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Coronavirus (COVID-19): Analysis

Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 17)

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 3 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, it also looks at whether certain parts of Scotland are exceeding the number of cases which we would expect at this point in the epidemic, and then goes on to introduce improved modelling based on how many contacts people have with one another.

Key Points

- The reproduction rate R in Scotland is currently estimated as being between 1.1 and 1.5.
- The growth rate for Scotland is estimated as being between +3% and +9%.
- The number of new daily infections for Scotland is estimated as being between 0 and 13 per 100,000 people.
- There has been a sustained rise in positive new cases in most local authority areas rather than a small number exceeding expected levels in the week leading up to 7 September.

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.

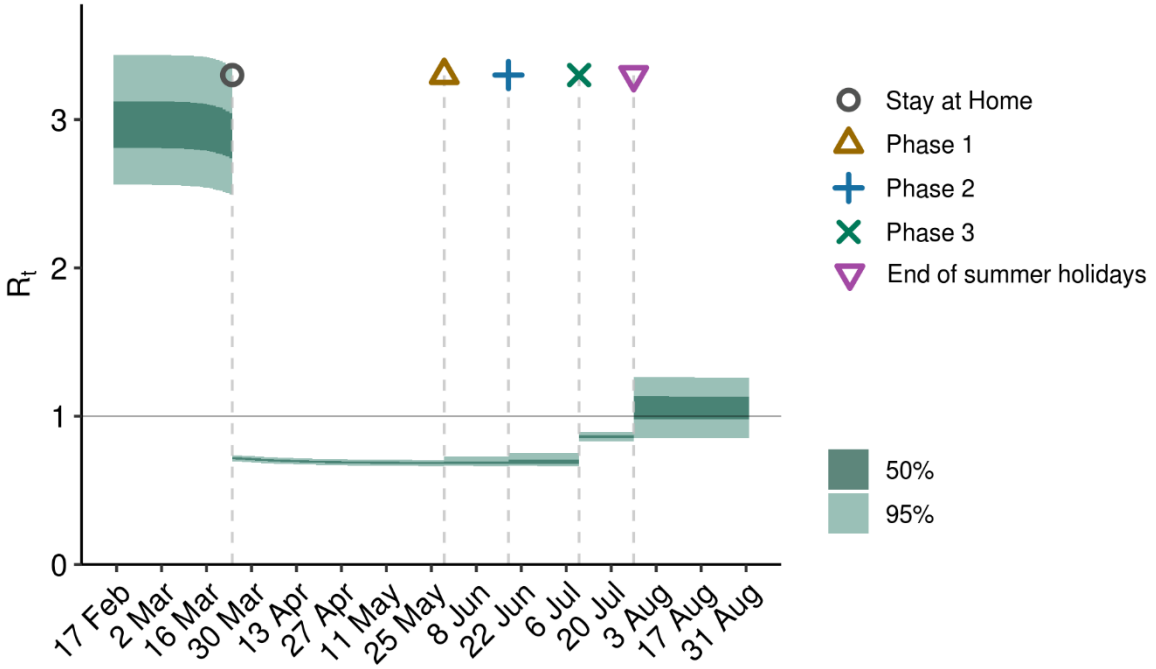
Firstly, modelling outputs are provided here on the current epidemic in Scotland as a whole, based on a range of methods. Because it takes a little over three weeks on average for a person who catches Covid-19 to show symptoms, become sick, and either die or recover, there is a time lag in what this 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.

Modelling is provided this week around the number of positive test results we are seeing, and on a short-term forecast of cases. 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.

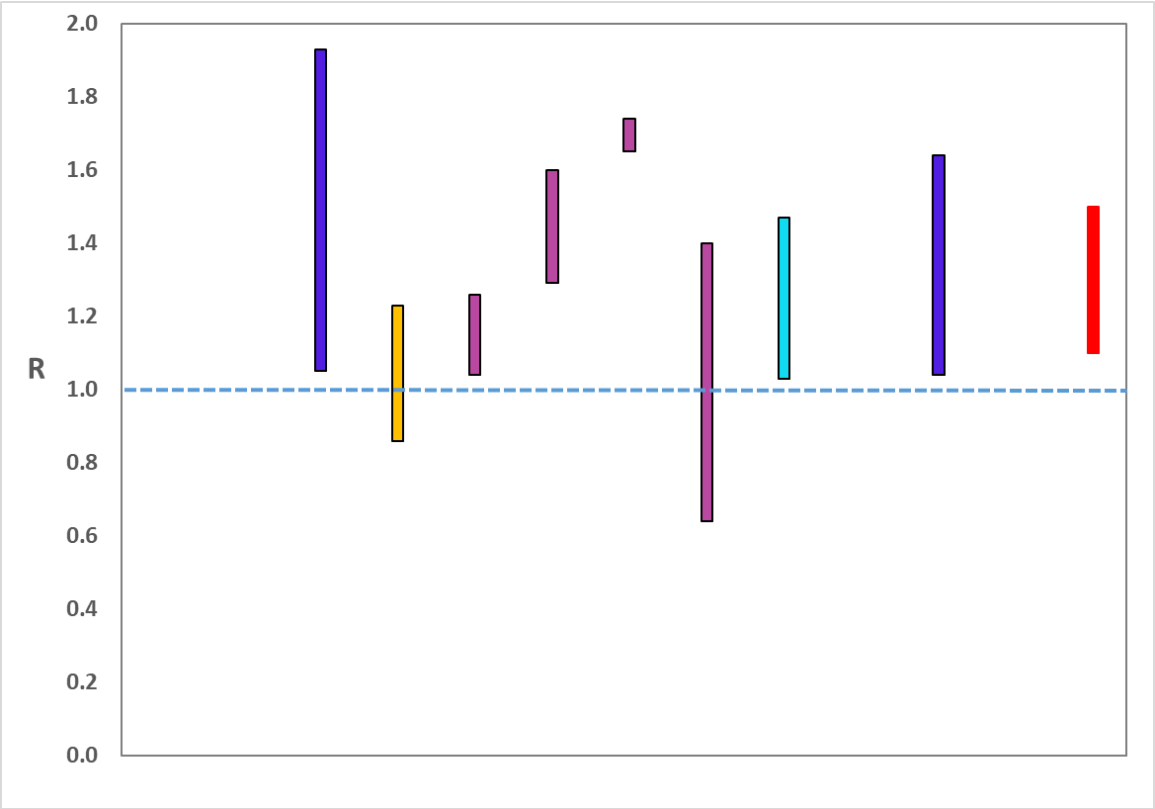
Figure 1: Trends in R_t for Scotland, 2020



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 9 September, was that the value of R_t in Scotland was above 1, between 1.1 and 1.5, 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 9 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).



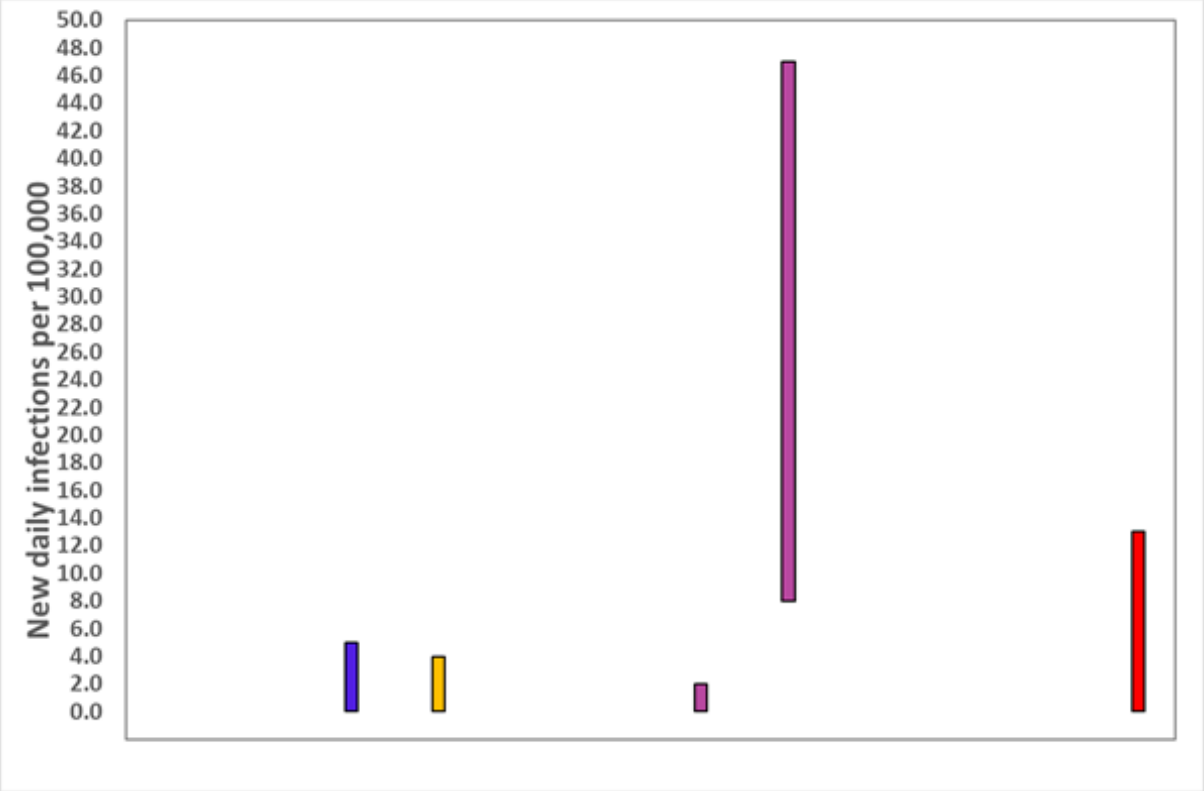
Source: Scientific Advisory Group for Emergencies (SAGE).

On 8 September, Public Health Scotland recorded 176[1] positive new cases, with 755 positive new cases over the week of 1 – 7 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 9 September, was that the incidence of new daily infections in Scotland was between 0 and 13 new infections per 100,000. The incidence value estimated by the Scottish Government falls within this range. This equates to between 0 – 700 people becoming infected each day in Scotland. Given the level of asymptomatic infected people, 176 positive confirmed tests remains 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 9 September, including 90% confidence intervals, produced by SPI-M. 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).

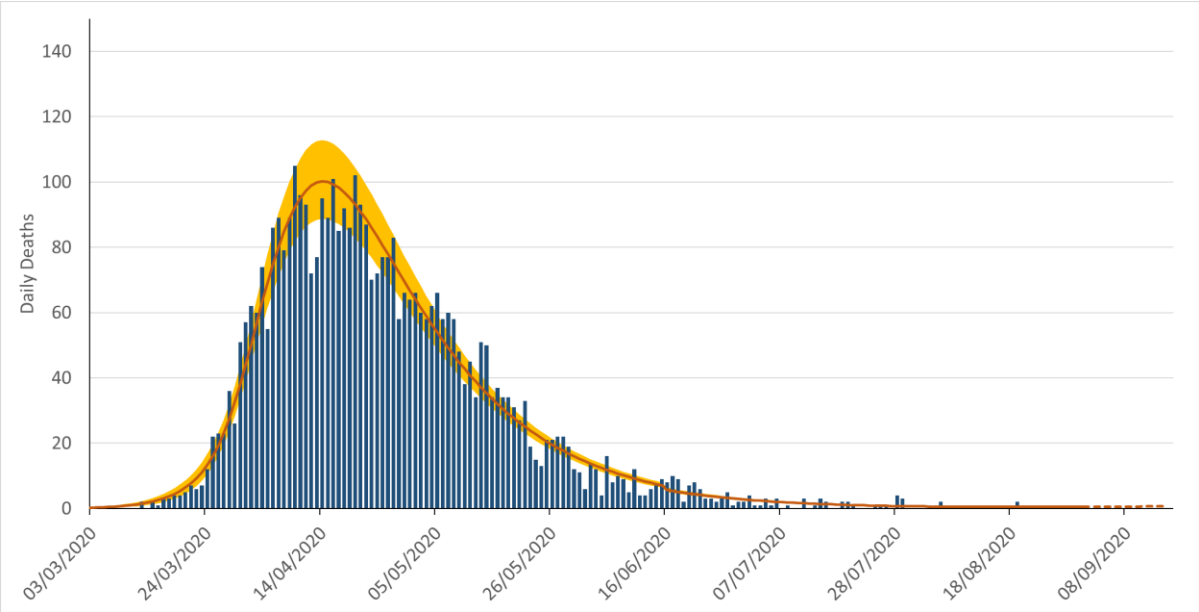


Source: Scientific Pandemic Influenza Group on Modelling (SPI-M).

The consensus from SAGE for this week is that the growth rate in Scotland is between +3% and +9% per day. This is an increase, compared to last week, where growth rate was in the range -1% to +8%.

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 remain near zero 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 (3 September).



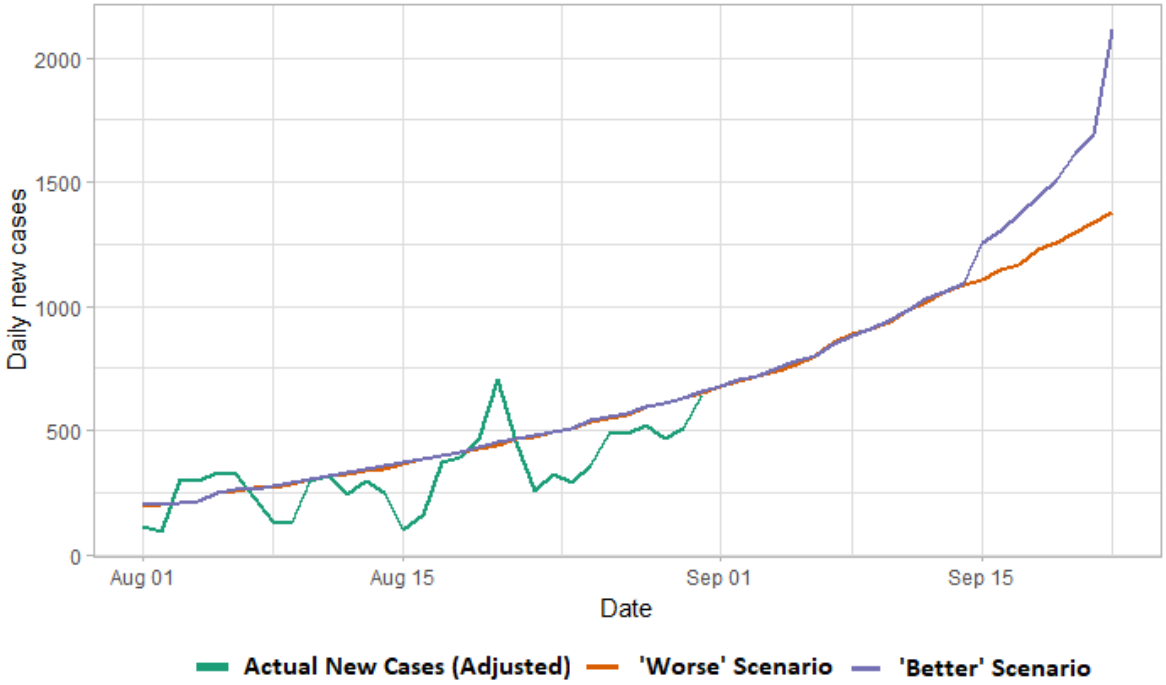
Source: Scottish Government modelled estimates using Imperial College model code; actual data from https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/deaths-involving-coronavirus-covid-19-in-scotland

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 number of actual cases, adjusted 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 judgement.

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.

Figure 5. Short term forecast of new cases, from Scottish Government modelling (actual data up to 30 August).



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

While metrics such as the reproductive rate - the R number - have been useful in guiding our response to Coronavirus so far, the models we use rely on numbers of deaths to track the epidemic. These fell to low levels, which prompted us to find new ways to monitor trends in the epidemic. One of the ways we can do this is to calculate whether the number of confirmed infections (based on testing) in each area exceeds the number that was expected, given the number recorded across the country - this is called "exceedance". An analysis of trends across Local Authorities in Scotland has been developed by modellers at the University of Warwick on behalf of the Scottish Government.

Numbers of positive tests recorded each day, adjusted for population of each local authority and number of cases seen in preceding weeks, should fall within a certain distribution of values, which will rise and fall depending on the number of cases being seen nationally. Areas where the number of positive test results fall beyond the upper 95th percentile of this distribution may be at risk of seeing increased local transmission of Covid and heightened vigilance may be required. This happens when the cumulative exceedance is higher than 6.0.

Unlike previous weeks which have been characterised by local outbreaks in places like Aberdeen and Perthshire, in the week up to 7 September, the picture across Scotland was one of a general and widespread increase in the number of new confirmed cases. As a result, no local authority areas recorded “significant” (>6.0, $p > 0.05$) levels of cumulative exceedance (Figure 6). The analysis identified Dumfries and Galloway (5.4), Renfrewshire (3.7), West Lothian (3.3) and Glasgow City (3.1) as areas of higher risk of transmission, however given the rising background of positive new cases across the country, these were only slightly above expected levels (Figure 7).

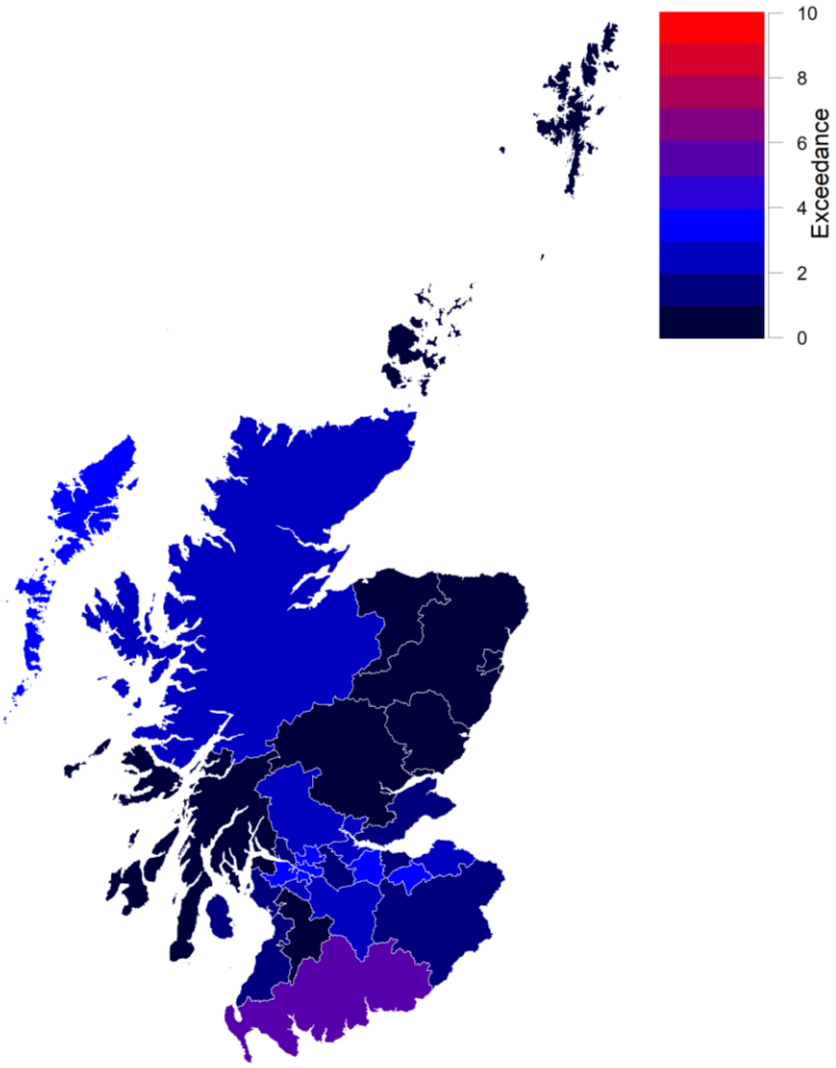


Figure 6. Map of cumulative exceedance, 7 September, for Scottish Local Authorities.

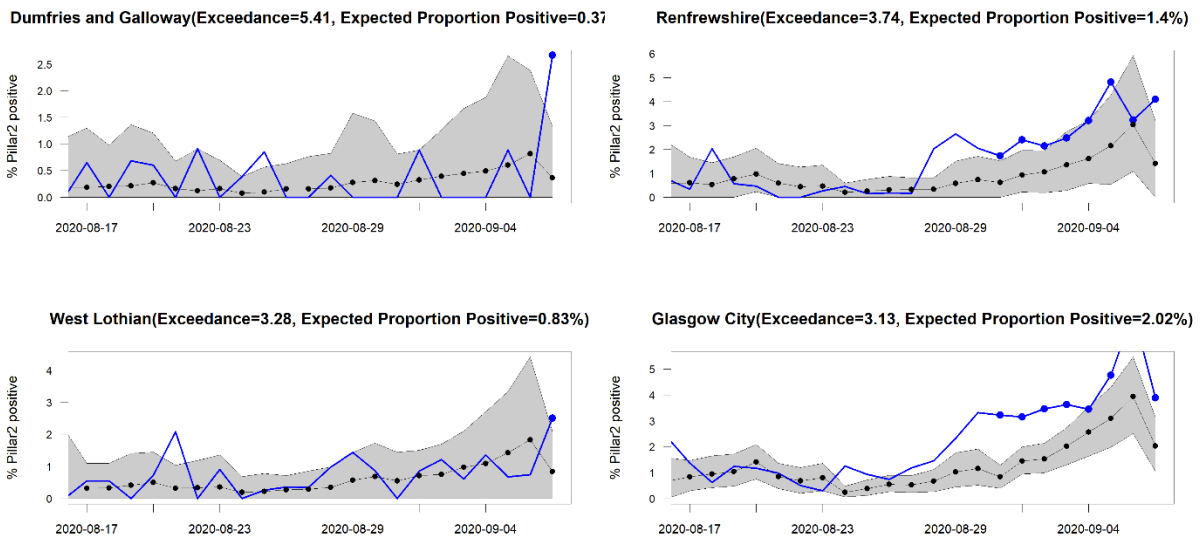


Figure 7. Graphs of cumulative exceedance (blue) and the range of expected values (grey) for the local authorities deemed as higher risk over the period 1 - 7 September.

What next?

The Scottish Government has also been working with a number of academic modelling groups to develop other estimates of the epidemic in Scotland. Recently, we introduced the Exceedance method developed by the University of Warwick, and next week we hope to introduce a new way of measuring the epidemic which is based on a survey of people's behaviours, rather than numbers of cases or deaths.

The London School of Hygiene and Tropical Medicine have developed a modelling technique called "CoMix" which is based on how may contact people have each week. The contacts people have are collected via an online survey. Until now Scotland has been included in their modelling but represented by around 10% of respondents (under 150 people) leading to a high level of uncertainty in the results. Scottish Government are now running a Scottish survey to boost these numbers to over 3,000 people, the "COVID-19 online research panel". The outputs of the model will provide alternative measures of the epidemic at the time (e.g. R number) and will provide an early indication of a resurgence in the virus. Having a range of different types of models for Scotland is the best chance of spotting an upturn in cases and help us plan what to do if this happens.

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.

This publication will be available in accessible HTML on the gov.scot website

The views expressed in this report are those of the researcher and do not necessarily represent those of the Scottish Government or Scottish Ministers.

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