Te Pūnaha Matatini
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Effective reproduction number and likelihood of cases outside Auckland

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Executive Summary

- The effective reproduction number R_{eff} measures the potential for COVID-19 to spread. If $R_{eff} > 1$, new daily cases are likely to increase over time, if $R_{eff} < 1$ new daily cases will decrease over time.
- For the March-April outbreak, R_{eff} was between 1.2 and 2.2 before moving to Level 4 and between 0.35 and 0.55 during Level 4.
- For the August-September outbreak, R_{eff} was between 2.3 and 2.7 before Auckland moved to Level 3 and between 0.5 and 0.8 during Level 3.
- In both March and August, the Alert Level response was successful in reducing R_{eff} below 1 and hence containing the outbreak.
- The bigger relative reduction in R_{eff} achieved by lockdown in August relative to lockdown in March may be explained by better performance of the testing and contact tracing system.
- The higher value for pre-lockdown R_{eff} in August compared to March may be due to a combination of factors, including Level 1 conditions (no gathering size restrictions, etc.), different behaviour of cases associated with international travel in March/April, higher transmission rates in winter, and potentially higher rates of crowded housing in affected communities.
- It is still too early to produce a reliable estimate for R_{eff} at Alert Level 2.5 in Auckland. The confidence interval for R_{eff} is very wide and it is possible that $R_{eff} > 1$ under current conditions.
- The likelihood of undetected active cases outside the Auckland region is also uncertain and could be up to 40% for the North Island and up to 20% for the South Island. The possibility of spread to other regions will remain as long as there are active cases in the Auckland cluster combined with near normal rates of inter-regional travel.

Effective reproduction number

We used three different methods for estimating the effective reproduction number R_{eff}, all using data on confirmed and probable cases of COVID-19 in New Zealand acquired domestically (i.e. excluding cases with a recent history of international travel).

Method 1. Reconstruction of the epidemiological tree. We perform Monte Carlo reconstructions of the epidemiological transmission tree using contact tracing data on the index case and serial interval distribution (James et al., 2020; Lauer et al., 2020). From a reconstructed tree, we can directly estimate the number of secondary infections attributed to each case. We calculate R_{eff} by averaging these across all cases with symptom onset dates in the relevant time period.

Method 2. Fitting a model for the spread of COVID-19. We fit the stochastic branching process model calibrated to New Zealand conditions (Plank et al., 2020) to daily reported case counts as described by (Binny et al., 2020).

Method 3. EpiNow – an open source method for estimating R_{eff} from daily reported case counts (Abbott et al., 2020). EpiNow produces daily estimates and confidence intervals for R_{eff}. We averaged these estimates over the relevant time periods, weighting by the number of new daily cases. Caution is needed in interpreting these results because of the lag from infection time to reporting time.

Results are shown in Table 1 for the pre- and post-lockdown period of the first and second outbreaks.

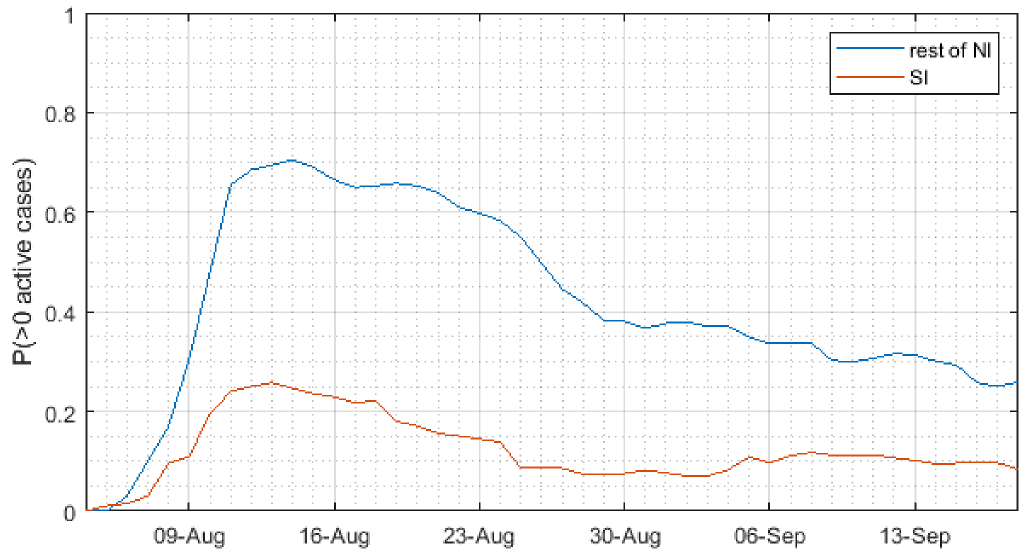
	Before lockdown	During lockdown (AL3-4)
March-April outbreak	M1: 1.21 [1.19, 1.23] M2: 1.80 [1.44, 1.94] M3: 2.2 [1.42, 3.37]	M1: 0.54 [0.53, 0.55] M2: 0.35 [0.28, 0.44] M3: 0.47 [0.16, 1.41]
August-September outbreak	M1: 2.49 [2.31, 2.66] M2: 2.30 M3: 1.78 [1.33, 2.37]*	M1: 0.59 [0.53, 0.62] M2: 0.77 M3: 0.68 [0.26, 1.34]

Table 1. Estimates for the effective reproduction number R_{eff} for the two outbreaks before and during lockdown using three different methods M1-M3. Results for the first outbreak for M2 have been previously reported in (Binny et al., 2020). *Results from M3 for the pre-lockdown August period are unreliable because they are weighted by case reporting dates, which are all 11 Aug or later because transmission prior to this time was undetected.

Likelihood of active undetected cases outside the Auckland region

Using travel data on flights and road transport in and out of the Auckland region, the graphs show the probability that there is more than one active case outside of Auckland resulting in the South Island or the rest of the North Island resulting from the Auckland outbreak under the assumption that the mean length of stay of travellers from Auckland is a) four days and b) two days.

(a) Mean length of stay = 4 days



(b) Mean length of stay = 2 days

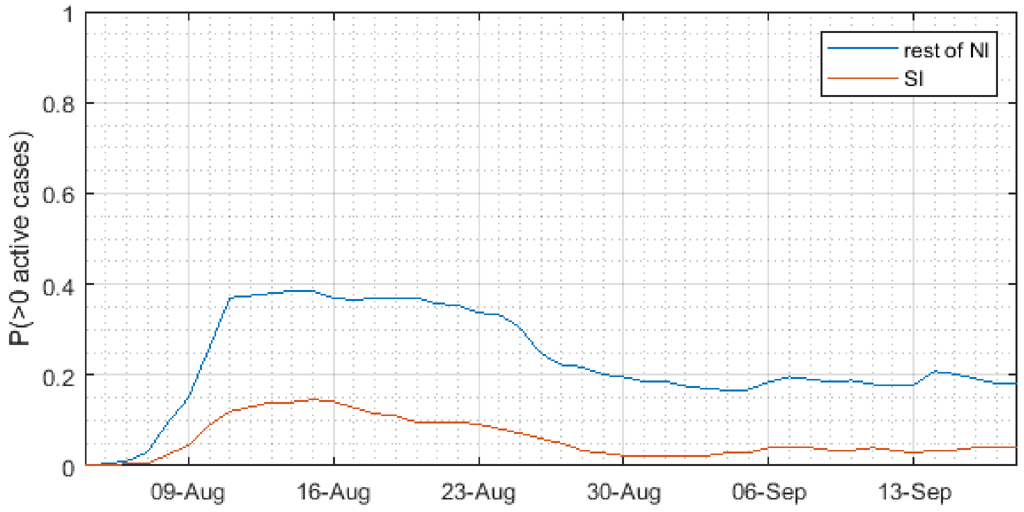


Figure 1. Probability there are active undetected cases in the rest of the North Island outside of the Auckland region (red) and the South Island (blue).

There is a lot of uncertainty around these results due to uncertainty in estimates of travel volumes and the length of stay distribution for inter-regional travel.

Note: these results also assume Reff = 1.1 for the Auckland cluster at Alert Level 2.5. If this cluster spreads more rapidly, the likelihood of cases in other parts of New Zealand will also increase.

Model details

Model assumptions:

- Assumed travel volumes shown in Table 1 below.
- Each resident of region A has equal probability of travelling to region B each day.
- When people travel to a different region, length of stay is exponentially distributed $LOS \sim Exp(\mu)$ with mean μ = 2 days or 4 days
- Populations within each region are assumed to be well mixed
- Proportion of clinical cases who get tested: 90% (Auckland region), 50% (elsewhere)
- Mean time from symptom onset to testing: 2 days (Auckland region), 6 days (elsewhere).
- Effective reproduction number assumed to be 2.2 (Level 1), 1.1 (Level 2-2.5), 0.6 (Level 3)

	Number of people travelling per day		
	Before 12 Aug	12 Aug to 30 Aug	From 31 Aug
Auckland -> rest of NI	10000	2000	9000
Auckland -> SI	3000	400	2200

Table 1: the volume of travellers from Auckland -> South Island are estimated from Air New Zealand daily passenger counts before versus after 12 August. Travellers from Auckland -> rest of North Island estimated from Air New Zealand daily passenger counts plus 25% of telemetry data for Wellsford and Rosehill to exclude commuting and other short trips at low risk of transmission. Road traffic was assumed to drop to 20% of pre-lockdown levels during Alert Level 3.

References

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