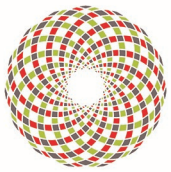

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This paper has not yet undergone external peer review

Preliminary modelling of a new community case of COVID-19 as of 17 August 2021

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EXECUTIVE SUMMARY

We use an Aotearoa-specific, individual-based network contagion model to simulate the spread of COVID-19 in the community, assuming a single seed-case with **transmission parameters comparable to those observed for the Delta variant**. **We assume around 15% of individuals over the age of 15 have been vaccinated**, with resulting reductions in probability of infection and probability of onward transmission. **This corresponds to approximately 13% of the total population being fully vaccinated**.

We find that for a baseline vaccine efficacy (70% reduction in infection, 50% reduction in onward transmission for those who get infected), the **time to detection**, from the initial exposure event has a **median of 13 days** (Lower Quartile=10, Upper Quartile=17). The median number of **cumulative cases in the outbreak at the time of detection is 29** [LQ=10, UQ=49]. Given a detection date of 17 August, this would imply an **estimate of the initial seed case date as sometime between 31 July – 7 August**.

If we assume that the first detected case has a generation number of 3 or higher, we then find that the median number of **cumulative cases in the outbreak at the time of detection is 37** [LQ=25, UQ=66].

We also use an independent network-based estimate of transmission risk to identify those SA2 regions connected to Devonport via co-incident employment relationships. This shows that **Devonport is strongly linked to an area that approximately corresponds to the extent of the Auckland Region**. Weaker links exist to Thames-Coromandel, northern Waikato, and southern Northland.

Introduction

We use a detailed individual-based network contagion model that explicitly represents ~ 5 million individuals along with the the contexts in which they interact. This network model includes stochasticity, spatial information, and individual demographic information, along with multiple distinct 'transmission contexts' including dwellings, workplaces, schools, and more generally in the community. Details of both the network and the contagion process are broadly similar to those in[1,2].

Key include assumptions:

- The simulations consider the case of *community* transmission, with no known link to a border worker or to an individual with mandated testing.
- Each simulation was seeded by setting the state to infected (specifically to 'Exposed') for a single, randomly selected, individual in Auckland.
- We do not explicitly consider super-spreading behaviour at the individual level (individuals with higher viral load), though individuals have different distributions of contacts and transmission rates vary by context.
- Pre-detection testing rates and behaviour were the best estimate of Alert Level 1 (AL1) in Auckland; as detailed below.
- Our vaccine coverage parameters are currently relatively approximate, as detailed below.

Characterisation and parameterisation

Here we outline further important aspects of our parameterisation for our modelling of the new community case.

Vaccination coverage

The scenario we consider has vaccination levels of 15% for those aged 15–29, 16.1% for those aged 30–59, and 15.4% for those aged 60+. This results in approximately 13% of the total population being fully vaccinated. This coverage is slightly different to the Auckland Metro Area vaccination status as at 27th July 2021 (3 weeks prior to August 17th — this being the date at which a person would need to have received their second dose, in order to have an immune response comparable to the vaccine effects modeled). In particular these vaccination levels are slightly too high for 15–29 year olds, and too low for over 60s. We also consider the case of no vaccinated individuals separately.

Vaccine efficacy

We consider 3 levels of vaccine efficacy that we label 'Baseline', 'Lower' and 'Higher'. For Baseline we consider the vaccine leads to a 70% reduction in infection, and for those who do get infected, a 50% reduction in onward transmission. For Lower we consider the vaccine leads to a 50% reduction in infection, and for those who do get infected, a 40% reduction in transmission. For Higher we consider the vaccine leads to a 90% reduction in infection, and for those who do get infected, a 50% reduction in transmission.

Transmission rate

For the delta variant we consider that the transmissibility rate parameter (β) is double that for the wild-type, and that the risk of severe consequences (hospitalisation) given infection is also doubled.

Testing

We assume that approximately 10% of cases with symptoms would seek a test, and of those, 90% would test positive, giving a 9% testing positive percentage. We assume that it would be a mean of 5 days from symptom onset to returning a positive test result (exponential distribution).

Number of simulations and initial seeding

We ran 200 simulations for each scenario of level of vaccination and vaccine effectiveness. Each simulation was seeded by setting the state to infected (specifically to 'Exposed') for a single, randomly selected, individual in Auckland.

Contagion simulation results

We find that the generation number of the first detected case has median 3 [LQ=2, UQ=4]. The generation time is an emergent property of these simulations and is approximately 5 days in the period before any interventions (e.g. Alert Level changes and contact tracing).

In Table 1 we list the median [lower quartile, upper quartile] values for the time to detection (days), cumulative cases at detection, and active cases at detection. These metrics are calculated for all seeded outbreaks, including those that are detected at any generation number.

Vaccine scenario	*n*	Time to detection	Cumulative cases at detection	Active cases at detection
No vaccination	189	12.5 [9.7, 15.6]	35 [12, 60]	33 [11, 55]
Lower vaccine efficacy	184	13 [9.4, 16.7]	28 [11, 52]	26 [10, 48]
Baseline vaccine efficacy	184	13.4 [10.1, 17.4]	29 [10, 49]	25 [9, 47]
Higher vaccine efficacy	178	14.1 [10.0, 17.6]	29 [13, 52]	26 [12, 48]

Table 1. Time to detection and size of outbreak at detection for spread of the delta variant with no vaccination, or with 13% of the population fully vaccinated, at different levels of vaccine efficacy. Metrics are median [LQ,UQ] unless otherwise stated. Here *n* is the number of the 200 simulations that reached detection.

Since the inter-quartile results reported in Table 1 may obscure the right-skewed nature of the outbreak sizes (i.e. the presence of large outbreaks that occur with low, but non-negligible, probability) we also report in Table 2 the breakdown of simulations by size at detection according to bin sizes of 2–10, 11–20, 21–50, 51–100, and 101+.

Vaccine scenario	Size 2-10	Size 11-20	Size 21-50	Size 51-100	Size 101+
No vaccination	22%	13%	33%	19%	12%
Lower vaccine efficacy	25%	14%	36%	20%	6%
Baseline vaccine efficacy	26%	14%	36%	21%	4%
Higher vaccine efficacy	22%	17%	35%	18%	7%

Table 2. Proportion of outbreaks (simulations) in each size bin at detection, for all simulations with detection.

In Table 3, we separately consider the subset of results where the first case detected was a generation 3 case or older.

Vaccine scenario	*n*	Time to detection	Cumulative cases at detection	Active cases at detection
No vaccination	118	13.9 [11.8, 17.4]	48 [30, 77]	45 [26, 71]
Lower vaccine efficacy	102	14.9 [12.6, 17.8]	39 [26, 76]	37 [25, 69]
Baseline vaccine efficacy	119	14.9 [12.0, 18.5]	37 [25, 66]	34 [22, 60]
Higher vaccine efficacy	111	15.4 [12.7, 18.8]	39 [20, 67]	35 [20, 62]

Table 3. Time to detection and size of outbreak at detection for simulations with first detected case at generation 3 or later. We consider a population with no vaccination, or with 13% of the population fully vaccinated, at three different levels of vaccine efficacy. Metrics are median [LQ,UQ] unless otherwise stated. Here *n* is the number of the 200 simulations that reached detection and where the detected case had a generation number of 3 or higher.

Spatial transmission risk

Independently of the contagion simulations we use a spatial co-incidence network to calculate a proxy for transmission risk based on workplace and education contacts for each SA2 in Aotearoa. The method used for constructing the network and for calculating the transmission risk proxy is detailed in[3]. In brief, the co-incidence network calculates the number of connections that exist to or from an SA2 based on the number of co-employment or co-enrolment links that all the people who are usually resident at a dwelling in that SA2 have with individuals who are usually resident in any other location. Given that the first detected case for the outbreak under consideration was a 58 year old male, we limit our analysis to only those connections related to co-employment.

Figure 1 shows the regions connected to the Devonport SA2 by co-employment relationships. We find that Devonport is strongly connected (at least 100 links) to most of the Auckland Region. It is less strongly connected to the neighbouring regions of southern Northland, northern Waikato, and Thames-Coromandel.

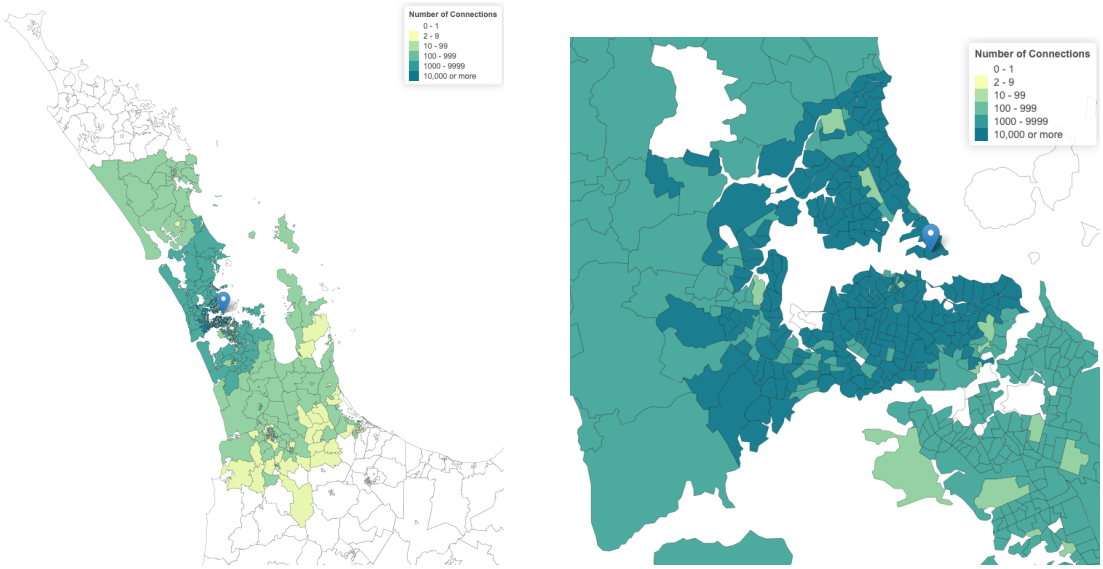

Figure 1. Map of SA2s linked to Devonport (indicated by blue pin) by co-employment relationships. Darker colours indicate more links. Most SA2s within the Auckland Region have between 100–1000 connections to Devonport; those SA2s located closer to the Auckland isthmus often have 1000–10,000 connections to Devonport. It is worth noting that the number of connections are totals for the SA2 as opposed to probabilities that have been normalised by population.

References

1. Harvey, E. *et al.* Network-based simulations of re-emergence and spread of COVID-19 in Aotearoa New Zealand. Tech. Rep., Te Pūnaha Matatini (2020).

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