

Coronavirus (COVID-19): Analysis

Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 11)

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 24 July 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.

Now that numbers of deaths in Scotland are at a low level, this edition of the research findings focuses on the epidemic as a whole, looking at how many people in Scotland are likely to be infected with Covid at the present time, and in the next few weeks, and then goes on to introduce a new approach to modelling this point in the epidemic.

Key Points

- Modelling of the epidemic in Scotland estimates that on 24 July there were around 30 new infections and 300 people who could be infectious with Covid-19. Both of these numbers have fallen significantly in the last week and this is expected to continue.
- The rate of growth has increased from -31% to -24% which would suggest the rate of reduction in cases is smaller than it was 5 weeks ago.
- On 29 July, R in Scotland was estimated to be between 0.6 & 0.9.
- The epidemiological forecasts were based on estimates of moving into phase 2 guidance, implemented from 18 June. Changes associated with the move to phase 3 will not be fully seen until early August. The longer term forecasts will be closely monitored against actual cases over the next few weeks as the situation changes.

Overview of Scottish Government Modelling

Epidemiology is the study of how diseases spread within populations. One way we do this is to use 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 that 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.

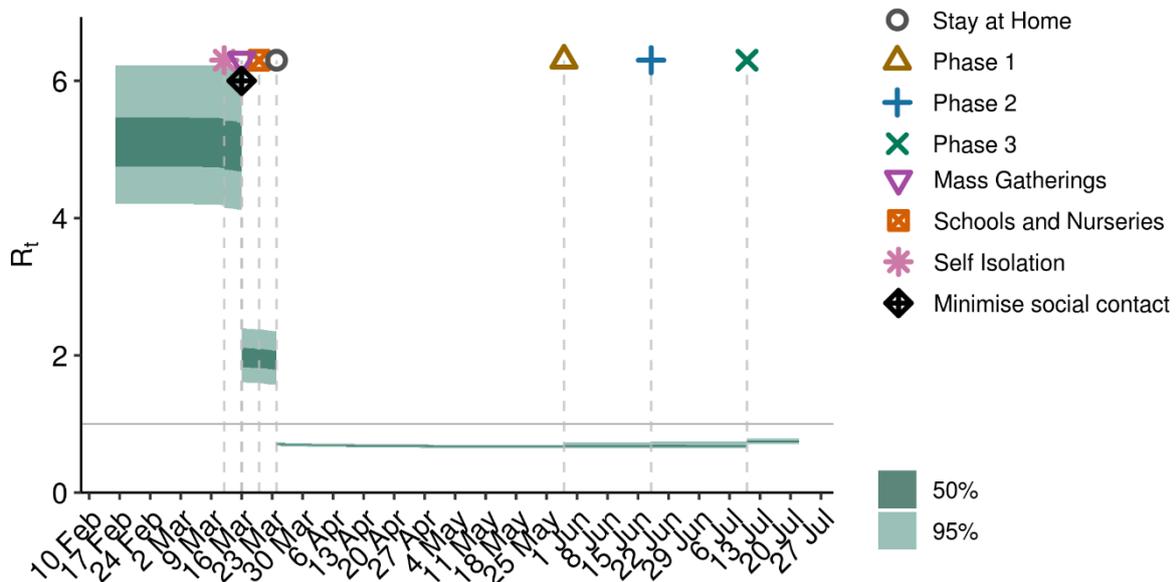
Firstly, modelling outputs are provided here on the current epidemic in Scotland as a whole, based on daily deaths and other data. This includes modelled estimates of the numbers of new cases and infectious people. Because it takes a little over three weeks on average for a person who catches Covid-19 to show symptoms, become sick, and either die or recover, there is a time lag in what this model can tell us about any re-emergence of the epidemic and where in Scotland this might occur. However modelling of Covid deaths across the epidemic is an important measure of where Scotland lies in its epidemic as a whole. In addition the modelling groups which feed into the SPI consensus use a range of other data along with deaths in their estimates of R. These outputs are provided in the first part of this research findings.

Secondly, going forward modelling will be provided around short term forecasts and measures of whether what we are seeing exceeds what would be expected. This replaces the short term modelling of NHS capacity provided in these reports previously, as the focus at this stage of the epidemic is around identifying any possible re-emergence of the virus in Scotland rather than whether there is sufficient hospital capacity to treat large numbers of Covid cases. This type of modelling uses early indicator data such as testing, contact and movement data. The first of these outputs will be provided in the second part of this research findings next week.

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 4 and 6 before any interventions were put in place.

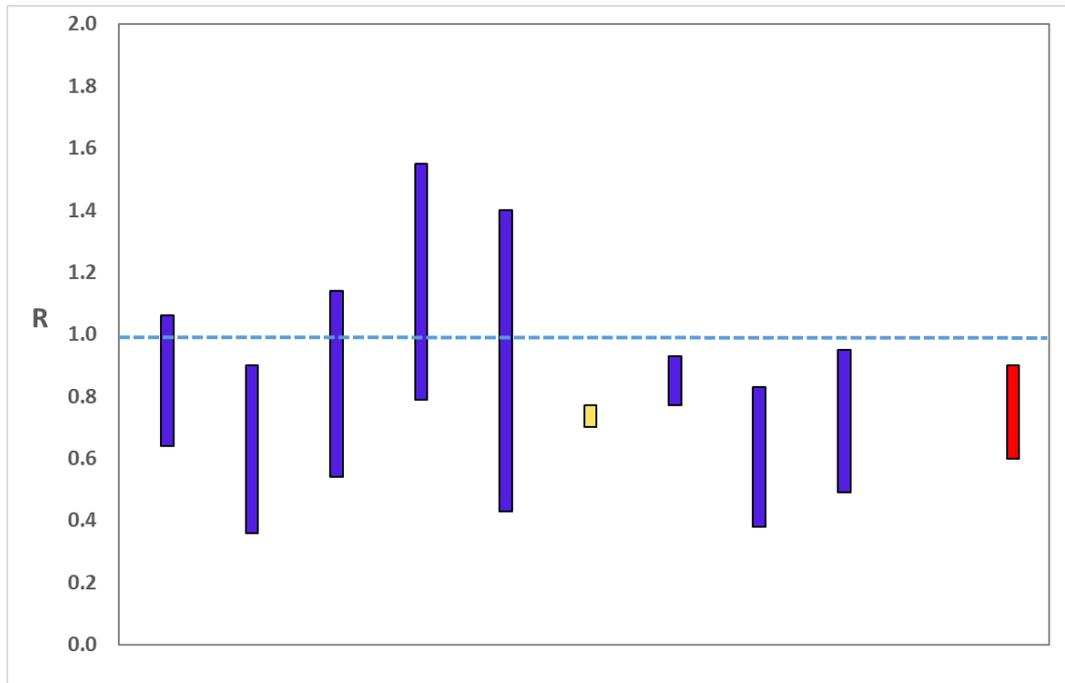
Figure 1: Trends in R_t for Scotland, 2020



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 R_t value estimated by the Scottish Government falls within the range of values estimated by other modelling groups and considered by SPI-M and SAGE (Figure 2). SAGE’s consensus view, as of 29 July, was that the value of R_t in Scotland was between 0.6 and 0.9.

Figure 2. Estimates of R_t for Scotland, as of 29 July, including 90% confidence intervals, produced by SAGE. The estimate produced by the Scottish Government is the 6th from left (yellow), while the SAGE consensus range is the right-most (red).



Source: Scientific Advisory Group for Emergencies (SAGE).

The Scottish Government's epidemiological model estimates that on 24 July there were around 30 new cases of Covid-19 in Scotland (see Table 1), while the number of people in Scotland who could be infectious on this date was around 300 (see Table 2). Our estimates indicate this number is declining by around 25% each week, and will continue to decline at a similar rate over the next two weeks.

Table 1: Estimated daily number of new Covid-19 cases in Scotland, rounded to nearest 10.

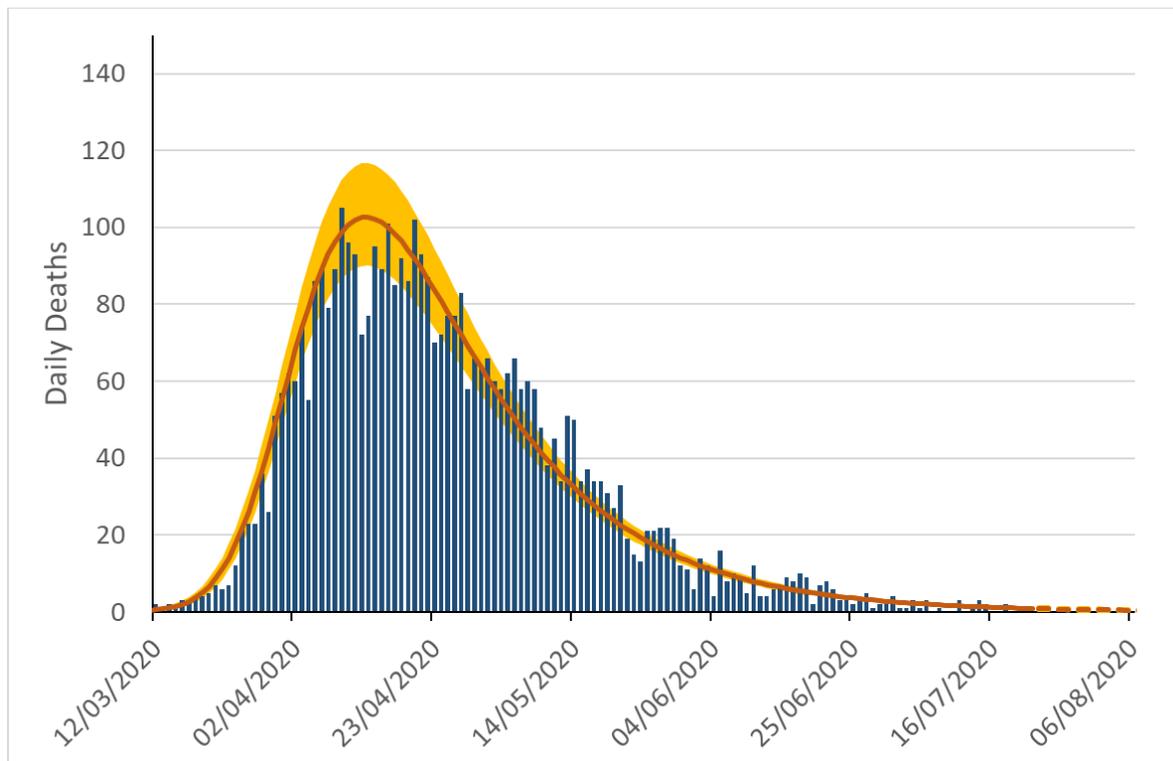
Estimated new daily infections			
Date	Mid	Lower	Upper
15 May	820	650	1,000
22 May	560	440	710
29 May	390	310	500
05 June	270	210	350
12 June	190	140	250
19 June	130	100	180
26 June	90	70	130
03 July	70	40	90
10 July	50	30	70
17 July	40	20	60
24 July	30	20	40
31 July	20	10	30
07 August	20	10	30

Table 2: Estimated number of people in Scotland who could be infectious, rounded to nearest 100.

Estimated Infectious Pool				
Date	Mid	Lower	Upper	Percentage Weekly Change
15 May	10,500	8,400	12,900	-31%
22 May	7,200	5,700	9,000	-31%
29 May	5,000	3,900	6,300	-31%
05 June	3,500	2,700	4,400	-30%
12 June	2,400	1,800	3,100	-30%
19 June	1,700	1,300	2,200	-30%
26 June	1,200	900	1,600	-30%
03 July	800	600	1,200	-30%
10 July	600	400	900	-29%
17 July	400	300	600	-24%
24 July	300	200	500	-24%
31 July	300	200	400	-24%
07 August	200	100	300	-24%

Figure 3 shows the epidemiological model forecasts of daily deaths produced by the Scottish Government, given the present set of interventions. This measure of the epidemic has declined to a very low level.

Figure 3. Scottish Government short-term forecast of the number of deaths from Covid-19 in Scotland, based on actual data (24 July).



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>

What the modelling tells us about whether Covid infections exceeded what would be expected at this stage in the epidemic

One of the ways we can look at this point in the epidemic is to calculate whether the number of confirmed infections (based on testing) exceeds the number that was expected - this is called “exceedance”, and analysis of trends across Local Authorities in Scotland has been carried out by modellers at Warwick University on behalf of the Scottish Government.

More information about exceedance is provided in the technical annex, ahead of publication next week.

What next?

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

Technical Annex

This technical annex outlines the new modelling work included in this research findings on exceedance.

Exceedance is defined by Health Protection Scotland as a: greater than expected rate of infection compared with the usual background rate for the place and time where the incident has occurred¹, we assume that the daily number of new positive cases should fall within a certain distribution of values, given the number of tests carried out each day, and the proportion of those we expect to be positive. The probability of getting the observed value of positive tests or greater can then be calculated. If this probability is small, the daily number of positive cases is much larger than would be expected by chance. We can now provide this at Local Authority level in Scotland using a model developed and run by Warwick University using Scottish testing data.

We can aggregate positive test results across several days to identify periods when the proportion of confirmed infections is high. This “cumulative exceedance” measure is more robust as it smooths variability in the data caused by, for example, multiple cases within larger households. As this cumulative exceedance value falls back to background levels, we can be confident that any outbreaks have been dealt with, as can be seen in the results for Dumfries and Galloway, in relation to the localised outbreak seen at the end of June (Figure 4).

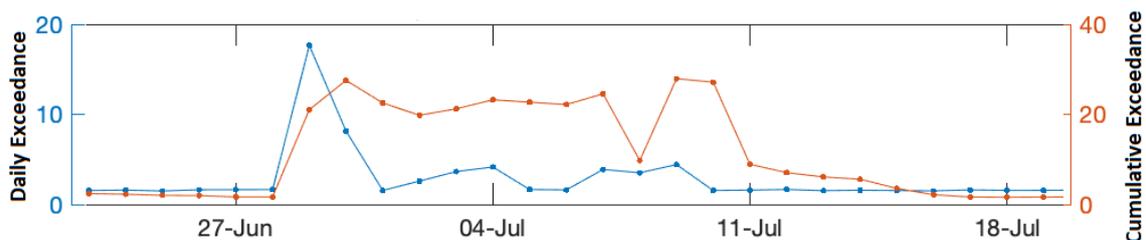


Figure 4. Trends of daily and cumulative exceedance for Dumfries and Galloway, 23 June – 19 July, showing a peak associated with the localised outbreak, before levels return to background.

Daily Exceedance

The daily exceedance is a measure of how far above the expected number of positive test today's results are, based on the number of tests, the national tests and the particular attributes of each Local Authority.

¹ https://hpspubsrepo.blob.core.windows.net/hps-website/nss/2181/documents/1_chapter-3-literature-review-v1.0.pdf

The expected proportion of positive tests EP for a given Local Authority is based on the daily pattern of positive tests from elsewhere in the country (and hence naturally accounts for the impact of both a declining epidemic and the impact of weekend effects); this value is scaled by the mean proportion of positive tests in the Local Authority over the past six weeks. We assume that the daily number of new positive cases should be drawn from a binomial distribution for the given number of tests and the expected proportion positive. The probability of getting the observed value or above can then be calculated. When this is small, the daily number of positive cases is much larger than would be expected by chance. We define the exceedance as:

- log (probability of getting today's number of positive cases or higher by chance)

Large values correspond to highly unlikely large positive values.

Recent Cumulative Exceedance

We can apply this approach backwards in time, to assess whether a Local Authority has had consistently high values over a period of many days. Again assuming a binomial distribution, we calculate the probability of observing the given cumulative number of positive cases over a given period compared with the expected number.

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