Draft Report 2: Work Package 2, First Nations, Remote Communities
with 1 attachment (Technical Appendix)

Summary

This report uses an agent based infectious disease model to consider protective factors that can reduce the risk of COVID-19 outbreaks in remote Aboriginal and Torres Strait Islander (hereafter respectfully referred to as Indigenous) communities and defines the most effective response strategies in the event of incursions, including reactive immunisation. The model captures key features of age structure, household composition and social connections in remote Indigenous communities of different sizes.

Key questions

What coverage targets are appropriate for populations at higher risk of transmission and disease impacts? What is the role of reactive vaccination in response should outbreaks occur in such localised groups and settings in the context of suboptimal coverage? What additional public health response measures will be most useful to regain control of transmission should outbreaks occur?

Key findings

- High levels of pre-emptive vaccine coverage can substantially reduce COVID-19 transmission and health impacts in remote Indigenous communities.
- Of the strategies recommended in the current remote outbreak response guidelines, a policy that assumes relocation of contacts of cases to a hospital or safe location outside the community for the duration of quarantine is associated with improved outbreak control and lower disease burden.
- Reactive vaccination is a useful adjunct to community engaged and led outbreak response, and can reduce health impacts, particularly in larger communities with low initial vaccine coverage.
- Providing access to effective treatments will further promote health outcomes, particularly where clinical access is limited.

Background

Aboriginal and Torres Strait Islander Australians living in remote communities are anticipated to experience higher than average transmission rates of COVID-19 because of a younger population demographic and household sizes three times larger than the national average. Vaccination of the population aged 12 years and above has less effect on transmission when children under 12 make up a larger proportion of the total population and live in larger households. Both factors increase their contribution to transmission despite lower susceptibility and infectiousness than adults.

Our remote communities model reports outbreak trajectories following silent introduction of infection in the context of different levels of prior vaccine coverage and given different response measures including reactive vaccination. Modelled infections are translated into anticipated clinical outcomes using the clinical pathways model employed in our earlier phase work, with updated assumptions.

Given the high prevalence of underlying health risk determinants in remote Indigenous communities the likelihood of severe health outcomes by age commences from the age of 20 years and in each cohort thereafter maps to the non-Indigenous population 10 years older. This starting assumption has been approved by the Aboriginal and Torres Strait Islander Advisory group and benchmarked as reasonable against available data from NSW which demonstrates a higher prevalence of severe outcomes for Indigenous Australians.

Model

We consider the outcome of silent introduction of an infection into exemplar communities of different sizes, and with different achieved vaccine coverages, under

- **Contain and trace strategies with pre-emptive vaccination** (Table 1), with achieved two dose vaccine threshold targets of 50, 70, and 80% for ages 12 +
- **Contain and trace strategies with reactive vaccination for ages 12+** (Table 2) in three exemplar under vaccinated communities, given differential one and two dose vaccine effectiveness and time to completion of the vaccine course, and under different age-dependent achieved vaccine coverages (Table 3).

The transmission model (Figure 1) assumes transmission and vaccine effectiveness parameters for the Delta variant, consistent with those employed for other projects in this phase of work to support the National Plan. Community contact rates have been estimated for remote communities based on available Australian data.

Clinical outcomes were estimated using the clinical pathways model described in Ref. [2] assuming severity and vaccine efficacy parameters for the Delta variant, inclusion of age-stratified length of stay in clinical states and adapted to estimates of severity for Aboriginal and Torres Strait Islander Australians (Figure 2, section A.1.2, Technical Appendix). Specifically,

- the probabilities associated with severe outcomes are assumed to be the same for people <20 years old compared to the general Australian population.
- for people over 20 years old, the **probabilities associated with severe outcomes are shifted by 10 years** (and 20 years for the sensitivity analysis described in Technical appendix, sections A.3.3 and A.3.5)**;** for example, a symptomatic 30-year-old First Nations Australian will be hospitalised at the rate of a symptomatic 40-year-old person from the general population.
- At any point where the probability of a severe outcome decreased by age in the general population, the severity was assumed to remain constant (the biggest difference here is the probability of being admitted to ICU given hospitalisation in the oldest age groups).
- The age-stratified length of stay in clinical states are also assumed to shift by 10 years (or 20 years for the sensitivity analysis) to coincide with the changes in severe outcomes.
- For the reactive vaccination scenarios, we assume that there is a 14-day delay in gaining protection against severe outcomes after the first dose of a vaccine, and a 5-day delay in gaining the additional protection against severe outcomes from a second vaccine dose.

The clinical pathways model takes inputs of daily symptomatic individuals, stratified by age and vaccination status, from the transmission model, and translates these into a time course of clinical outcomes. There is a delay between the onset of symptoms and presentation to health services. Upon arrival to health services individuals are either admitted to ward immediately, admitted to ICU immediately, or if health services are at capacity, individuals are not admitted and may re-present the next day. We assume that only symptomatic cases requiring hospitalisation present to health services. Individuals who are initially admitted to the ward may have a subsequent ICU stay and vice versa.

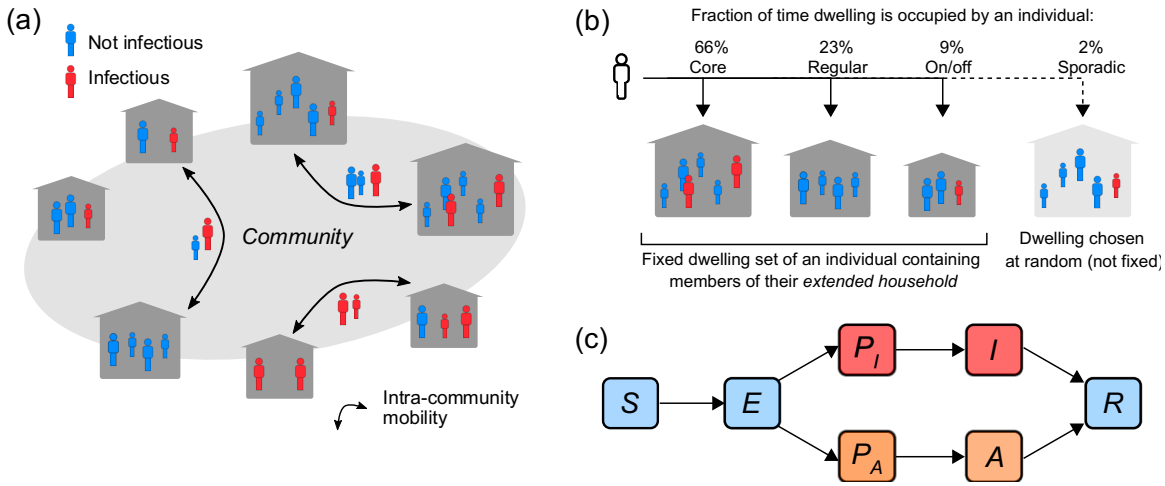

Figure 1. Schematic diagram of the model of (a) community structure, (b) intra-community mobility and (c) disease progression between the Susceptible (S), Exposed (E), Pre-symptomatic Infectious (PI), Symptomatic Infectious (I), Asymptomatic Infectious compartment 2 (A), and Recovered (R) states.

The transmission model is an individual-based model (adapted from Ref. [1], to COVID-19) that explicitly represents each individual in a remote community (Figure 1a), and the impact of pre-emptive vaccination and various public health response strategies on an outbreak. It follows a susceptible, exposed, pre-symptomatic infectious, symptomatic infectious, asymptomatic infectious, recovered paradigm (Figure 1c).

Individuals are assumed to have close family connections across a total of three dwellings in the community, between which their time is distributed as follows: main dwelling (core) 66% of the time, second dwelling (regular) 23% of the time, and third dwelling (on/off) 9% of the time. Their remaining time (i.e., 2%) is spent at a dwelling randomly allocated at the start of each day (Figure 1b). Individuals with the same home dwelling location on a given day are grouped into current households, which we refer to as an individual's *current household*. Individuals who are associated with a dwelling as either a core, regular, or on/off residence are grouped into *extended households*.

Contacts between individuals (that are necessary for transmission of infection) are explicitly modelled and can occur between current household members (household contacts) and among individuals who are not in the same current household (community contacts). Infection is assumed to generally transmit more easily between household contacts (the relative risk of transmission between household contacts compared to community contacts is generally assumed to be greater than one).

An individual's probability of developing symptoms once infected is assumed to depend on age and on vaccination status (number of doses received and vaccine type). The probability of transmission given contact with an infected individual is assumed to depend on the age and vaccination status of both the infector and infectee. Vaccine-induced protection is assumed to reduce infection rates and the chance of developing symptoms on a per-exposure basis and reduce the infectiousness of breakthrough infections. Asymptomatic infections are assumed to be 50% as infectious as symptomatic infections (with the same age and vaccination status). Further details of the model are provided in the Technical Appendix.

Table 1. COVID-19 "Contain and Test" outbreak response policies. Further details of the contain and test policies are provided in the Technical Appendix (section A.1).

Contain and Test policy	Lockdown	Case management	Contact management
CTP 1: contain and test with relocation of cases, home quarantine of contacts	Once return of first positive test, restrict all movement in and out of community for 14 days, and confine all community members to their main house and yard. Multiple rounds of testing whole community while in lockdown (on entry, and on day 12).	Re-locate to hospital or safe location (100% effective isolation) for 10 days. Clearance test on day 8.	Quarantine in main household for 14 days (contact between household members still possible). Test on entry. Clearance test on day 12.
CTP 2: contain and test with relocation of cases and contacts	As above	As above	Re-locate to hospital or safe location (100% effective quarantine) for 14 days. Test on entry. Clearance test on day 12.

Table 2. COVID-19 "Reactive Vaccination" outbreak response policy RVP1. Ages <60 are assumed to be vaccinated with Pfizer, ages 60+ with AstraZeneca. The policy is enacted with either contain and trace policy CTP1 or CTP2. Delays considered: 2, 4 days. Vaccine hesitant = 6.87% of unvaccinated population (NT data). Rate of surge vaccination based on NT estimates with lower bound estimated to be achievable with 3 door-to-door vaccinating teams (team consists of 2 vaccinators and 1 administration/liaison officer), and upper bound estimated to be achievable with 9 vaccinating teams.

Initiation of RVP1 program and scheduling of second dose

Initiated after the first case is identified, and after a delay. Only susceptible individuals are vaccinated. Older individuals are vaccinated first. Second dose scheduled for:
Pfizer: 3 weeks; AstraZeneca: 4 weeks, after first dose.

Daily rate of first dose surge vaccination

Exemplar community (Population size)		1 (220)	2 (580)	3 (1018)
Number to vaccinate	Dose 1	14	220	405
	Dose 2	42	74	204
Vaccination rate (doses per day)	L	30	40	30
	M	60	100	75
	H	100	150	120

Non-surge vaccinations

At the start of the simulation:
- all individuals with one dose are assumed to be scheduled for a second dose and so are assigned a date when they will receive second dose during simulation (time to vaccination assumed to be uniform distribution with bounds, Pfizer: 0-3 weeks, AstraZeneca: 0-4 weeks).
- all individuals who are double dosed are assumed to have reached full vaccine efficacy

Table 3. Starting vaccination coverage in exemplar communities considered in the "Reactive Vaccination" outbreak response scenarios. Characteristics of exemplar communities (size, initial vaccination coverage in age groups) were determined in consultation with the Aboriginal and Torres Strait Islander Advisory Group in COVID-19. Ages <60 are assumed to vaccinated with Pfizer, ages 60+ with AstraZeneca.

Exemplar (Population size)	Initial vaccination coverage, Dose 1					Initial vaccination coverage, Dose 2				
	12-15	16-39	40-59	60-79	80+	12-15	16-39	40-59	60-79	80+
1. (220)	35.3%	30.3%	12.2%	15%	N/A	41.2%	60.7%	83.7%	85.0%	N/A
2. (580)	20.0%	19.2%	14.7%	12.8%	0%	7.5%	21.4%	47.7%	59.0%	100%
3. (1018)	5.5%	9.3%	6.0%	3.8%	0%	5.3%	6.5%	37.7%	57.8%	0%

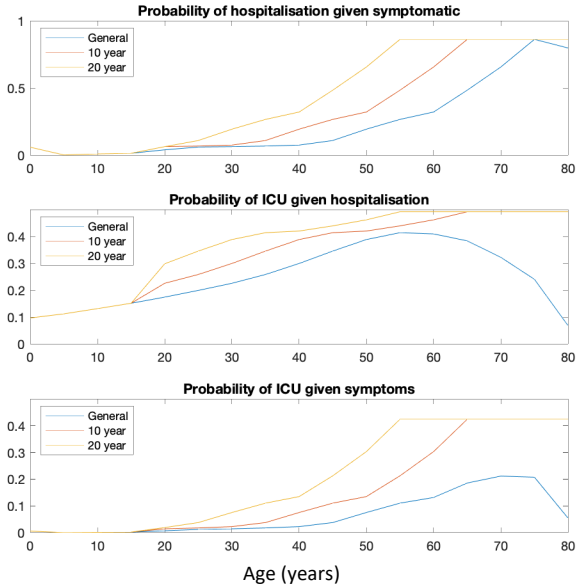

Figure 2. Estimates of severity used in the clinical pathways model for Aboriginal and Torres Strait Islander Australians (10-year age shift in severity, red; 20-year age shift in severity, yellow), compared to whole population estimates (blue). At any point where the probability of a severe outcome decreased by age in the general population, the severity was assumed to remain constant.

In all response scenarios considered, lockdown is assumed to last for 14 days only – it is not reinstated over the remainder of the outbreak, even when escalation of cases occurs so represents a 'worst case' response. Compliance with lockdown is assumed to be 90%. In all results presented in the main report, we assume a starting transmission potential of R_0=10.7 and a downward 10-year age shift in severity relative to the general population, which is consistent with available observations. Given uncertainty in R_0 for remote communities and severity of disease in Australian Aboriginal and Torres Strait Islander people relative to the general population, under the advice of the Aboriginal and Torres Strait Islander Advisory Group on COVID-19, in the Technical Appendix (section A.3) we also considered response scenarios under the assumption of R_0=5 and/or with a downward 20-year age shift in severity relative to the general population.

Results

Pre-emptive vaccination.

Figures 3 and 4 report the prevalence of all infections (with or without symptoms) over time following introduction of infection in a community of size 1000, and Table 4 reports the corresponding cumulative number of infections broken down by age and vaccination status. These results allow comparison of outbreak dynamics under Contain and Test response policies CTP1 and CTP2, and with 0% vaccine coverage and achieved two dose vaccine threshold targets of 50, 70, and 80% for ages 12+. Tables 5 to7 report corresponding clinical burdens. Note that values in these clinical burden tables are central estimates arising from approximately 100 simulations.

These results show that there is sensitivity to both the choice of contain and test response policy, and the level of achieved two-dose vaccine coverage. Higher vaccine coverage levels lead to smaller outbreaks. Contain and Test policy CTP2, where it is assumed that contacts of cases are re-located to hospital or a safe location, outperforms Contain and Test policy CTP1 for all coverage scenarios considered, where it is assumed that contacts of cases

quarantine in main home (outbreak size, size of peak and clinical burden are all smaller in comparison). This is also true in scenarios with a lower starting transmission potential of R_0=5, or when we assume a downward 20-year age shift in severity relative to the general population (Technical Appendix, sections A.3.2-A.3.3). These results provide quantitative support for implementing CTP2 where possible, and for additional wrap around support in contexts where it is only possible to implement CTP1.

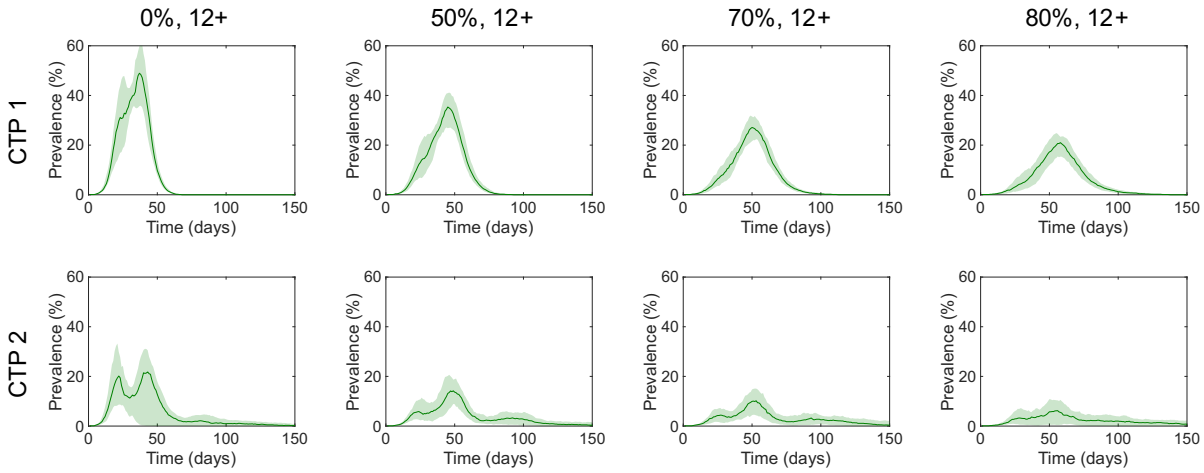

Figure 3. Prevalence of infection in whole community over time, for each response policy (top row: CTP 1; bottom row: CTP 2), and for each achieved uniform vaccination coverage level (column 1: 0%; column 2: 50%, 12+; column 3: 70%, 12+; column 4: 80%, 12+;). Solid lines: median prevalence, shaded regions: interquartile range of 100 simulations.

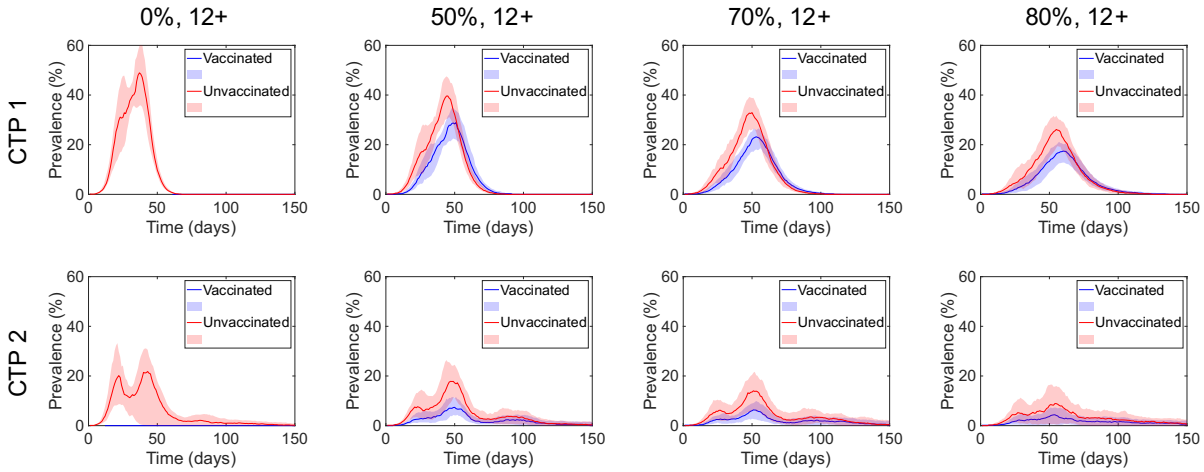

Figure 4. Prevalence of infection within the vaccinated (blue) and non-vaccinated (red) subpopulations over time, for each response policy (top row: CTP 1; bottom row: CTP 2), and for each achieved uniform vaccination coverage level (column 1: 0%; column 2: 50%, 12+; column 3: 70%, 12+; column 4: 80%, 12+;). Solid lines: median prevalence, shaded regions: interquartile range of 100 simulations.

Table 4. Total cumulative infections for a community of 1000 people, stratified by age and vaccination status. Median and interquartile range of cumulative infections are shown by age group, vaccination status, and for each response policy (CTP1, CTP2).

Achieved vaccination coverage scenario	Vaccination status of infected	Outbreak response policy									
		CTP 1					CTP 2				
		<12	12-<15	15-<40	40-<60	60+	<12	12-<15	15-<40	40-<60	60+
No coverage (12+, 0%)	Vaccinated	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
	Not vaccinated	213 (204, 221)	57 (52, 62)	432 (423, 444)	218 (208, 228)	67 (60, 71)	154 (139, 171)	47 (40, 54)	403 (385, 417)	209 (197, 220)	62 (56, 69)
Uniform coverage 1 (12+, 50%)	Vaccinated	0 (0, 0)	10 (8, 12)	159 (149, 166)	86 (81, 91)	31 (26, 34)	0 (0, 0)	5 (3, 6)	84 (67, 97)	47 (36, 53)	19 (15, 22)
	Not vaccinated	201 (190, 209)	36 (32, 41)	212 (208, 218)	110 (105, 114)	33 (30, 36)	135 (111, 151)	29 (24, 34)	191 (173, 199)	99 (88, 105)	30 (26, 33)
Uniform coverage 2 (12+, 70%)	Vaccinated	0 (0, 0)	12 (9, 14)	199 (190, 208)	109 (101, 117)	39 (34, 42)	0 (0, 0)	5 (3, 7)	111 (80, 127)	60 (48, 71)	24 (18, 30)
	Not vaccinated	184 (176, 195)	29 (25, 34)	124 (120, 128)	66 (62, 69)	20 (17, 21)	131 (104, 147)	24 (18, 28)	112 (93, 119)	59 (48, 62)	17 (14, 19)
Uniform coverage 3 (12+, 80%)	Vaccinated	0 (0, 0)	11 (7, 14)	207 (194, 220)	116 (108, 125)	41 (37, 46)	0 (0, 0)	6 (2, 8)	120 (66, 149)	68 (37, 82)	27 (11, 33)
	Not vaccinated	178 (164, 192)	25 (20, 28)	81 (77, 84)	43 (40, 45)	13 (11, 14)	132 (74, 149)	19 (11, 27)	74 (50, 79)	38 (28, 41)	12 (5, 14)

Table 5. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks for achieved two dose vaccine threshold targets of 50, 70, and 80% for ages 12+. Results presented assume response policy CTP1.

Average cumulative number	Achieved vaccination coverage scenario		
	50%, 12+	70%, 12+	80%, 12+
Symptomatic infections	203	147	112
Ward admissions	43	27	19
ICU admissions	17	10	7

The breakdown of infections by severity of clinical outcome by age and vaccine status is reported for contain and trace policies CTP1 and CTP2, for achieved two dose vaccine threshold targets of 50, 70, and 80% for ages 12+ in Tables 6 and 7, respectively. They show that more severe outcomes occur more frequently in the older age groups, and in the unvaccinated subpopulation.

Table 6. CTP1. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks stratified by age and vaccination status for achieved two dose vaccine threshold targets of 50, 70, and 80% for ages 12+. Results presented assume response policy CTP1.

Average cumulative number	Achieved coverage scenario	<15 yrs		15-39 yrs		40-59 yrs		60+ yrs	
		Vacc'd	Unvac	Vacc'd	Unvac	Vacc'd	Unvac	Vacc'd	Unvac
Symptomatic infections	50%	0	64	7	56	6	45	5	20
	70%	1	56	8	32	7	26	6	11
	80%	0	49	8	19	7	16	6	7
Ward admissions	50%	0	1	0	4	1	15	4	17
	70%	0	1	0	2	1	8	4	10
	80%	0	1	0	1	1	5	4	6
ICU admissions	50%	0	0	0	1	0	6	1	8
	70%	0	0	0	1	0	3	1	4
	80%	0	0	0	0	0	2	1	3

Table 7. CTP2. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks stratified by age and vaccination status for achieved two dose vaccine threshold targets of 50, 70, and 80% for ages 12+. Results presented assume response policy CTP2.

Average cumulative number	Achieved coverage scenario	<15 yrs		15-39 yrs		40-59 yrs		60+ yrs	
		Vacc'd	Unvac	Vacc'd	Unvac	Vacc'd	Unvac	Vacc'd	Unvac
Symptomatic infections	50%	0	39	3	46	3	36	3	16
	70%	0	36	4	25	4	21	4	8
	80%	0	31	5	15	4	12	3	5
Ward admissions	50%	0	1	0	3	0	12	3	14
	70%	0	1	0	2	0	7	3	7
	80%	0	1	0	1	0	4	2	5
ICU admissions	50%	0	0	0	1	0	5	1	6
	70%	0	0	0	1	0	3	1	3
	80%	0	0	0	0	0	1	1	2

Reactive vaccination.

Working closely with the Aboriginal and Torres Strait Islander Advisory Group on COVID-19, we have defined case studies of communities of differing size and current vaccine coverage (Exemplar communities 1-3, Table 2) to consider how reactive vaccine strategies might be used as an adjunct to currently recommended outbreak response measures. We consider how vaccines rolled out at different rates might augment the public health response in these communities. Rates of achievable delivery are based on advice from the Northern Territory, assuming different numbers of teams deployed for implementation. High acceptance is assumed (6.57% hesitancy in the uninfected and unvaccinated).

Vaccination programs continue until all eligible (ages 12+), non-infected, and non-vaccine hesitant people are vaccinated (see Figure 5 for vaccination coverage over time).

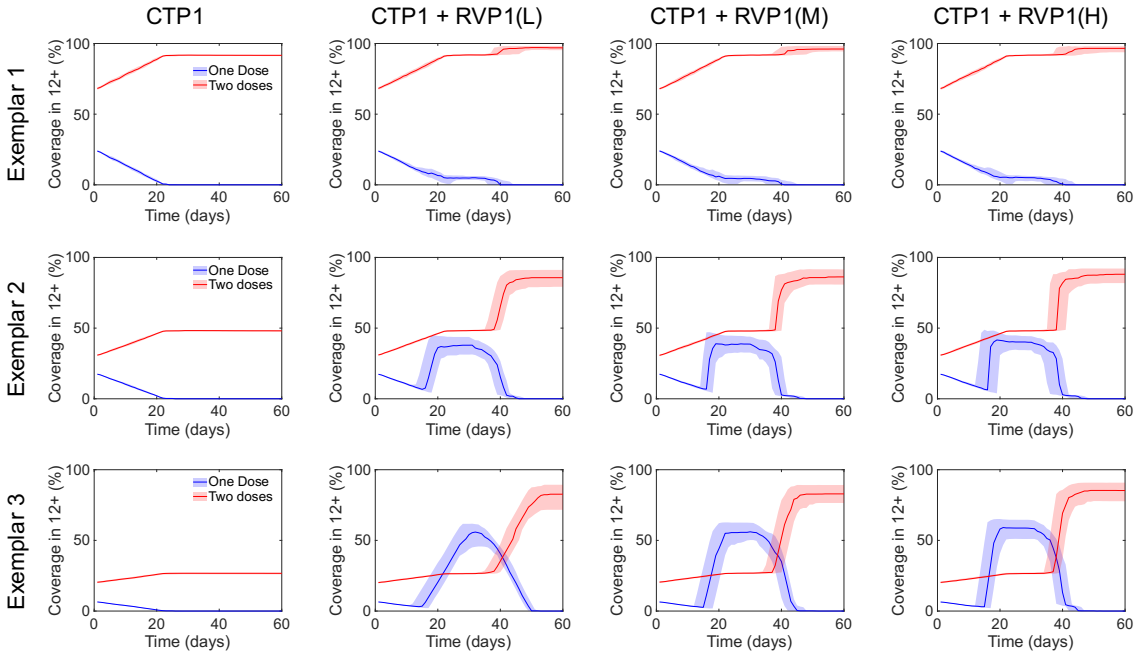

Figure 5. Vaccination coverage in 12+ over time (blue, 1 dose coverage; red, 2 dose coverage) in exemplar communities (top row: community 1, middle row: community 2, bottom row: community 3) for response policies (column 1) CTP1; (column 2) CTP1+RVP1 (low rate); (column 3) CTP1+RVP1 (medium rate); (column 4) CTP1+RVP1 (high rate). Solid lines: median prevalence, shaded regions: interquartile range of 100 simulations.

Figures 6-8 report the prevalence of all infections (with or without symptoms) over time following introduction of infection into the exemplar communities when reactive vaccination policy RVP1 is used in conjunction with Contain and Trace Policy CTP1. Tables 8-10 report the corresponding cumulative number of infections broken down by age and vaccination status. These results allow comparison of outbreak dynamics under increasing rates of reactive vaccination. Tables 11-14 report corresponding clinical burdens.

The greatest benefit of the reactive vaccination program occurs in Exemplar community 3 which has the lowest vaccine coverage before the outbreak (Figure 8). This community has just over 1,000 people and low baseline vaccine coverage. In Exemplar community 3, reactive vaccination reduces ward and ICU admissions by 47% (Table 13) because vaccine protection against severe outcomes kicks in faster than effects against any infection (5 days vs 2 weeks for second dose), even following a single dose (14 days, vs 3 weeks). In this example, lockdown measures are only maintained for 14 days, but if it were possible to extend beyond this duration to slow down spread, greater vaccine benefits might be observed. It is reassuring to note that benefits of immunization are not diminished with the slower pace of rollout in this example (Tables 14, 15), noting reasonably high baseline coverage in the 50+ years at the beginning of the outbreak.

These findings also apply to scenarios with a lower starting transmission potential of R_0=5, or when we assume a downward 20-year age shift in severity relative to the general population (Technical Appendix, sections A.3.4-A.3.5).

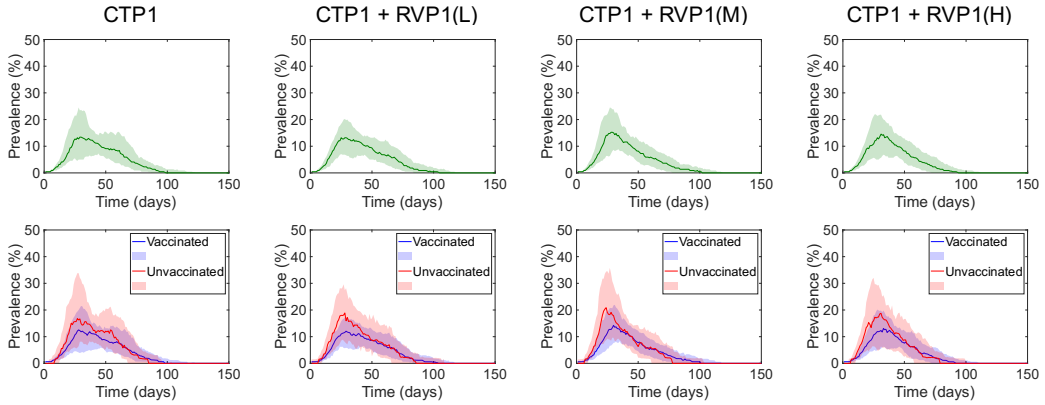

Figure 6. Prevalence of infection in Exemplar community 1 (N = 220, high coverage) within (top row) the whole population; (bottom row) the vaccinated (blue) and non-vaccinated (red) subpopulations, over time, for response policies (column 1) CTP1; (column 2) CTP1+RVP1 (low rate); (column 3) CTP1+RVP1 (medium rate); (column 4) CTP1+RVP1 (high rate). Solid lines: median prevalence, shaded regions: interquartile range of 100 simulations.

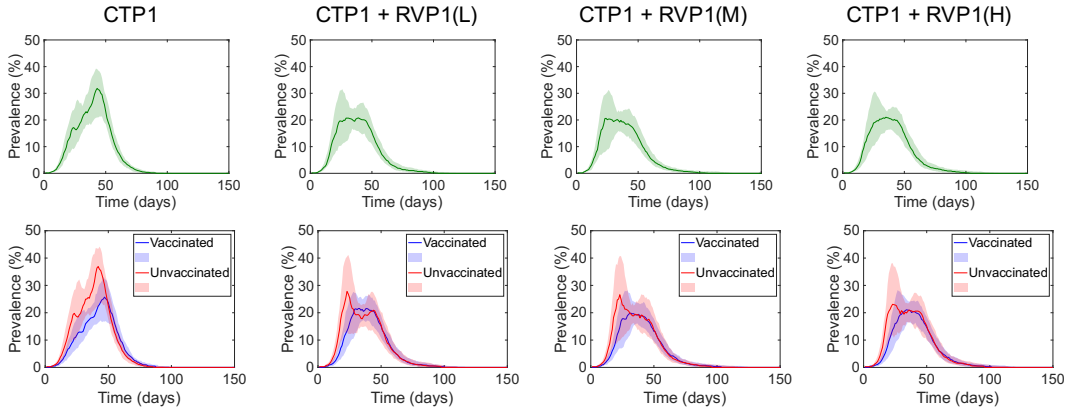

Figure 7. Prevalence of infection in Exemplar community 2 (N = 580, medium coverage) within (top row) the whole community; (bottom row) the vaccinated (blue) and non-vaccinated (red) subpopulations, for response policies (column 1) CTP1; (column 2) CTP1+RVP1 (low rate); (column 3) CTP1+RVP1 (medium rate); (column 4) CTP1+RVP1 (high rate). Solid lines: median prevalence, shaded regions: interquartile range of 100 simulations.

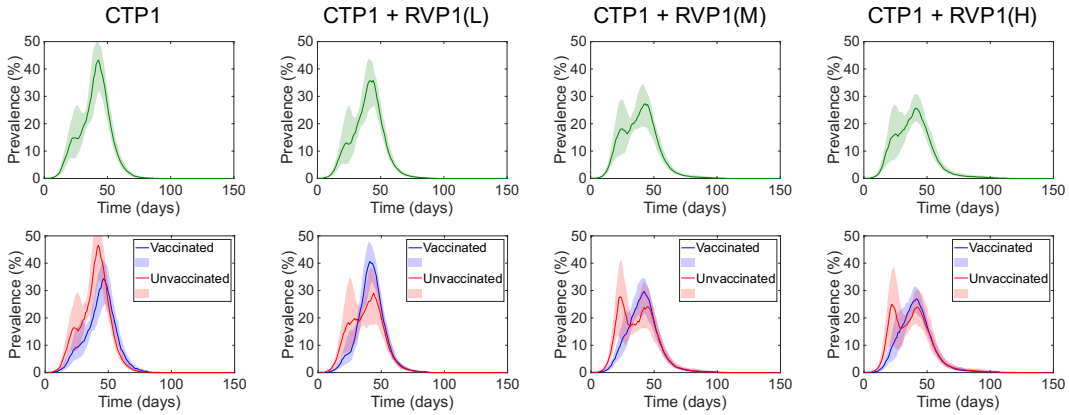

Figure 8. Prevalence of infection in Exemplar community 3 (N = 1018, low coverage) within (top row) the whole community; (bottom row) the vaccinated (blue) and non-vaccinated (red) subpopulations, for response policies (column 1) CTP1; (column 2) CTP1+RVP1 (low rate); (column 3) CTP1+RVP1 (medium rate); (column 4) CTP1+RVP1 (high rate). Solid lines: median prevalence, shaded regions: interquartile range of 100 simulations.

Table 8. Total cumulative infections for Exemplar community 1 (220 people, high vaccination coverage), stratified by age and vaccination status. Median and interquartile range of cumulative infections are shown by age group and vaccination status. Results presented assume response policy CTP1 and reactive vaccination policy RVP1 for low, medium, and high vaccination rates, and a 2-day delay to initiation of the reactive vaccination program.

Reactive vaccination rate	Vaccination status of infected	Age groups				
		<12	12-<15	15-<40	40-<60	60+
0	Vaccinated	0 (0, 0)	2 (1, 4)	48 (44, 53)	30 (25, 33)	15 (12, 18)
	Not vaccinated	31 (27, 36)	5 (4, 7)	9 (8, 10)	2 (1, 3)	0 (0, 0)
Low (30/day)	Vaccinated	0 (0, 0)	3 (2, 4)	49 (41, 56)	27 (23, 33)	15 (12, 19)
	Not vaccinated	32 (27, 36)	4 (2, 5)	3 (2, 5)	1 (0, 1)	0 (0, 0)
Medium (60/day)	Vaccinated	0 (0, 0)	3 (2, 4)	51 (44, 57)	29 (23, 33)	14 (12, 18)
	Not vaccinated	32 (26, 36)	3 (2, 5)	4 (1, 6)	1 (0, 2)	0 (0, 0)
High (100/day)	Vaccinated	0 (0, 0)	3 (1, 4)	49 (40, 56)	27 (21, 33)	15 (11, 17)
	Not vaccinated	30 (22, 34)	3 (2, 5)	3 (1, 5)	0 (0, 1)	0 (0, 0)

Table 9. Total cumulative infections for Exemplar community 2 (580 people, medium vaccination coverage), stratified by age and vaccination status. Median and interquartile range of cumulative infections are shown by age group and vaccination status. Results presented assume response policy CTP1 and reactive vaccination policy RVP1 for low, medium, and high vaccination rates, and a 2-day delay to initiation of the reactive vaccination program.

Reactive vaccination rate	Vaccination status of infected	Age groups				
		<12	12-<15	15-<40	40-<60	60+
0	Vaccinated	0 (0, 0)	3 (2, 4)	68 (63, 74)	50 (44, 54)	28 (25, 31)
	Not vaccinated	121 (113, 128)	26 (23, 29)	145 (140, 150)	43 (40, 47)	13 (12, 15)
Low (30/day)	Vaccinated	0 (0, 0)	9 (7, 11)	128 (116, 143)	68 (63, 77)	33 (29, 37)
	Not vaccinated	109 (103, 119)	15 (13, 18)	45 (23, 66)	10 (7, 18)	3 (1, 5)
Medium (60/day)	Vaccinated	0 (0, 0)	9 (7, 12)	128 (118, 143)	64 (57, 71)	31 (29, 36)
	Not vaccinated	109 (101, 116)	15 (11, 18)	38 (23, 59)	11 (6, 18)	2 (1, 4)
High (100/day)	Vaccinated	0 (0, 0)	9 (7, 12)	132 (120, 142)	66 (58, 73)	32 (28, 36)
	Not vaccinated	112 (104, 123)	14 (11, 18)	37 (22, 56)	10 (7, 18)	2 (1, 4)

Table 10. Total cumulative infections for Exemplar community 3 (1018 people, low vaccination coverage), stratified by age and vaccination status. Median and interquartile range of cumulative infections are shown by age group and vaccination status. Results presented assume response policy CTP1 and reactive vaccination policy RVP1 for low, medium, and high vaccination rates, and a 2-day delay to initiation of the reactive vaccination program.

Reactive vaccination rate	Vaccination status of infected	Age groups				
		<12	12-<15	15-<40	40-<60	60+
0	Vaccinated	0 (0, 0)	2 (1, 2)	35 (32, 38)	67 (63, 70)	48 (45, 52)
	Not vaccinated	199 (190, 209)	54 (49, 59)	368 (360, 379)	114 (109, 119)	34 (32, 38)
Low (30/day)	Vaccinated	0 (0, 0)	20 (15, 24)	256 (199, 295)	130 (117, 143)	65 (60, 72)
	Not vaccinated	187 (179, 197)	30 (25, 34)	98 (53, 164)	24 (15, 37)	4 (3, 8)
Medium (60/day)	Vaccinated	0 (0, 0)	17 (14, 21)	231 (197, 258)	119 (107, 131)	64 (59, 69)
	Not vaccinated	178 (171, 187)	28 (23, 33)	101 (59, 143)	25 (16, 37)	5 (3, 8)
High (100/day)	Vaccinated	0 (0, 0)	18 (15, 21)	224 (201, 247)	117 (109, 126)	61 (57, 68)
	Not vaccinated	178 (166, 189)	27 (22, 31)	84 (49, 126)	21 (13, 34)	5 (3, 8)

Table 11. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks in Exemplar community 1 with CTP1 and RVP1 (medium rate) switched on or off. Results presented assume a 2-day delay to initiation of the reactive vaccination program.

Average cumulative number	CTP1	CTP1 and RVP1(M)
Symptomatic infections	21	20
Ward admissions	4	3
ICU admissions	1	1

Table 12. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks in Exemplar community 2 with CTP1 and RVP1 (medium rate) switched on or off. Results presented assume a 2-day delay to initiation of the reactive vaccination program.

Average cumulative number	CTP1	CTP1 and RVP1(M)
Symptomatic infections	120	89
Ward admissions	21	14
ICU admissions	8	5

Table 13. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks in Exemplar community 3 with CTP1 and RVP1 (medium rate) switched on or off. Results presented assume a 2-day delay to initiation of the reactive vaccination program.

Average cumulative number	CTP1	CTP1 and RVP1(M)
Symptomatic infections	248	166
Ward admissions	49	26
ICU admissions	19	10

Table 14. Varying rate of reactive vaccination in Exemplar community 3. Average cumulative number of symptomatic infections, ward admissions and ICU admissions over the course of outbreaks with CTP1 and RVP1 with a daily rate of surge vaccination of 0, 30, 75 and 150 doses. Results presented assume a 2-day delay to initiation of the reactive vaccination program.

Average cumulative number	Daily rate of vaccination			
	0	30 (L)	75 (M)	150 (H)
Symptomatic infections	248	180	166	160
Ward admissions	49	26	26	26
ICU admissions	19	9	10	9

Table 15. Increase in delay to initiation of the reactive vaccination program in Exemplar community 3. Total cumulative infections stratified by age and vaccination status. Median and interquartile range of cumulative infections are shown by age group and vaccination status. Results presented assume response policy CTP1 and reactive vaccination policy RVP1 for low, medium, and high vaccination rates, and a 4-day delay to initiation of the reactive vaccination program.

Reactive vaccination rate	Vaccination status of infected	Age groups				
		<12	12-<15	15-<40	40-<60	60+
0	Vaccinated	0 (0, 0)	2 (1, 2)	35 (32, 38)	67 (63, 70)	48 (45, 52)
	Not vaccinated	199 (190, 209)	54 (49, 59)	368 (360, 379)	114 (109, 119)	34 (32, 38)
Low (30/day)	Vaccinated	0 (0, 0)	19 (16, 22)	246 (200, 292)	131 (114, 140)	68 (61, 75)
	Not vaccinated	190 (177, 198)	32 (27, 37)	115 (75, 167)	30 (18, 41)	7 (4, 10)
Medium (60/day)	Vaccinated	0 (0, 0)	19 (14, 22)	245 (192, 278)	122 (110, 137)	66 (58, 73)
	Not vaccinated	181 (172, 196)	29 (23, 34)	100 (59, 154)	26 (14, 42)	6 (3, 11)
High (100/day)	Vaccinated	0 (0, 0)	19 (15, 23)	235 (195, 266)	120 (109, 132)	63 (57, 69)
	Not vaccinated	182 (169, 194)	28 (23, 33)	97 (61, 141)	26 (16, 39)	7 (5, 9)

The breakdown of infections by severity of clinical outcome by age and vaccine status is reported for reactive vaccination policy RVP1 in conjunction with contain and trace policies CTP1 and CTP2 in Table 16. These results provide quantitative support for implementing reactive vaccination in conjunction with CTP2 in under vaccinated communities where possible, and for additional wrap around support in contexts where it is only possible to implement reactive vaccination in conjunction with CTP1.

Table 16. Average cumulative number of symptomatic infections, ward admissions and ICU admissions stratified by age and vaccination status over the course of outbreaks in Exemplar Population 3 when reactive vaccination policy RVP1 (medium rate) and either CTP1 or CTP2 are employed. Results presented assume a 2-day delay to initiation of the reactive vaccination program.

Average cumulative number	CTP	<15 yrs		15-39 yrs		40-59 yrs		60+ yrs	
		Vacc'd	Unvac	Vacc'd	Unvac	Vacc'd	Unvac	Vacc'd	Unvac
Symptomatic infections	1	1	58	10	47	8	21	11	9
	2	1	41	7	37	4	16	7	6
Ward admissions	1	0	1	0	3	1	7	6	8
	2	0	1	0	3	0	5	4	6
ICU admissions	1	0	0	0	1	0	3	2	4
	2	0	0	0	1	0	2	1	3

We are continuing to consult with the Advisory Group to develop extended narrative case studies of combined vaccine and other public health measures that may be feasible and implementable in remote settings with different starting vaccination coverage by age to maximise outbreak response impacts. Given the high prevalence of underlying health risk determinants in such settings, our projections of severe clinical outcomes remain uncertain and require ongoing review. Consideration of access to treatments that have been demonstrated to reduce ongoing burden of severe disease is strongly recommended, given limitations of clinical services in regional and remote Australia.

References

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