This report is a pre-print. It has been subject to internal peer review.

Covid-19 Modelling Aotearoa

Estimating the effect of changes in case isolation on the effective reproduction number of COVID-19 in Aotearoa: September 2022

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Information in this report was provided to NZ Ministry of Health on **2nd September 2022**, via e-mail and virtual meetings, as part of a rapid response to requests for modelling advice on consequences of removing case isolation. The deadlines associated with the request for advice were too short to allow for results and contextual information to be compiled into a report in advance of 2nd September.

This document collates the results and advice into a single report, along with an explanation of how the results can be used for decision making related to case isolation. The report was provided to the NZ Ministry of Health **15th September 2022**.

This version of the report includes minor revisions following internal peer review, as well as reference to an Addendum where we present the findings of sensitivity testing of transmission within households during quarantine.

Background

This work follows simulations and analysis delivered by COVID-19 Modelling Aotearoa (CMA) in mid-August 2022 [1], which estimated the relative change in the effective reproduction number (Rt) for COVID-19 across a range of scenarios with different policy settings for:

- isolation requirements for confirmed cases,
- testing and quarantine requirements for household contacts of confirmed cases; and
- community context: transmission reduction behaviours, including mask wearing, reducing in-person interactions, improved ventilation etc.

The scenarios in the August report were investigated using an individual based Network Contagion Model (NCM) developed by CMA to represent the spread of COVID-19 in Aotearoa. Simulations estimated the effect of policy changes in the context of a period of decreasing case numbers, following a recent wave of cases, and with a sizable associated pool of individuals with high levels of immunity from past infection. A range of underlying background transmission environments were used to ensure that any estimates of the effect size for changes in Rt were applicable across a range of Rt values before the policy change; for example, the tendency of people to work from home (when not infected) or to attend events other than work and school interactions.

This report uses the same methods as [1] to investigate updated scenarios of case isolation settings, exploring the effect of two relevant model parameters that correspond to i) the fraction of symptomatic infected individuals who make some isolation-like behaviour change; and ii) the average effectiveness, or size, of the behaviour change made by those individuals.

An Addendum to this report has also been published on the COVID-19 Modelling Aotearoa website [2], where we present results where the assumption of perfect intra-dwelling isolation is replaced with the assumption of no reduction in transmission within dwelling.

How to use these results

Modelled simulation settings are intended to capture the relative impact of changes in policy settings, as opposed to being a forecast of future cases based on the current situation. The estimated changes to the effective reproduction number (Rt) presented in this work can be used as inputs to models, such as the CMA ODE model [3], in order to estimate longer term impacts of policy changes on new infections and hospitalisations.

Scenario assumptions

The effect of policy changes are measured relative to a baseline that is intended to represent the transmission environment in August 2022. However, we expect the relative changes with respect to a baseline scenario to be generally applicable across changes in that baseline.

Baseline scenario

The modelled 'status quo' baseline is our best guess of the transmission environment in August 2022 in terms of COVID-19 Protection Framework (CPF) settings and related community transmission reduction behaviours ('community context'), case isolation rules, and contact quarantine rules. These are based on choosing parameters values that give a good fit between simulation results and past case data. The parameters related to case isolation behaviour are set such that 70% of individuals with symptomatic infections would take action to reduce transmission (i.e. would isolate or quarantine), and that action would reduce transmission outside the household by 90% ('case leak rate' of 10%).

In [1] we presented the results of simulated scenarios across a range of 'background transmission' levels to test sensitivity of results to this setting. We found that the effect of changing other policy dimensions are affected by 'background transmission level', and that the effect size is at most ~2.5 percentage points. Here we use the 'Background transmission = Low' setting for these simulations as this is the most conservative setting in terms of any resulting increase in Rt due to the simulated policy changes. Based on the assumption that removing public health protections at the same time as rapidly rising cases, we also think it more likely that these policy changes would take place in a time of low Rt.

Specific settings:

- Background transmission = Low. (This setting ensures that we are at a period of flat case numbers (Rt close to 1 and decreasing) for the 'baseline'.)
- Community context = CPF Orange[1]
- Household contact rules = 7 days quarantine, test if symptomatic and on days 3 and 7
- Confirmed cases rules = 7 days isolation. Transmission from infected individuals to anyone outside their dwelling is reduced by 90% from time of detection.[2]

Details of model implementation for each of these settings are described in [1].

[1] 'Community context' refers to the effect of CPF masking and transmission reduction recommendations which are assumed to be producing a 20% reduction in transmission between close contacts in work & school, and a 50% reduction in casual contact transmission in work, school, & community. When this is taken 'off', the reduction is removed.
[2] The case leak rate applies from a mean of 1 day after symptom onset until cases recover. All 'cases' have a mean of half a day in a 'waiting' state at the beginning of their 'isolation' which has a 10% leak rate, even when we change parameters for the 'case leak rate' in the scenarios.

Modelling the removal of the case isolation requirement

In order to estimate the likely effects of removing case isolation requirements, we have used simulations from the NCM to quantify the effect of two parameters related to the behaviour of infected individuals. These parameters can be interpreted as:

1. **Proclivity to change behaviour**: the proportion of symptomatic infections who would take some sort of action to reduce transmission (including not only those who test positive and report, but also those who take any transmission reduction action based on their symptoms).
2. **How much people change behaviour**: how effective is the action that people take (specifically, the reduction in transmission outside the household for those people taking action).

For the alternate scenarios investigated here, we have modelled all combinations of:

1. Changes in proportion of individuals with symptomatic infections taking action: reductions of 0%, 25%, 50%, 75%, and 100% relative to the 70% baseline. These correspond to absolute values of 70%, 52.5%, 35%, 17.5%, and 0% of individuals taking action, if symptomatic.
2. Reduction in the effectiveness of actions (relative to a baseline with a 10% leak rate): 0%, 25%, 50%, 75%, 100%. These correspond to absolute values for the leak rate of 10%, 32.5%, 55%, 77.5%, and 100% respectively.

This gives us 25 scenarios in total, plus the 'status quo' baseline, which assumes August-September 2022 community transmission reduction behaviours ('CPF Orange'), as well as the current case isolation and household contact quarantine requirements (details in [1]). We run 10 simulations of each scenario from the same initial conditions. For each of the 25 combinations of the above parameters, we calculate the change in the effective reproduction number (Rt), following the policy change, relative to the 'status quo' baseline, using the method described in [1].

Assumptions common to all case isolation removal scenarios

- Background transmission = Low
- Community context = CPF Off

- Household contacts = guidance to test if symptomatic[3], no requirement to quarantine unless symptomatic. Strong intra-dwelling isolation is assumed for all scenarios.

All results presented in this report assume that when a case is isolating at home, all household contacts isolate perfectly from each other. i.e. there will be no transmission **within the dwelling** after the first case is detected. An Addendum to this report, *Addendum: Assumption of perfect case isolation within the home [2]*, presents results where the assumption of perfect intra-dwelling isolation is replaced with the assumption of no reduction in transmission within dwelling.

Results

The contour plot in **Figure 1** presents the fractional increase in the effective reproduction number (Rt) relative to the baseline scenario, that results from a policy change with the corresponding pair of parameter values. The results for the specific 25 scenarios are also presented in **Table 1** below.

- The further along (up) the y-axis, the greater the reduction[4] in the proportion of symptomatic people taking action to prevent transmission, such as isolating or reducing their interactions outside of the home.
- The further along (right) the x-axis, the greater the reduction in effectiveness of the actions that are taken[5]. For example, isolating for only 1-2 days instead of for 7 days or until testing negative on a rapid antigen test.
- Contours on the chart indicate the increase in Rt, calculated from the corresponding new infections timeseries for each of the 25 scenario combinations compared to the single baseline scenario. This assumes a baseline scenario where Rt is close to 1. If Rt is significantly different from 1 then results here will be less applicable.
- The value at the origin (0,0) is 11.4% because that is the estimated impact of other model parameters, independent of case isolation. That is the non-zero origin captures estimates of the effect of changing the community context from “CPF Orange” to “CPF Off” and removal of quarantine for household contacts, without any changes to case isolation requirements.

[3] The impact of ‘cases’ on household contacts is to increase their proclivity to take action if they develop symptoms. This captures the fact that people who do test and/or reduce transmission when they become symptomatic are more likely to be in a household with people who would act similarly.
[4] (from baseline scenario) e.g. a 50% reduction in the proportion of people taking action is a decrease from 70% to 35% in model parameters.
[5] (from baseline scenario) e.g. a 50% reduction in the effectiveness of actions is an increase in leak rate from 10% to 55% in model parameters.

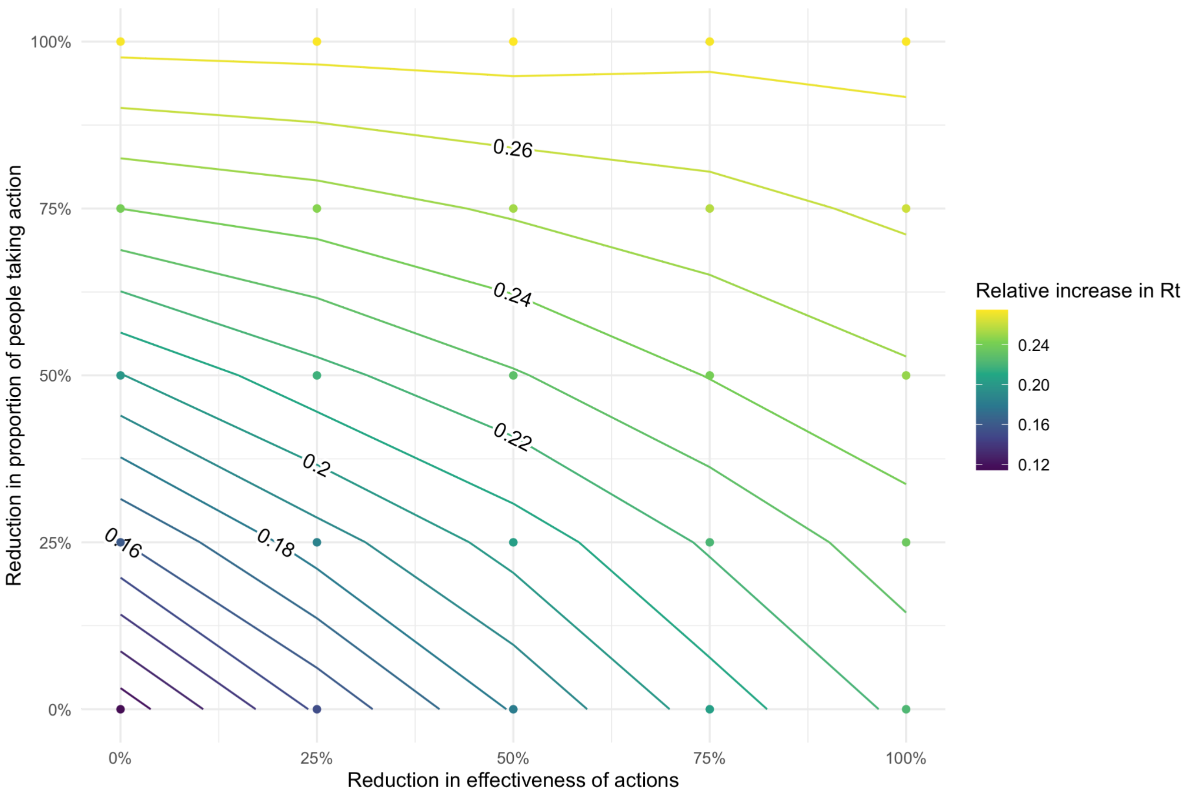

Figure 1: *Contour plot showing the* ***relative increase in Rt*** *due to a change in case isolation behaviour factors compared to an August 2022 baseline. The locations of the 25 specific scenario results are plotted as dots, and the values given in Table 1. In general, we find that a large fraction of people taking some action leads to a smaller increase in Rt than a small fraction of people taking a highly effective action - that is contours tend to be flatter than 45 degrees.*

		Reduction in *effectiveness* of actions				
		0%	**25%**	**50%**	**75%**	**100%**
Reduction in *proportion* of people taking action	**0%**	11.4%	15.2%	18.1%	20.5%	22.2%
	25%	16.0%	18.5%	20.4%	22.1%	23.5%
	50%	20.0%	21.7%	22.9%	24.0%	24.8%
	75%	24.0%	24.5%	25.2%	25.6%	26.2%
	100%	27.3%	27.4%	27.5%	27.3%	27.4%

Table 1: *Estimated mean percentage increase in Rt relative to baseline, for n=10 simulations when changing case isolation behaviour factors.*

Many people isolating imperfectly, is preferable to a few people isolating perfectly but others not changing their behaviour at all

1. Reducing the *proportion* of people taking action by 75% (an absolute reduction from 70% of people taking action down to 17.5% of people taking action) without reducing the *effectiveness* of their actions results in a 24% increase in Rt from baseline.
2. However, reducing the *effectiveness* of actions taken by 75% (i.e. leak rate increasing from 10% to 55%) without reducing the *proportion* of people taking action results in a smaller 20.5% increase in Rt from baseline.
   - This is almost equal to the increase in Rt for the scenario where 50% fewer people take action, but there is no reduction in effectiveness of these actions.

When we consider the same relative reduction in 'proportion of people taking action' and 'effectiveness of actions', reducing the proportion of people taking action results in a greater increase in Rt from baseline. This means a larger effective reproduction number, and a higher rate of infection transmission results from fewer people isolating perfectly, than for more people isolating imperfectly.

The above results can be explained by considering that the transmission reduction due to a case being confirmed is not just their own isolation, but also the flow on transmission reduction actions that the positive test result triggers in those around them. In these simulations, we do not assume that household contacts quarantine or test regularly, but we do assume that there is no transmission within the household after the first case is detected. This means that fewer household contacts will become infected, and this will reduce onward transmissions from household contacts to the community that would have otherwise occurred if household contacts had become infected.

Based on sensitivity test results in the addendum [2], the difference in effect between these two scenarios is significantly reduced when we remove the assumption of perfect isolation within the dwelling. However, the public health guidance for confirmed cases is to try to reduce spread within their household, so the reality is likely to be somewhere between the results in this report and those in the Addendum. Additionally, if household contacts were taking some additional precautions or testing even if not symptomatic, we would expect a similar effect, due to the flow-on impacts from cases beyond the isolation behaviour itself.

This finding has obvious equity implications, as communities with larger numbers of people who may be less able to isolate, both within their dwelling (e.g. due to crowding within the home) and beyond their dwelling, (e.g. due economic pressures requiring them to return to work) will experience fewer protections and higher rates of transmission compared with those communities where a larger fraction of individuals are able to isolate (both from the community and others in their dwelling) when infected.

Communities who are able to maintain lower rates of infections will also benefit from the lower overall case numbers that eventuate over time as infections accumulate in more vulnerable communities, reducing the total size of the susceptible population.

Limitations and considerations

In the NCM, the generation interval for infections is an emergent property of the simulations, rather than a specified input. This is because in the NCM, as in the real world, generation interval is affected by factors such as testing, isolation, and quarantine settings and on the immediate neighbours of infected individuals. A consequence of this is that when estimates of Rt from the NCM results are used with a model such as the CMA ODE model, which assumes a fixed generation interval as an input, the resulting change in Rt in the ODE model may not exactly match that of the NCM. These effects are expected to be small relative to other parameter uncertainty in both the NCM and the ODE model and can be addressed, for example, through confidence intervals in subsequent ODE model calculations.

Changes to case isolation policies can be expected to result in changes of people to test and to report test results. Hence in this report we use the number of new infections to calculate Rt, rather than confirmed cases. Any scenario that results in higher testing rates, may lead to higher reported case numbers than alternative scenarios, even if it results in lower numbers of underlying infections.

Although the interaction network used for the NCM simulations is representative of the population in Aotearoa, the results above only consider the estimated change in the effective reproduction number due to any policy change. They do not account for *who* is infected or what the outcomes of infection are for those people. Older individuals and Māori and Pasifika tend to experience more severe health outcomes from infection. Nor do the results in this report account for the clustering of factors that may mean that some communities are more or less able to isolate compared with others.

If any of the factors that might be correlated with reduced ability to isolate also align with factors indicative of poorer health outcomes from infections, then the additional infections that result from the estimated increases in Rt presented in this report will likely have larger increases in serious health outcomes. Providing support and clear messaging to enable (and encourage) people to isolate if they are infectious will remain important even if the legal requirement is removed.

References

[1] Harvey, E. et al. (2023) *Estimating the effect of Covid Protection Framework policy scenarios on the effective reproduction number of COVID-19 in Aotearoa: August 2022*, https://covid19modelling.blogs.auckland.ac.nz/estimating-the-effect-of-covid-protection-framework-policy-scenarios/

[2] Harvey, E. et al. (2023) *Addendum: Assumption of perfect case isolation within the home when estimating the effect of a change in case isolation policy*, https://covid19modelling.blogs.auckland.ac.nz/addendum-assumption-of-perfect-case-isolation-within-the-home/

[3] Vattiatio, G et al. (2022) *Modelling the dynamics of infection, waning of immunity and re- infection with the Omicron variant of SARS-CoV-2 in Aotearoa New Zealand*, https://www.covid19modelling.ac.nz/waning-of-immunity-and-re-infection-with-omicron/

Appendix A: Reading off the contour plot

This appendix provides an example of how to interpret specific points on the contour plot presented in the results section of the main body of this report.

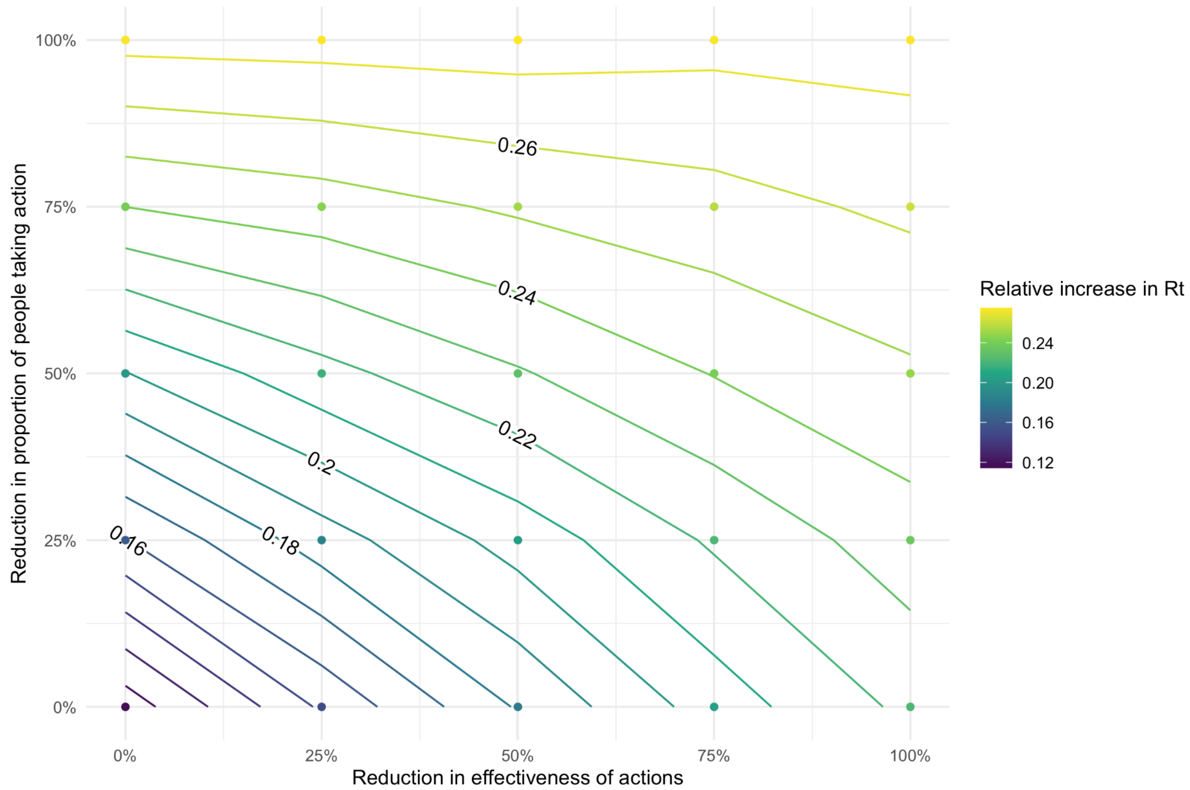

Figure A1: *Contour plot of relative increase in Rt due to a change in case isolation behaviour factors – reproduced from Figure 1.*

The contour plot in Figure A1 (reproduced from Figure 1) presents the fractional increase in the effective reproduction number (Rt) relative to the baseline scenario (which models the best guess at the August-September 2022 settings), that results from a case isolation policy change with the corresponding pair of parameter values. The results for the specific 25 combinations of parameters that we modelled are also presented in **Table 1**.

It is important to note that these contour values are the estimated relative increase in Rt (effective reproduction number) NOT the estimated increase in total infections, hospitalisations, or deaths.

All scenarios in the contour plot include:

- Community context changing from “CPF Orange” to “CPF Off”, with the removal of associated community transmission reduction behaviours such as mask requirements
- Household contact quarantine policy being changed to no contact quarantine requirement, and contacts only advised to test if symptomatic.

Our previous modelling estimated that these two changes, with no change in requirements or behaviour for confirmed cases, produced an 11.4% change in Rt relative to the baseline scenario, which is our best guess for the situation in August 2022. **This means that the value at the origin (0,0) is 11.4%**.

Example of using the contour plot to estimate a change in growth rate

Let us take the point (30%, 60%) on the contour plot. The contour line that has a value of 0.23 is very close to this point, so we estimate that at this point the contour value is ~0.23.

Table A1 below presents what these values would be interpreted as in terms of real world behaviour changes and what they relate to in the context of parameters for the NCM model.

Table A1: *Interpretation of plot values and translation to NCM model parameters*

	Value	What this represents in terms of real world behaviour changes	Corresponding model parameter change
Y-axis value	60%	A 60% reduction in the proportion of symptomatic people taking action to prevent transmission, compared to the baseline (as in August 2022)	A 60% reduction from 70% of symptomatic people taking action to reduce transmission, to 28% of symptomatic people taking action.
X-axis value	30%	A 30% reduction in effectiveness of actions taken by symptomatic people that do take action *–see Y-axis value–* compared to baseline (as in August 2022)	A 30% reduction from 90% of transmission prevented as a result of case behaviour, to 63% of transmission prevented. An increase in leak rate from 10% to 37% in model parameters.
Contour value	0.23	We estimate Rt would increase by 23% compared to the baseline scenario, for a case isolation policy change with the corresponding parameter values (30%,60%) as described in the rows above	N/A (Rt is estimated from the new infections time series produced by the model, it is not a model parameter)