Te Pūnaha Matatini
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Note: This paper has not yet undergone formal peer review

Probability of elimination for COVID-19 in Aotearoa New Zealand

5 June 2020

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Executive Summary

- Our model of COVID-19 spread estimates that after 2-3 weeks of no new reported cases, there is a 95% probability that COVID-19 has been eliminated in New Zealand.
- A 95% probability of elimination is achieved after 10 consecutive days with no new reported cases under an optimistic scenario with high detection of clinical cases, and after 22 days under a more pessimistic scenario with low case detection.

Probability of elimination

The stochastic model of Plank et al (2020) can be simulated to estimate the probability, *P(elim)*, of having eliminated COVID-19 in NZ (as the proportion of model realisations that achieve elimination) after a given number of consecutive days with no new reported cases. Such estimates are important to inform decisions on timings for the easing of certain COVID-19 restrictions. Under an optimistic scenario with high detection and reporting of clinical cases and moderate effectiveness of Alert Levels 2-3, the model estimates *P(elim)*=0.95 after 10 consecutive days with no reported cases (Fig. 1). For a pessimistic scenario with low detection of clinical cases and low effectiveness of Alert Levels 2 and 3, *P(elim)*=0.95 is achieved after 22 days with no reported cases (Fig. 1). So long as the probability of elimination is less than one, there remains a chance of undetected cases in NZ and the risk of a new outbreak arising.

A full description of the model is given in Plank et al (2020). Estimates were obtained by simulating 1000 realisations of the model using the parameter values given in Plank et al (2020) and James et al (2020), with a longer reporting delay of 6 days (distribution from isolation to reporting, $\Gamma(\text{shape} = 1,\ \text{scale} = 6)$). We used the best-fit estimates for reproduction number R_{eff} prior to and during Alert Level 4 reported in Binny et al (2020). For the optimistic scenario, we assumed 75% of clinical cases are detected and reported (p_R=75%) and the transmission rate relative to no population-wide control, *C(t)*, was set to *C(t)*=1, 0.75, 0.4 and 0.15 (corresponding to R_{eff} = 2.37, 1.78, 0.95 and 0.35) for Alert Levels 1-4, respectively. The pessimistic scenario used a lower p_R=20% and *C(t)* = 1, 0.95, 0.9 and 0.15 (corresponding to R_{eff} = 2.47, 2.34, 2.22 and 0.36). The model was simulated using case data (sourced from Ministry of Health) up to 28th May 2020.

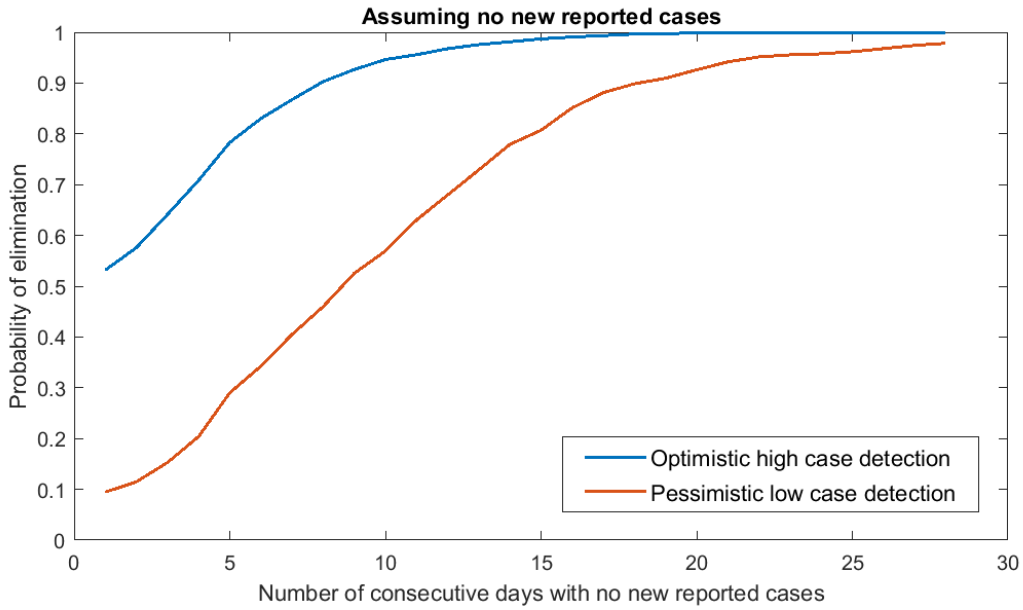

Figure 1: Probability of elimination, P(elim), after different numbers of consecutive days with no new reported cases. Optimistic scenario with high detection and reporting of clinical cases (p_R=75%) and moderate effectiveness of Alert Levels 2 (C(t)=0.75, Reff=1.8) and 3 (C(t)=0.4, Reff=0.95). Pessimistic scenario with low detection and reporting of clinical cases (p_R=20%) and low effectiveness of Alert Levels 2 (C(t)=0.95, Reff=2.3) and 3 (C(t)=0.9, Reff=2.2).

Sensitivity analyses

We assessed to what extent probability of elimination varied under different proportions of clinical cases that are detected and reported, p_R, different distributions of generation times, and for different relative transmission rates, *C(t),* for Alert Levels 2 and 3. For sensitivity analyses we used the shorter reporting delay employed in Plank et al (2020) (distribution from isolation to reporting, $\Gamma(\text{shape} = 1,\ \text{scale} = 3.48)$; following Price et al (2020) and estimation using limited NZ data). For the scenarios above, using this shorter reporting delay gave similar results to those in Fig. 1, with *P(elim)*=0.95 achieved after 12 consecutive days with no reported cases in the optimistic scenario (Table 1) and after 22 days in the pessimistic scenario (results not shown).

Results were moderately sensitive to changing the proportion of clinical cases that are detected and reported, p_R (Table 1) and to the mean of the Weibull-distributed generation time (Table 2). For instance, with low detection and reporting of clinical cases (p_R=20%), 22 consecutive days with no new reported cases are required to achieve *P(elim)*=0.95. When detection is very high (p_R=90%), *P(elim)*=0.95 can be achieved after 10 days. Increasing the mean generation time from 5 days ($Wei(\text{scale} = 5.67,\ \text{shape} = 2.83)$) to 8 days ($Wei(\text{scale} = 9.0,\ \text{shape} = 2.83)$) increased the consecutive number of days required to achieve *P(elim)*=0.95 to 22 days. Results were relatively insensitive to different choices of relative transmission rate *C(t)* for Alert Levels 2 (Table 3) and 3 (Table 4).

Table 1: Sensitivity of P(elim) to varying proportion of clinical cases detected and reported, P_R. Relative transmission rate C(t)=1, 0.75, 0.4 and 0.15 for Alert Levels 1-4, respectively.

Proportion of clinical cases detected and reported	P_R=20% (low detection)	P_R=50%	P_R=75%	P_R=90% (high detection)
R_{eff} when *C(t)*=1	2.47	2.42	2.37	2.35
Days until *P(elim)*=0.95	22	14	12	10

Table 2: Sensitivity of P(elim) to varying the mean and variance of the Weibull-distributed generation time. Relative transmission rate C(t)=1, 0.75, 0.4 and 0.15 for Alert Levels 1-4, respectively. Proportion of clinical cases detected and reported, p_R=75%.

Generation time distribution	$Wei(\text{scale} = 5.67,\ \text{shape} = 2.83)$	$Wei(\text{scale} = 9.0,\ \text{shape} = 2.83)$	$Wei(\text{scale} = 5.67,\ \text{shape} = 1.5)$
R_{eff} when *C(t)*=1	2.37	2.21	2.36
Days until *P(elim)*=0.95	12	22	13

Table 3: Sensitivity of P(elim) to varying the relative transmission rate, C(t), of Alert level 3. Relative transmission rate C(t)=1, 0.75 and 0.15 (corresponding to R_{eff} = 2.37, 1.78 and 0.35) for Alert Levels 1, 2 and 4, respectively. Proportion of clinical cases detected and reported, p_R=75%.

Alert Level 3 transmission	*C(t)=0.2, Reff=0.47 (high effectiveness)*	*C(t)=0.3, Reff=0.72*	*C(t)=0.4 Reff=0.95*	*C(t)=0.5, Reff=1.19*	*C(t)=0.6, Reff=1.42*	*C(t)=0.7, Reff=1.66 (low effectiveness)*
Days until *P(elim)*=0.95	9	12	12	12	12	12

Table 4: Sensitivity of P(elim) to varying the relative transmission rate, C(t), of Alert level 2. Relative transmission rate C(t)=1, 0.4 and 0.15 (corresponding to R_{eff} = 2.37, 0.95 and 0.35) for Alert Levels 1, 3 and 4, respectively. Proportion of clinical cases detected and reported, p_R=75%.

Alert Level 2 transmission	*C(t)=0.6, Reff=1.42 (high effectiveness)*	*C(t)=0.75 Reff=1.78*	*C(t)=0.9 Reff=2.14*	*C(t)=1, Reff=2.37 (low effectiveness)*
Days until *P(elim)*=0.95	10	12	12	12

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