

Coronavirus (COVID-19): Analysis

Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 19)

Background

This is a report on the Scottish Government modelling of the spread and level of Covid-19. This updates the previous publication on modelling of Covid-19 in Scotland published on 17 September 2020. The estimates in this document help the Scottish Government, the health service and the wider public sector plan and put in place what is needed to keep us safe and treat people who have the virus.

This edition of the research findings focuses on the epidemic as a whole, looking at estimates of R, growth rate and incidence.

Key Points

- The reproduction rate R in Scotland is currently estimated as being between 1.2 and 1.6.
- The number of new daily infections for Scotland is estimated as being between 8 and 32, per 100,000 people.
- Scottish Government modelling of the epidemic estimates that on 21 September, there were around 5,700 (between 1,600 and 11,000) people in Scotland who could be infectious with Covid-19.
- The growth rate for Scotland is estimated as being between +4% and +9%.
- The estimated doubling time for Scotland is between 8.4 and 15.4 days.

Overview of Scottish Government Modelling

Epidemiology is the study of how diseases spread within populations. One way we do this is using our best understanding of the way the infection is passed on and how it affects people who catch it to create mathematical simulations. Because people who catch Covid-19 have a relatively long period in which they can pass it on to others before they begin to have symptoms, and the majority of people infected with the virus will experience mild symptoms, this “epidemiological modelling” provides insights into the epidemic that cannot easily be measured through testing e.g. of those with symptoms, as it estimates the total number of new daily infections and infectious people, including those who are asymptomatic or have mild symptoms.

Modelling also allows us to make short-term forecasts of what may happen with a degree of uncertainty. These can be used in health care and other planning. The modelling in this research findings is undertaken using different types of data which going forward aims to both model the progress of the epidemic in Scotland and provide early indications of where any changes are taking place.

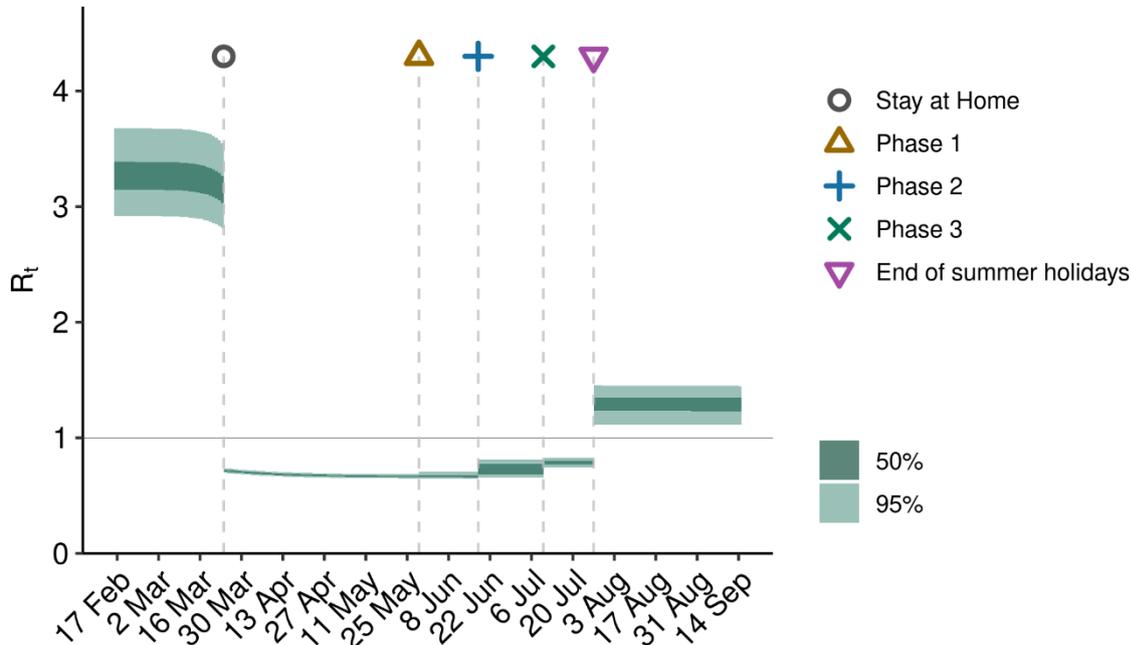
Modelling outputs are provided here on the current epidemic in Scotland as a whole, based on a range of methods. Because it takes a little over three weeks on average for a person who catches Covid-19 to show symptoms, become sick, and either die or recover, there is a time lag in what our model can tell us about any re-emergence of the epidemic and where in Scotland this might occur. However modelling of Covid deaths is an important measure of where Scotland lies in its epidemic as a whole. In addition the modelling groups which feed into the SAGE consensus use a range of other data along with deaths in their estimates of R and growth rate. These outputs are provided in the first part of this research findings. This week the type of data used in each model to estimate R is highlighted in Figure 2.

A short term forecast of the number of cases in the next two weeks is also provided, as the focus at this stage of the epidemic is the re-emergence of the virus in Scotland rather than whether there is sufficient hospital capacity to treat large numbers of Covid cases.

What the modelling tells us about the epidemic as a whole

Figure 1 shows how R_t has changed since February. Before the “stay at home” restrictions were put in place R_t was above 1, and most likely to have been between 2 and 4 before any interventions were put in place.

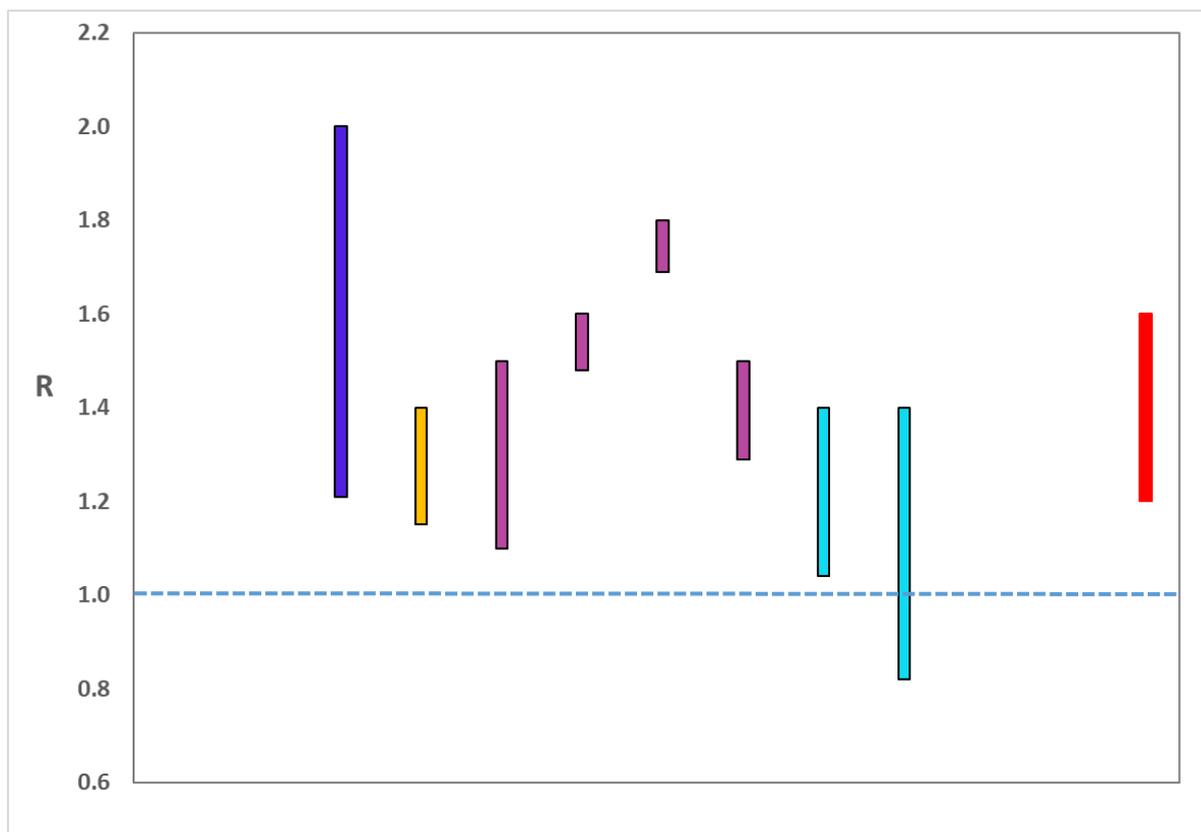
Figure 1: Trends in R_t for Scotland, 2020



Source: Scottish Government modelled estimates using Imperial College model code; actual data from <https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/deaths-involving-coronavirus-covid-19-in-scotland>

The various groups which report to the Scientific Pandemic Influenza Group on Modelling (SPI-M) use different sources of data in their models (i.e. deaths, hospital admissions, cases) so their estimates of R are also based on these different methods. SAGE’s consensus view across these methods, as of 23 September, was that the value of R_t in Scotland was above 1, between 1.2 and 1.6, meaning that the epidemic is growing exponentially. The R value estimated by the Scottish Government falls within this range, and is similar to the estimates of other modelling groups (Figure 2).

Figure 2. Estimates of R_t for Scotland, as of 23 September, including 90% confidence intervals, produced by SAGE. The blue bars are death-based models, purple use multiple sources of data and cyan use Covid-19 test results. The estimate produced by the Scottish Government (a semi-mechanistic model) is the 2nd from left (yellow), while the SAGE consensus range is the right-most (red).



Source: Scientific Advisory Group for Emergencies (SAGE).

On 22 September, Public Health Scotland recorded 383¹ positive new cases, with 1437 positive new cases over the week of 15 – 21 September.

The various groups which report to the Scientific Pandemic Influenza Group on Modelling (SPI-M) use different sources of data in their models to produce estimates of incidence. SPI-M's consensus view across these methods, as of 23 September, was that the incidence of new daily infections in Scotland was between 8 and 32 new infections per 100,000. This equates to between 460 – 1720 people becoming infected each day in Scotland. The incidence value estimated by the Scottish Government falls within this range.

¹ https://public.tableau.com/profile/phs.covid.19#!/vizhome/COVID-19DailyDashboard_15960160643010/Overview

Figure 3. Estimates of incidence for Scotland, as of 23 September, including 90% confidence intervals, produced by SPI-M. The purple bars represent models which use multiple sources of data. The estimate produced by the Scottish Government (a semi-mechanistic model) is the left-most (yellow), while the SAGE consensus range is the right-most (red).



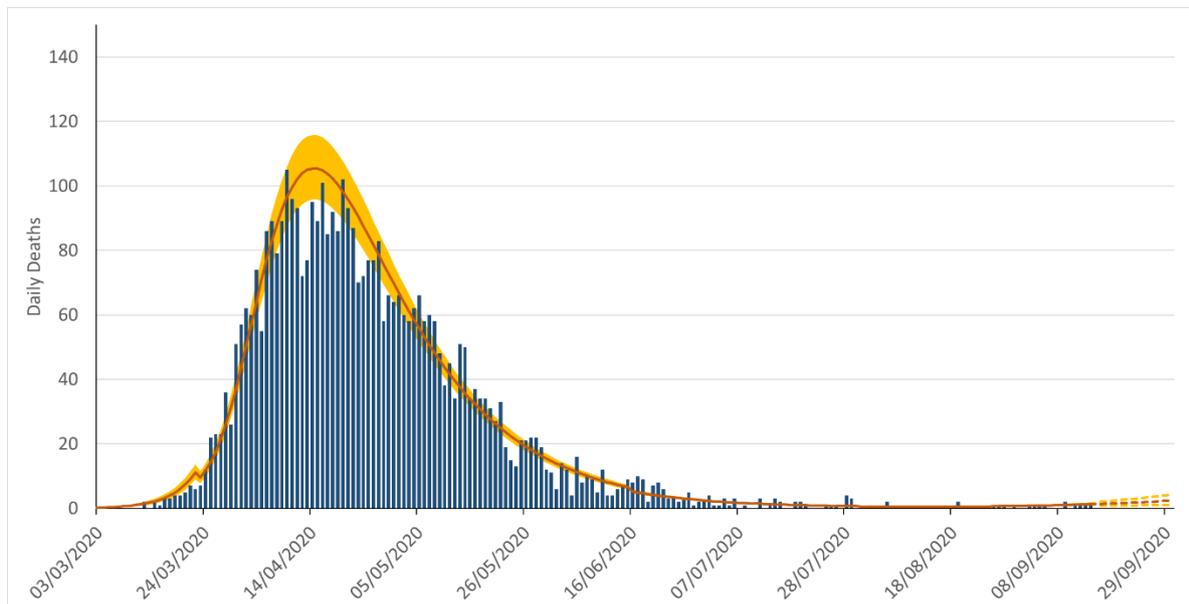
Source: Scientific Pandemic Influenza Group on Modelling (SPI-M).

The consensus from SAGE for this week is that the growth rate in Scotland is between +4% and +9% per day. This is higher than last week, when the growth rate was in the range +1% to +8%.

The spread of the epidemic can be expressed in terms of the length of time it takes for numbers of new daily cases to double. Doubling times were provided by SPI-M on 23 September. The consensus estimated doubling time for Scotland was between 8.4 and 15.4 days.

Figure 4 shows the epidemiological model forecasts of daily deaths produced by the Scottish Government, given the present set of interventions. This measure of the epidemic is forecast to increase in the weeks ahead.

Figure 4. Scottish Government short-term forecast of the number of deaths from Covid-19 in Scotland, based on actual data (10 September).



Source: Scottish Government modelled estimates using Imperial College model code; actual data from <https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/deaths-involving-coronavirus-covid-19-in-scotland>

Modifications outlined in the technical annex allow the Scottish Government model to once again be used to provide estimates of the likely number of people in Scotland who might be infectious (Table 1). This number has risen in recent weeks, and this is forecast to continue. These forecasts do not account for any changes in transmission associated with the measures announced on 22 September.

	Numbers of people in Scotland who might be infectious
07/09/2020	3200 (1600 - 5400)
14/09/2020	4250 (1850 - 7800)
21/09/2020	5700 (2150 - 11150)
28/09/2020	7650 (2500 - 16050)
05/10/2020	10250 (2850 - 23050)

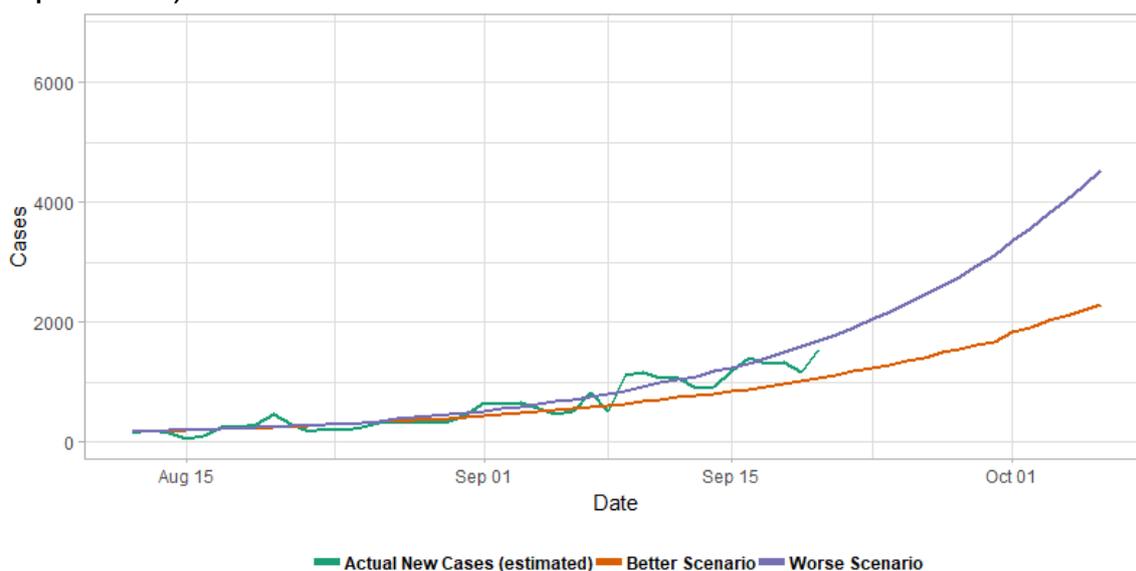
Table 1. Estimates, from Scottish Government modelling using Imperial College code of numbers of people in Scotland who might be infectious. 95% confidence ranges are given in parentheses. Forecast values are in shaded cells.

The logistical model developed by Scottish Government analysts to assess implications for health care demand (see previous Research Findings) has been adapted to produce a short-term forecast of cases.

The following two week ahead predictions use this model to extend the estimated number of infections from the Imperial College model, in a manner that fits with the estimated number of actual cases, adjusting positive tests to account for asymptomatic and undetected infections. The extension begins in mid-July, and assumes an R_0 value of around 1.3. Future R_0 values are based on agreed assumptions.

Figure 5 shows two predictions from this model - a “better scenario”, which assumes the current R_0 value remains constant over the next two weeks, and a “worse scenario”, which assumes that transmission increases in mid-September. Note that these scenarios do not account for the new measures announced on 22 September.

Figure 5. Short term forecast of new cases, with 90% prediction intervals, from Scottish Government modelling (actual data up to 21 September).



Exceedance is a tool which helps us to spot hotspots of Covid where the number of new cases exceeds what was expected. As cases rise across the country, it becomes less informative as the background level of expected cases increases. As a result, this will not be reported this week.

Last week we published the latest findings of the Scottish Contact Survey. A new tranche of results are being processed, and will be reported in future weeks.

What next?

The Scottish Government continues to work with a number of academic modelling groups to develop other estimates of the epidemic in Scotland.

The modelled estimates of the numbers of new cases and infectious people will continue to be provided as measures of the epidemic as a whole, along with measures of the current point in the epidemic such as exceedance. R_t and growth rate will also be provided. Further information can be found at <https://www.gov.scot/coronavirus-covid-19>.

Technical Annex: Development of semi-mechanistic Bayesian hierarchical epidemiological model

Scottish Government is using a publically available Imperial College London Covid-19 model² as described in previous issues of this publication series.

Our approach to modelling has changed as additional information has become available.

The infection-fatality rate (IFR) has been modified to reflect changes in the number of people in different age ranges interacting at different stages within the epidemic. The connectivity for each age classes was described in the previous issue. Furthermore the introduction of dexamethasone reduced the fatality rate.

As the focus of the modelling has shifted to fit the model for more recent data, the model has been amended to combine non-pharmaceutical interventions before-stay-at-home advice in to a single covariate.

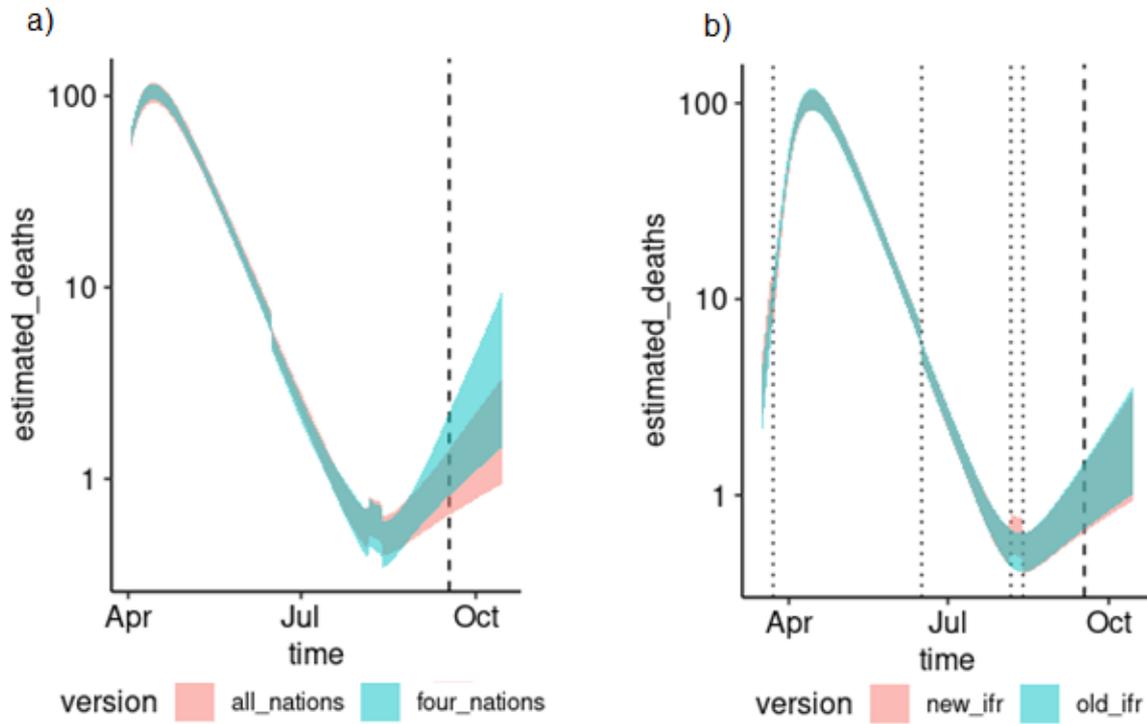
The model continues to reflect covariates representing the movement through phases. In addition to this, as a result of the behavioural changes observed through the Scottish Contact Survey an end of summer covariate is included.

A further modification to the model structure is sampling is taken only from the four UK nations due to the increase in the data time series across Europe increasing the computational processing times.

Sensitivity analysis of these change demonstrates limited influence in changes in the epidemic trajectory

² <https://github.com/ImperialCollegeLondon/covid19model>

Figure 6. Example model sensitivity comparisons of a) using original set of European nations compared to UK nations and b) the original IFR settings compared to an SCS-informed IFR.



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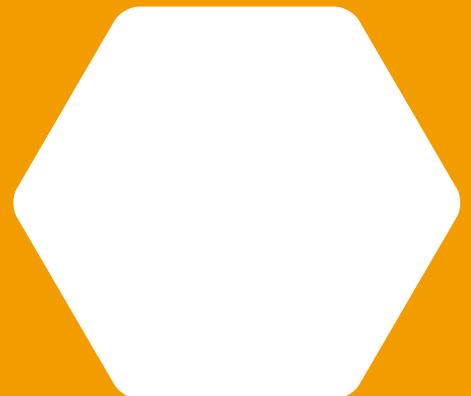
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