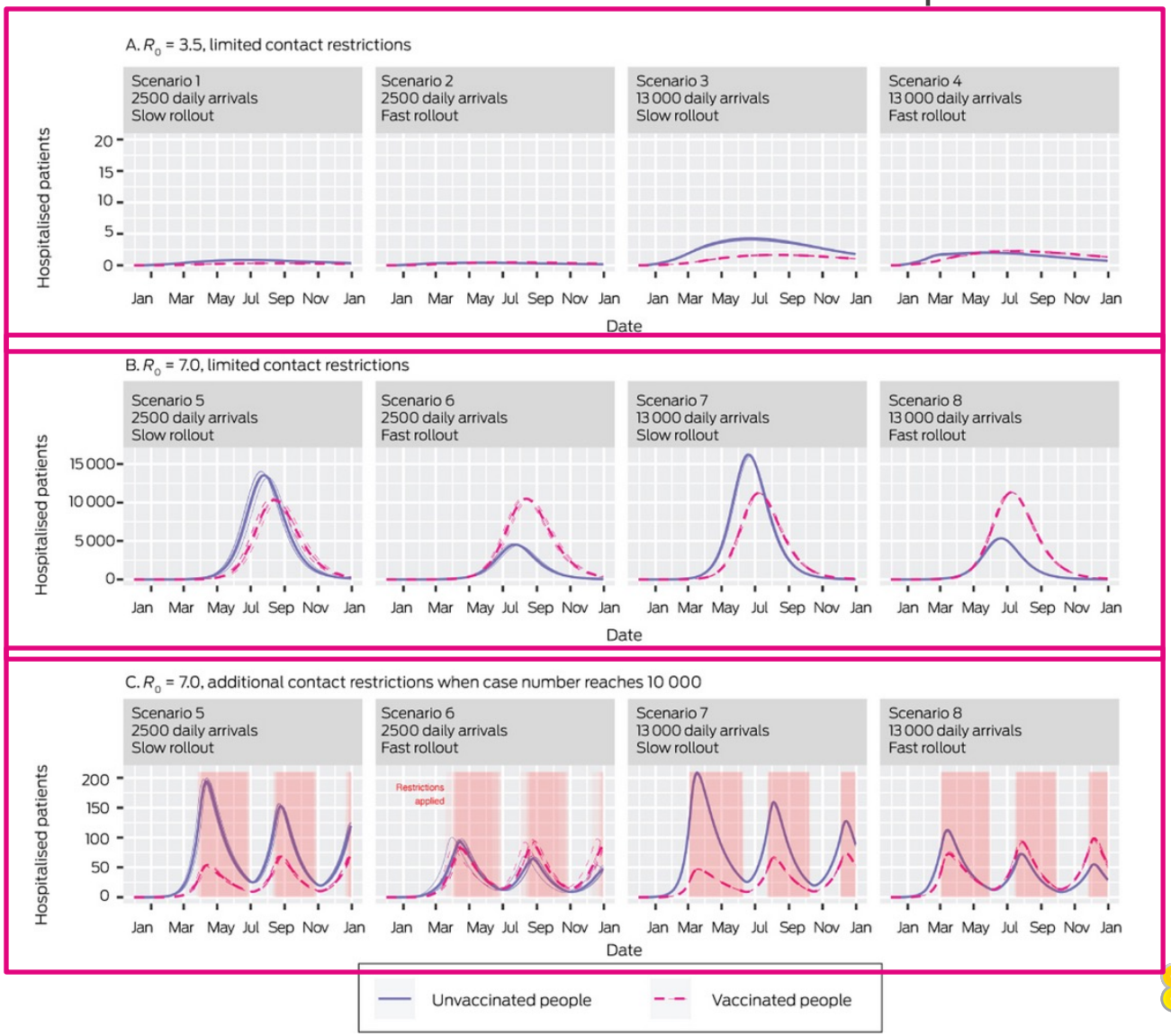
No Problems!

High R_0 and limited restrictions

Big Problems!

High R_0 with additional restrictions

Under control!



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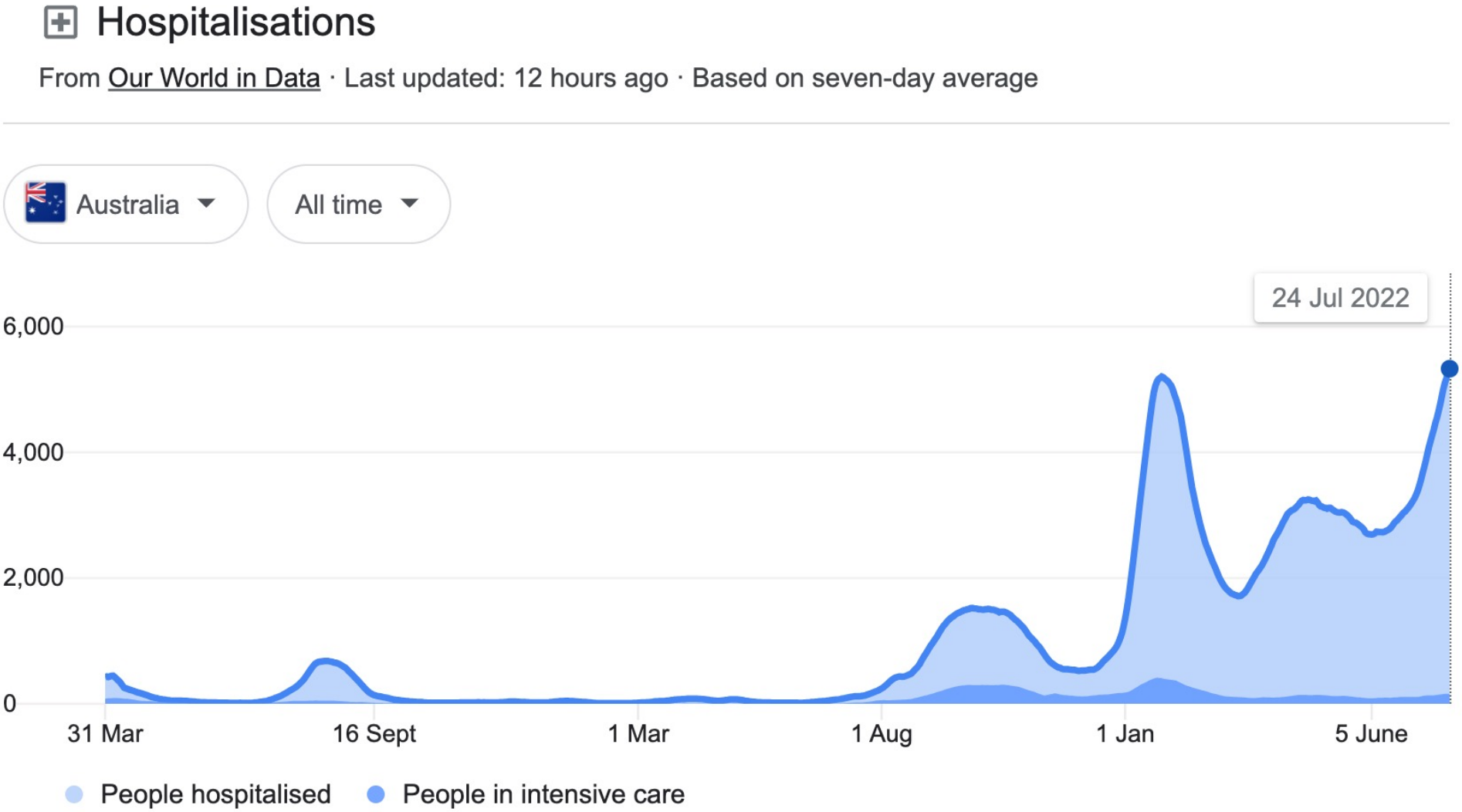
Modelling COVID-19 Hospitalisations

> The Australian health system will remain at risk of disruptive outbreaks beyond these dates if only minimal social and mobility restrictions are retained

> Mass vaccination is unlikely to achieve complete protection against COVID-19 and health system capacity will still be at risk in the most realistic vaccination coverage scenarios

Modelling COVID-19 Hospitalisations



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Modelling COVID-19 Hospitalisations

Health

Covid hospitalisations in Australia hit new record, surpassing January peak

Experts say lower ICU figures partly due to aged care deaths, while AMA vice president labels number of Covid patients 'massive'

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- **Get our free news app, morning email briefing and daily news podcast**

Josh Nicholas *and* Cait Kelly

Tue 26 Jul 2022 03.30 AEST

> "The bottom line is on the ground, my colleagues are angry, desperate, **fatigued** and they have a terrible situation where there are **not enough beds or nurses**.
>
> *- Dr Chris Moy, VP of the AMA*

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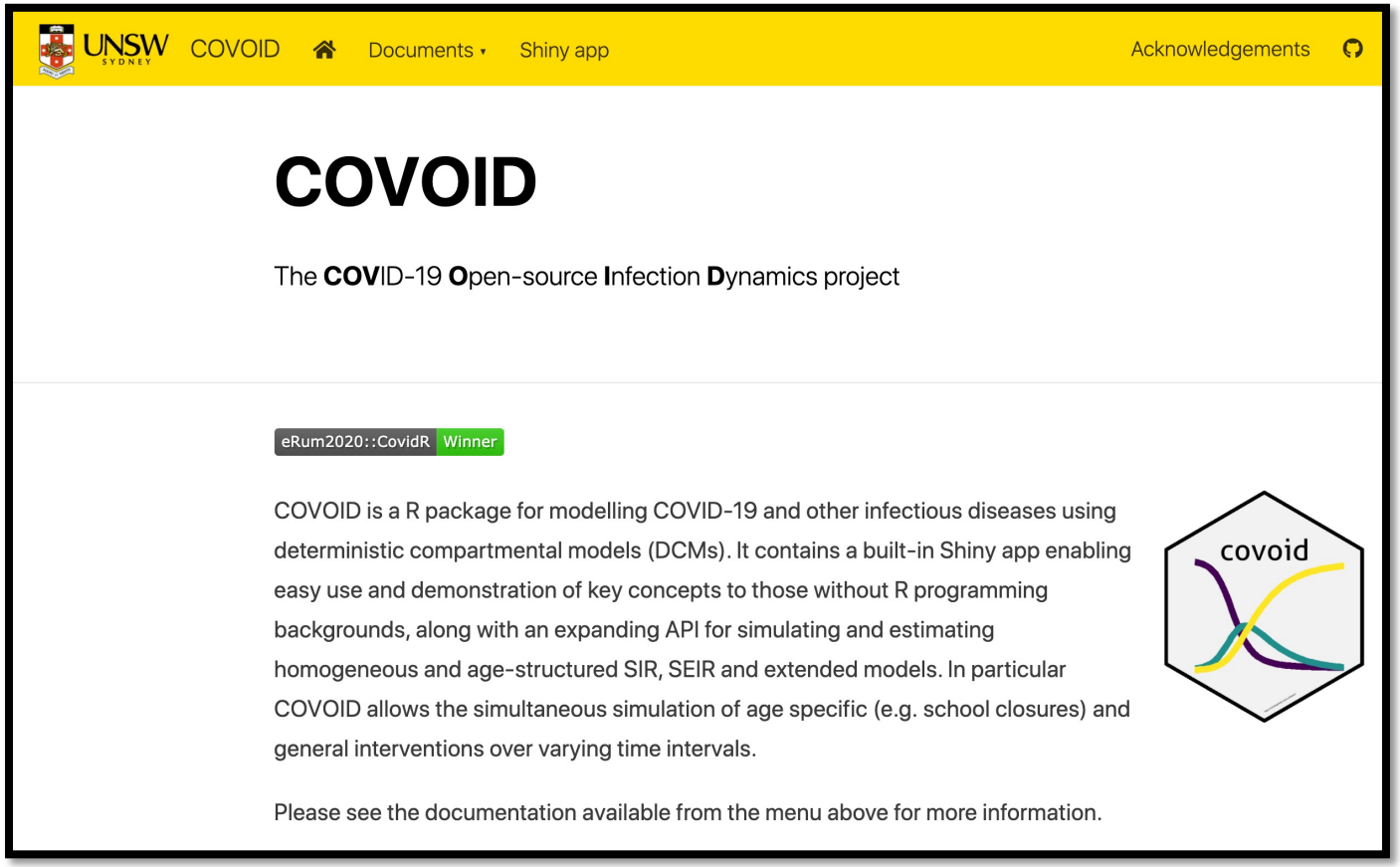
Modelling COVID-19 Hospitalisations

COVOID R Package



cbdrh.github.io/covoidance

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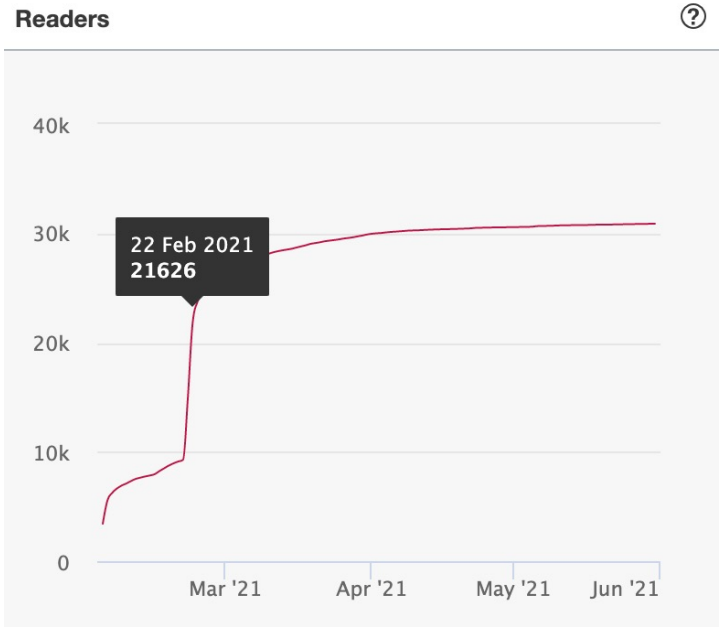
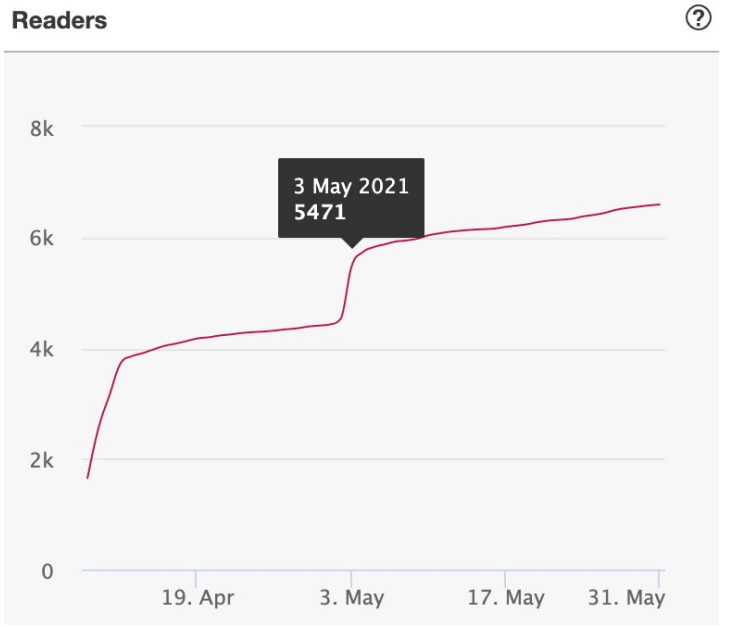
Publishing in The Conversation





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Ian Sharp, **philanthropic supporter** of UNSW research

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Thank you for listening!

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