Statistics Jersey

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21 May 2020 update: The modelling described in this report has not been updated further at this point in time, as the statistical technique requires a minimum number of confirmed cases in each time period in order to produce robust estimates. The total number of confirmed positive cases with date of symptom onset between 24 April and 10 May inclusive was 9, which is below the minimum number required to produce an updated measure of R_t. We will continue to monitor the case numbers, and will produce further estimates if and when robust estimates are possible.

Estimation of instantaneous reproduction number (R_t) for Covid-19 in Jersey Preliminary results

What is the reproduction number R?

The reproduction number of an infection describes how quickly the infection is spreading. It can be thought of as the number of subsequent infections that are introduced into a population by each infection. If this number is below 1, each successive generation of infections is smaller than the previous, and the number of infections dies out in time. Any number above 1, and successive generations of infection will be larger, and the number of new infections will grow.

R0, the basic reproduction number, is defined as the number of infections that would be introduced into a completely susceptible population by a single infection – i.e. if there were no immune or vaccinated members of the population – right at the beginning of an epidemic.

R_t is the *instantaneous* reproduction number and measures a similar concept – i.e. the number of new infections that are subsequently introduced into a population by each infection – but at any point in time, t. The instantaneous reproduction number assumes that the rate of spread of infection doesn't change during the infectious period of the new infections at time t. However, R_t may vary due to other factors – including aspects of the infection itself, as well as the size and behaviour of the susceptible population. The actual value of R_t may potentially change on a daily basis.

Not only may the actual value of R_t change on a daily basis, but there are many different methods that can be used to estimate R_t, and these may give slightly different results.

However, producing an estimate of R_t through time can give useful insight into changes in the rate of spread of infection during different phases of mitigation, and indicate the likelihood of infection numbers increasing.

How have we modelled R_t?

The particular estimation method used here was developed by scientists at Imperial College, London in 2013[1]. It uses the time-series of new incidences (i.e. the numbers of daily positive confirmed cases over time), and certain other assumptions (see below) to create a central estimate of R_t and a 95% credible interval[2] for each day.

The central, or median, estimate of R_t could be interpreted as the *most likely value* of R_t each day *under the set of model assumptions*. The 95% credible interval[2] indicates a *range of likely values* of the R_t estimates for each day. The width of the 95% credible interval indicates the uncertainty around the estimates. It is particularly high at the beginning of the incidence data.

[1] *Cori et al. (2003) "A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics", American Journal of Epidemiology, Vol 178, No. 9*

[2] *The credible interval can be thought of as the Bayesian equivalent of the confidence interval used in frequentist statistics*

If the 95% credible interval for a particular day includes a value just above '1', it is possible that R_t for that day was above 1, and the spread of infection could have been increasing. If the 95% credible interval for R_t for a particular day includes a value below '1', it is possible that R_t for that day was below 1, and the spread of infection was decreasing.

There could be periods where the credible interval includes numbers both above and below '1'. In this situation, the modelling outputs do not distinguish whether the spread of infection is increasing or decreasing at that point in time.

Modelling parameters and assumptions

The model requires an estimate of the distribution of the "serial interval" – the time between someone developing symptoms, and the persons they infect developing symptoms. The outputs in this report are based on the assumption of the serial interval being 4.4 days on average, with a standard deviation of 3 days[3]. The estimates could be improved by the use of individual serial interval data if available[4]. The model outputs have been found to be sensitive to this input parameter, particularly in the beginning of the curve.

The estimation assumes incidence data represents a constant proportion of new infections. Any changes to testing regime, e.g. how many are tested, which particular groups etc., will change the incidence data as a proportion of true cases; such changes have not been factored into the modelling of the estimation of R_t, but should be considered when interpreting the results. The estimation will therefore be optimal when testing regimes are stable and unchanging, and the only change in the incidence numbers are due to changes in incidences.

A ten-day estimation period was used to produce these outputs (i.e. the subsequent ten days of incidence data is used to estimate the R_t for a given day, under the assumption that the rate of infection spread remained stable during those ten days). Estimates will be more volatile with a smaller estimation period and smaller numbers of infections. A longer estimation period requires a longer subsequent time series to enable estimation of a particular time point, and the assumption of stability would generally not hold.

New confirmed cases (by date of symptom onset, where available, and by date of swab where not) were used, from 1st March to 5th May inclusive. Due to the ten-day estimation period, the chart shows R_t estimates up to 24 April 2020.

Results

The outputs of the modelling (see chart) can be used to provide estimates of instantaneous reproduction number at various stages of mitigation. Although there is a degree of uncertainty in these estimates, the broad trend and levels are useful to indicate the impact of mitigation and to inform further decision making.

The outputs indicate that R_t in Jersey reduced considerably following the introduction of social distancing for vulnerable groups, and also following 'Stay at home', during which latter period the daily estimates of R_t (and the corresponding 95% credible upper limits) are generally below 1.

For the first few weeks of April 2020, the daily R_t estimates range from 0.4 to 1.0, and the average of the daily median estimates is 0.8 for this time period. This behaviour is consistent with what can be inferred from the daily numbers of infections, and in particular the rate of change in these.

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[3] *Shi Zhaoet al. "Estimating the serial interval of 1 the novel coronavirus disease (COVID-19): A statistical analysis using the public data in Hong Kong from January 16 to February 15, 2020"*

[4] *Granular data of all, or a representative sample of, infections and the direct contact infections they generate, and details of the dates of symptom onset would give more accurate results and is something that could be considered when data is available*

Key:

●	Positive confirmed cases (moving average)
▬	Estimated daily R_t
(shaded)	95% credible interval for R_t

New confirmed cases (by date of symptom onset, where available, and by date of swab where not) were used in the modelling, from 1st March to 5th May inclusive. Due to the ten-day estimation period, the chart shows R_t estimates up to 24 April 2020.

Daily estimates of instantaneous reproduction number (R_t) for Covid-19 in Jersey