
VACCINATING AUSTRALIA: HOW LONG WILL IT TAKE?

A PREPRINT

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Abstract

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1 Introduction

The development and regulatory approval of multiple safe and efficacious COVID-19 vaccines in less than a year is a truly remarkable achievement. The logistical task of administering the vaccine rapidly and fairly to billions of people around the world will be no less of a challenge. National vaccination programs have commenced in many countries including Israel, the United States and the United Kingdom. Here in Australia, the government has entered into four agreements for the supply of COVID-19 vaccines (Table 1), with a view to starting distribution in late February, and an ambitious target to finish vaccinating the adult community in October.¹ This gives around 35 weeks to administer two doses each to some 20 million adult Australians.

Table 1: Australia’s vaccine agreements

Name	Type	Doses (millions)	Schedule	Status
Pfizer/BioNTech	mRNA vaccine	10	2 doses 21 days apart	Provisionally approved by the TGA
University of Oxford AstraZeneca	Viral vector vaccine	54	2 doses 28 days apart	Phase 3 clinical trials
Novavax	Protein vaccine	51	2 doses 21 days apart	Phase 3 clinical trials
COVAX Facility	Assorted	25	Assorted	9 candidate vaccines in various clinical trial stages

Adapted from <https://www.health.gov.au/initiatives-and-programs/covid-19-vaccines/about-covid-19-vaccines/australias-vaccine-agreements>

The national roll-out strategy divides the population into 16 groups, organised into five distinct phases (Table 2). Hospital hubs with access to cold chain storage facilities will administer the Pfizer/BioNTech vaccine to the highest priority groups scheduled in Phase 1a, which includes border workers, frontline healthcare staff, and aged care staff and residents. Pending approval, the Astra Zeneca vaccine would be administered to the bulk of the population through a network of GPs and pharmacies. The Prime Minister Scott Morrison has quoted a target of 80,000 vaccinations per day,² however a back of the envelope calculation would suggest that at this rate it would take some 500 days to vaccinate 20 million adult Australians twice, placing the finish line somewhere around the middle of 2022. To reach the October target would take closer to 160,000 daily vaccinations.

When it comes to vaccine roll-out, speed is of the essence. Statistical modelling has illustrated that epidemic duration, cases and deaths are minimised dramatically as the number of available daily vaccinations increases. For example, increasing the daily capacity by 25% from 75,000 to 100,000 would see a 60% reduction in total cases and deaths.³

An added complication is that the Pfizer/BioNTech and AstraZeneca vaccines both require two doses—a primer and a booster—which need to be delivered within a specified time frame after the initial shot. This complicates roll-out as the daily resources of both vaccine units and healthcare staff must be divided between those waiting for their first jab and those returning for their booster.

Table 2: Australia’s COVID-19 vaccine national roll-out strategy

Phase	Description	Size
1a	Quarantine & border workers	70,000
1a	Frontline health care workers	100,000
1a	Aged care and disability care staff	318,000
1a	Aged care and disability care residents	190,000
1b	Elderly adults aged 80 years and over	1,045,000
1b	Elderly adults aged 70-79 years	1,858,000
1b	Other health care workers	953,000
1b	Aboriginal and Torres Strait Islander people aged 55 years and over	87,000
1b	Younger adults with an underlying medical condition	2,000,000
1b	Critical and high risk workers	196,000
2a	Adults aged 60-69	2,650,000
2a	Adults aged 50-59	3,080,000
2a	Aboriginal and Torres Strait Islander people aged 18-54	387,000
2a	Other critical and high risk workers	453,000
2b	Balance of adult population	6,643,000
3	<18 if recommended	5,670,000

Adapted from <https://www.health.gov.au/sites/default/files/documents/2021/01/australia-s-covid-19-vaccine-national-roll-out-strategy.pdf>

Another unknown is the question of vaccine hesitancy, which refers to the delay in acceptance or refusal to take a vaccine despite one being available.⁴ Clearly, high levels of vaccine hesitancy would have the potential to undermine efforts to vaccinate the population. An online survey of over 3,000 Australian adults undertaken in August 2020 asked respondents if they would take a safe and effective vaccine for COVID-19, if one was developed. The population-weighted responses were 5.5% “definitely not”, 7.2% “probably not”, 28.7% “probably” and 58.5% “definitely”.⁵ This suggests relatively low levels of vaccine hesitancy, however this could still be problematic. At the time of writing it seems likely that the bulk of the Australian population will receive the Astra Zeneca vaccine, which has recorded an average efficacy of 70% across clinical trial arms.⁶ At this level, it would be necessary to immunise 86% of the entire population to achieve herd immunity.³

The aim of this analysis is to estimate how long it will take to distribute the two-dose COVID-19 vaccine schedule to the Australian population. We consider a variety of scenarios based on the daily vaccine capacity, the time frame between the first and second dose and the scale of vaccine hesitancy in the population. We conclude by comparing daily vaccination rates from countries where vaccination programs are already underway.

2 Methods

2.1 Population and priority groups

Our analysis was based on the 16 priority groups and five phases proposed by the Australian government (see Table 2). The implied population size is 25.7 million people, including 5.67 million children and adolescents under the age of 18. We assumed that equal priority was given to all groups within the same phase.

2.2 Vaccine roll out projections

Roll out projections were based on four parameters:

1. The daily vaccination capacity.
2. The minimum number of days between the first dose and the second dose.
3. The maximum number of days between the first dose and the second dose.
4. Vaccine hesitancy

2.3 Projection scenarios

Projection scenarios were based on a 2^k factorial design defined by three factors with two levels each. The scenarios are summarised in Table 3 and the three factors and levels are detailed below:

- Daily vaccination capacity (80,000 versus 170,000)
- Timing between first and second dose (3-6 weeks versus 3-12 weeks)
- Vaccine hesitancy (7% versus 13%).

Table 3: Projection scenarios

Scenario	Capacity (units per day)	Gap between doses	Hesitancy
1	80,000	3 to 6 weeks	7%
2	80,000	3 to 6 weeks	13%
3	80,000	3 to 12 weeks	7%
4	80,000	3 to 12 weeks	13%
5	170,000	3 to 6 weeks	7%
6	170,000	3 to 6 weeks	13%
7	170,000	3 to 12 weeks	7%
8	170,000	3 to 12 weeks	13%

The projections assumed that those who were hesitant would never receive the vaccine. The range of hesitancy rates were based on the survey data reported by Edwards et al,⁵ and only applied to general population groups. Border staff, healthcare and aged care workers, aged care residents and adults with a medical condition were assumed to have 0% vaccine hesitancy.

2.4 Vaccine allocation

We allocated the daily available vaccination doses according to the following algorithm:

1. Calculate the number of second doses due, based on the specified permissible range for the second dose. As an example, if the second dose is specified to be administered between 3 and 6 weeks, then the booster shots for people vaccinated on day 1 would be evenly distributed across the three weeks between day 22 and day 42).
2. Assign the remaining doses from the daily limit to those awaiting their first dose.
3. Identify the highest priority phase that haven't received all first doses.
4. Divide the available first doses between the subgroups in the highest priority phase, proportional to the number of unvaccinated individuals remaining in each subgroup.
5. Stop when all population members, minus those who are hesitant, have been vaccinated twice.

2.5 Software and code

The analysis was performed using R version 4.0.3. The source code can be accessed at <https://github.com/CBDRH/vaccinatingAustralia>.

3 Results

Results from the eight scenarios are presented in Table 3. Scenarios that assumed a vaccine hesitancy of 7% among the general population resulted in 48.3 million vaccine doses administered to 24.2 million people, corresponding to a population coverage of 94.0%. Scenarios that assumed the vaccine higher hesitancy rate of 13% resulted in 45.7 million vaccine doses administered to 22.9 million people for a coverage of 88.9%.

Under an most optimistic Scenario of 200,000 daily doses with the 7% hesitancy rate (Scenario 5), assuming a start date of 1 March, Phase 1a would be fully vaccinated (i.e. primer and booster doses administered) as early as 13 April—just six weeks. The entire adult population would be fully vaccinated by 25 October—in

line with government targets—and a further eight weeks would see the entire population include those under 18 vaccinated. Under this optimistic scenario, the vulnerable groups in Phase 2a, including adults aged 70 and above and those with underlying medical conditions, would be fully vaccinated before the onset of the colder winter months. Under this scenario, we would reach 50% population coverage in late July and 75% population Around the start of October (Figure 1A).

Table 4: Summary of vaccine roll-out projections for different scenarios

Scenario	Number of vacci- nations (millions)	Individuals vacci- nated (millions)	Population coverage (%)	Phase 1a complete	Phase 1b complete	Phase 2a complete	Phase 2b complete	Phase 3 complete
1	48.3	24.2	94.0	18/04/21	04/09/21	08/02/22	11/07/22	20/11/22
2	45.7	22.9	88.9	18/04/21	01/09/21	22/01/22	18/06/22	19/10/22
3	48.3	24.2	94.0	30/05/21	09/10/21	10/03/22	13/08/22	23/12/22
4	45.7	22.9	88.9	30/05/21	05/10/21	23/02/22	19/07/22	20/11/22
5	48.3	24.2	94.0	13/04/21	15/06/21	19/08/21	25/10/21	22/12/21
6	45.7	22.9	88.9	13/04/21	05/06/21	20/07/21	17/09/21	07/11/21
7	48.3	24.2	94.0	25/05/21	26/06/21	07/09/21	30/10/21	27/12/21
8	45.7	22.9	88.9	25/05/21	25/06/21	01/09/21	21/10/21	13/12/21

Under the less optimistic scenarios of 80,000 doses administered daily, it would take until June to August 2022 to vaccinate the adult population (Table 3). Under Scenario 1, we would reach 50% population coverage in January 2022 and 75% population coverage in July 2022 (Figure 1B).

4 Discussion

To meet the target of vaccinating all amenable adult Australians by the end of October 2021 there will need to be in the order of 200,000 doses delivered daily on average—a truly furious pace.

To put bounds on the feasibility of this target, a potentially illuminating exercise is to compare to the vaccination rates achieved by other countries who have already begun to roll out their vaccination programs (Figure 2). The stand out leader is Israel, where between 7,000 and 20,000 vaccinations per million population have been delivered daily through out January. Several factors have contributed to this success, including a young, centralised population and a strong public health infrastructure. Perhaps most important has been strong logistical planning, including coordination of delivery, cold-chain storage and staffing.⁷ Other countries have been less successful in their roll-out, including the United States (4,000 per million pop), the United Kingdom (5,000 per million pop) and the European Union (1,100 per million pop).

With a population of 25.7 million in Australia, the figure of 200,000 doses per day from our projections corresponds to around 7,800 daily doses per million population. It will be possible to vaccinate the Australian population in just eight months but we will need to do considerably better than the rates currently being achieved in most countries. Completing vaccination roll-out this year is possible, but it will require dedicated large-scale vaccination sites that are capable of delivering thousands of doses a day as well as the enthusiastic participation of GP practices and community pharmacies around the country. We need to start now, get up to speed quickly and maintain that pace. The recent invitation extended to community pharmacies to participate in the vaccination roll-out is a welcome development. There are some 5,800 community pharmacies across Australia; if each could vaccinate 20 community members a day that would represent half of the target of 200,000 daily doses to cross the finish line for community vaccination by the end of October.

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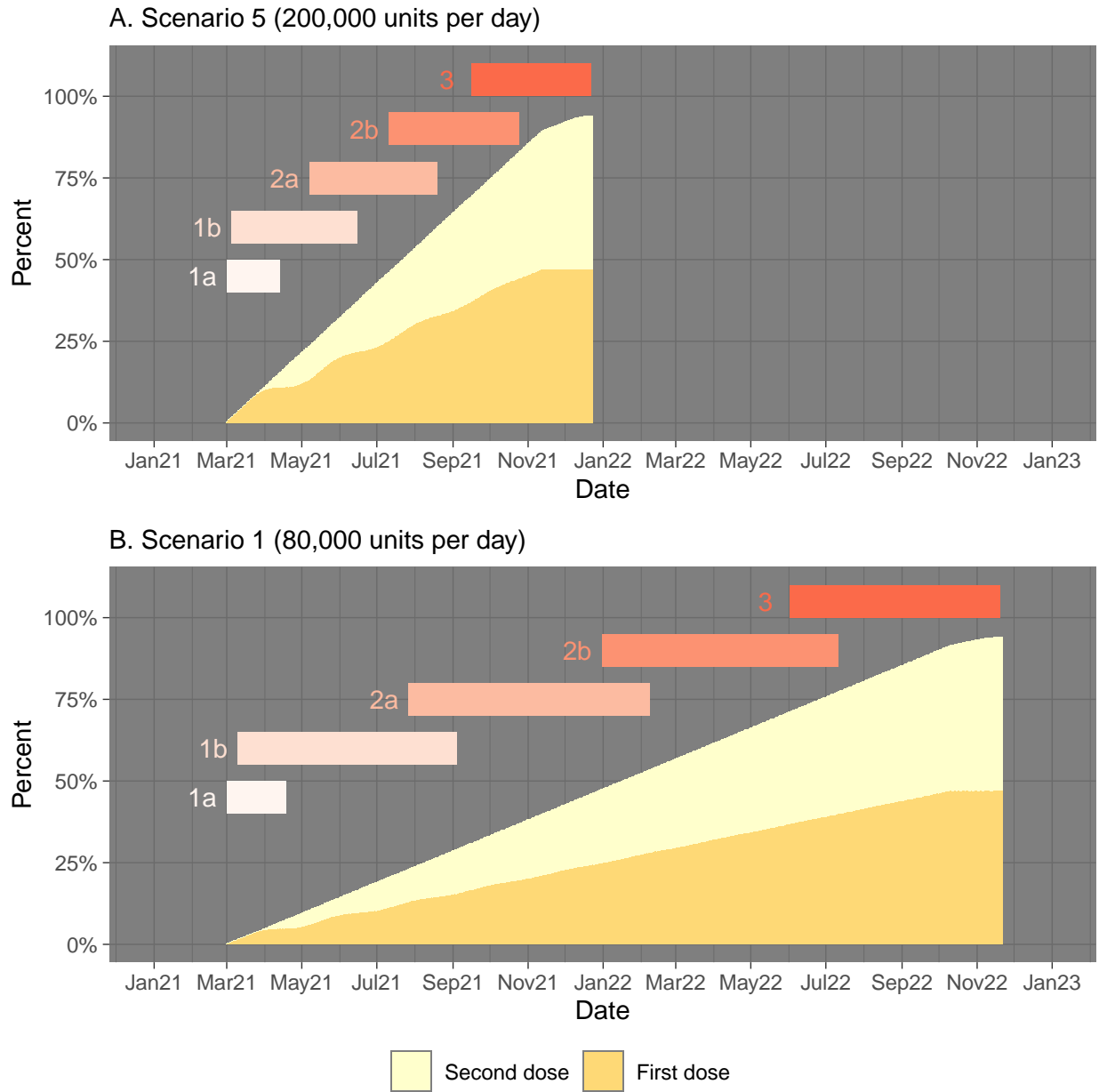


Figure 1: Cumulative vaccine doses over time

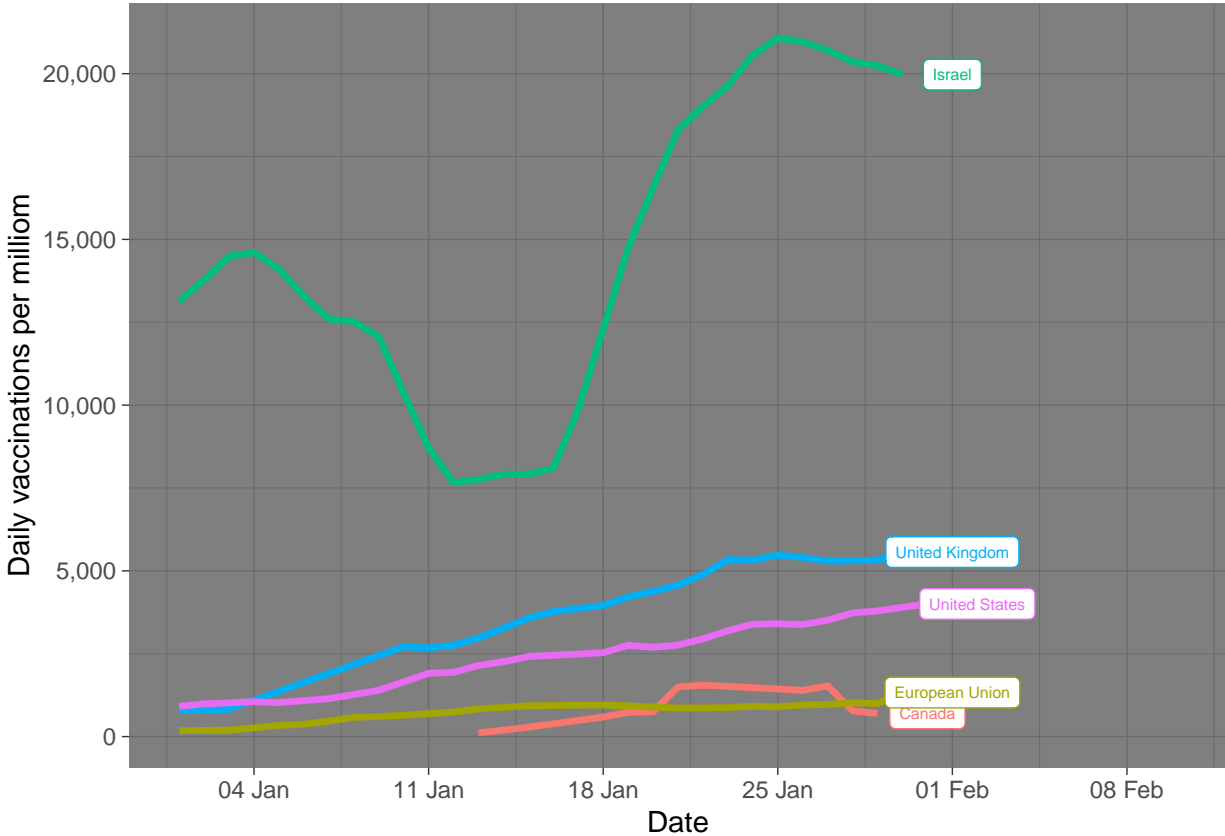


Figure 2: Daily COVID-19 vaccines administered per one million population

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