

Coronavirus (COVID-19): Analysis

Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 75)

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 21st October 2021. The estimates in this document help the Scottish Government, the health service and the wider public sector plan and put into 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 as well as local measures of change in the epidemic.

In Scotland, the modelled estimate for R is between 0.8 and 1.0, with the growth rate between -3% and 0%.

Key Points

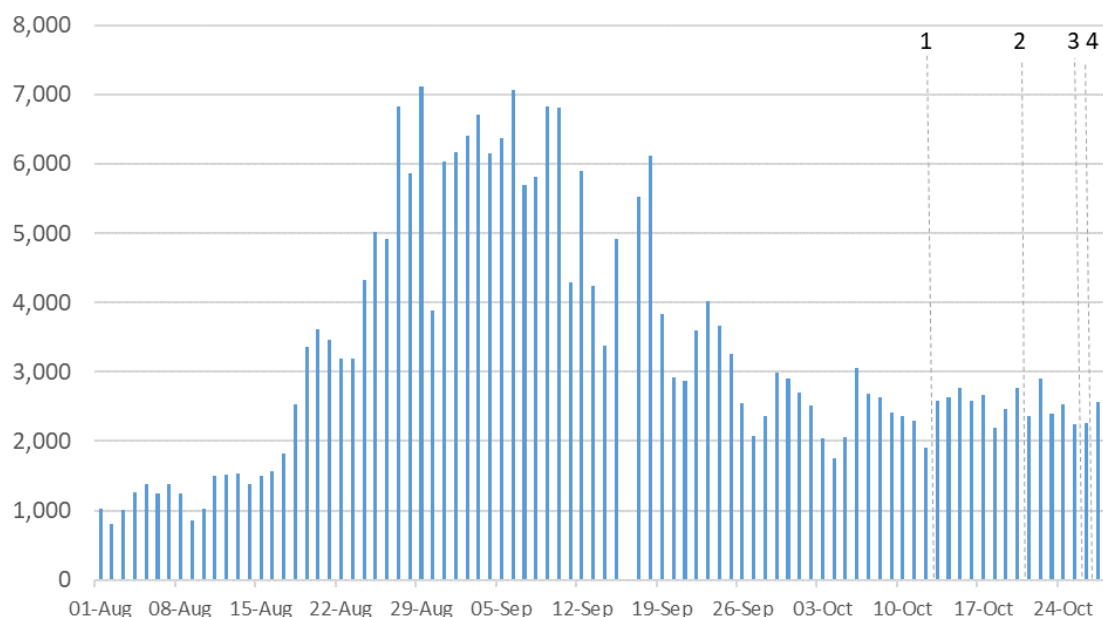
- The reproduction rate R in Scotland is currently estimated as being between 0.8 and 1.0, as of 12th October. This is unchanged from last week.
- The number of new daily infections for Scotland is estimated as being between 77 and 105, per 100,000 people. The upper limit has decreased since last week.
- The growth rate for Scotland is currently estimated as between -3% and 0%. This is unchanged from last week.
- Average contacts have remained at a similar level in the last two weeks (comparing surveys pertaining to 30th September - 6th October and 14th October - 20th October) with a current level of 4.6 daily contacts.
- Mean contacts within the work and home setting have decreased by around 16% and 6% respectively in the last two weeks. Contacts in the other setting (contacts outside home, school and work) have increased by 6% over the same period.

- Those aged between 30-39 have reported the biggest decrease in interactions with those aged under 18 in the last two weeks whereas interactions between the 18-29 age group with each other have doubled in the last two weeks.
- Visits to a non-essential shop have increased from approximately 41% to 46% with individuals attending a pub or restaurant increasing from 47% to 52% in the last two weeks.
- The proportion of contacts reported to have been indoors only has reduced slightly in the last two weeks from 68% to 66%.
- The number of people wearing a face covering where they have at least one contact outside of the home remains at a similar level to two weeks prior, currently at 80%.
- Hospital and ICU occupancies are in a plateau. There continues to be uncertainty over hospital occupancy and intensive care in the next three weeks.
- Modelled rates of positive tests per 100K using data to 25th October indicate that, for the week commencing 7th November 2021, there are 29 local authorities which are expected to exceed 50 cases per 100K with at least 75% probability.
- These 29 local authorities are also expected to exceed 100 cases per 100K with at least 75% probability.
- There are no local authorities which are expected to exceed 300 cases per 100K with at least 75% probability.
- Nationwide, Covid-19 levels in wastewater were similar or slightly lower than those seen last week (13th to 19th October). This brings levels in line with recent trends in case rates.
- Modelling of long Covid estimates that on 14th November 2021 between 1.3% and 2.8% of the population are projected to self-classify with long Covid for 12 weeks or more after their first suspected Covid infection in Scotland. The upper and lower limits of the estimate are higher than last week.

Recent cases

Figure 1 shows the number of Covid-19 cases reported in Scotland between July and October 2021. The vertical dashed lines indicate the cut off points for each of the modelling inputs; after these dates, the number of cases is not incorporated into the outputs.

Figure 1: Cases reported in Scotland to 28th October 2021¹



R, growth rate and incidence are as of 12th October (dashed line 1). The Scottish Contact Survey uses data to 20th October (dashed line 2). The Scottish Government modelling of infections, hospitalisations and ICU beds, the long Covid analysis, the medium term projections and modelled rates of positive tests per 100K use data to 25th October (dashed line 3). Wastewater analysis uses data to 26th October (dashed line 4).

Overview of Scottish Government Modelling

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-19 deaths is an important measure of where Scotland lies in its epidemic as a whole. In addition, the modelling groups that feed into the UK Health Security Agency (UKHSA) consensus use a range of other data along with deaths in their estimates of R and the growth rate. These outputs are provided in this research findings. The type of data used in each model to estimate R is highlighted in Figure 2.

We use the Scottish Contact Survey (SCS) to inform a modelling technique based on the number of contacts between people. Over time,

¹ On 16 September 2021, daily data on new cases and tests were not refreshed due to a technical issue affecting the availability of the data.

a greater proportion of the population will be vaccinated. This is likely to impact contact patterns and will become a greater part of the analysis going forwards.

The logistical model utilises results from the epidemiological modelling, principally the number of new infections. The results are split down by age group, and the model is used to give a projection of the number of people that will go to hospital, and potentially to ICU. This will continue to be based on both what we know about how different age groups are affected by the disease and the vaccination rate for those groups to estimate the proportion of cases that will require hospital, and the length of time people that people will stay there.

What the modelling tells us about the epidemic as a whole

The R value and growth rates are estimated by several independent modelling groups based in universities and the UKHSA. Estimates are considered, discussed and combined at the Epidemiology Modelling Review Group (EMRG), which sits within the UKHSA.

UKHSA's consensus view across these methods, was that the value of R as at 12th October² in Scotland was between 0.8 and 1.0 (see Figure 2)³.

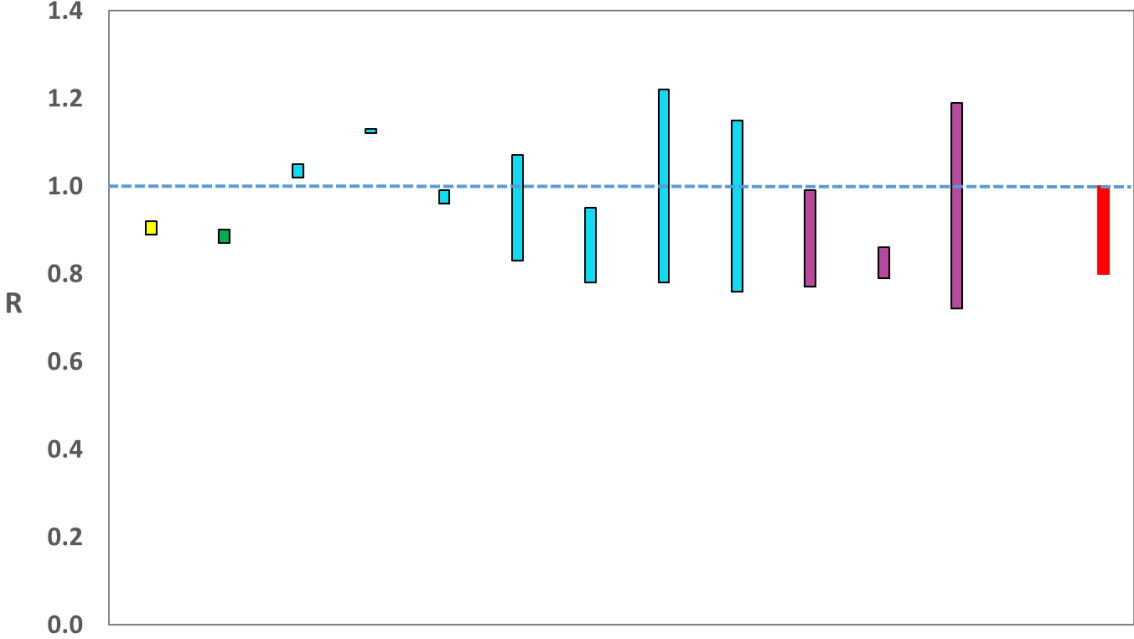
R is an indicator that lags by two to three weeks and therefore should not be expected to reflect recent fluctuations.

This week the Scottish Government presented two outputs to EMRG. The first uses confirmed cases, as published by Public Health Scotland (PHS), and deaths from National Records Scotland (NRS). The second uses instead wastewater data to estimate the number of cases, and deaths from NRS. Both outputs are shown in Figures 2 and 3.

² Using data to 25th October 2021.

³ Particular care should be taken when interpreting this estimate as it is based on low numbers of cases, hospitalisations, or deaths and / or dominated by clustered outbreaks. It should not be treated as robust enough to inform policy decisions alone.

Figure 2. Estimates of R_t for Scotland, as of 12th October, including 90% confidence intervals, produced by EMRG⁴.

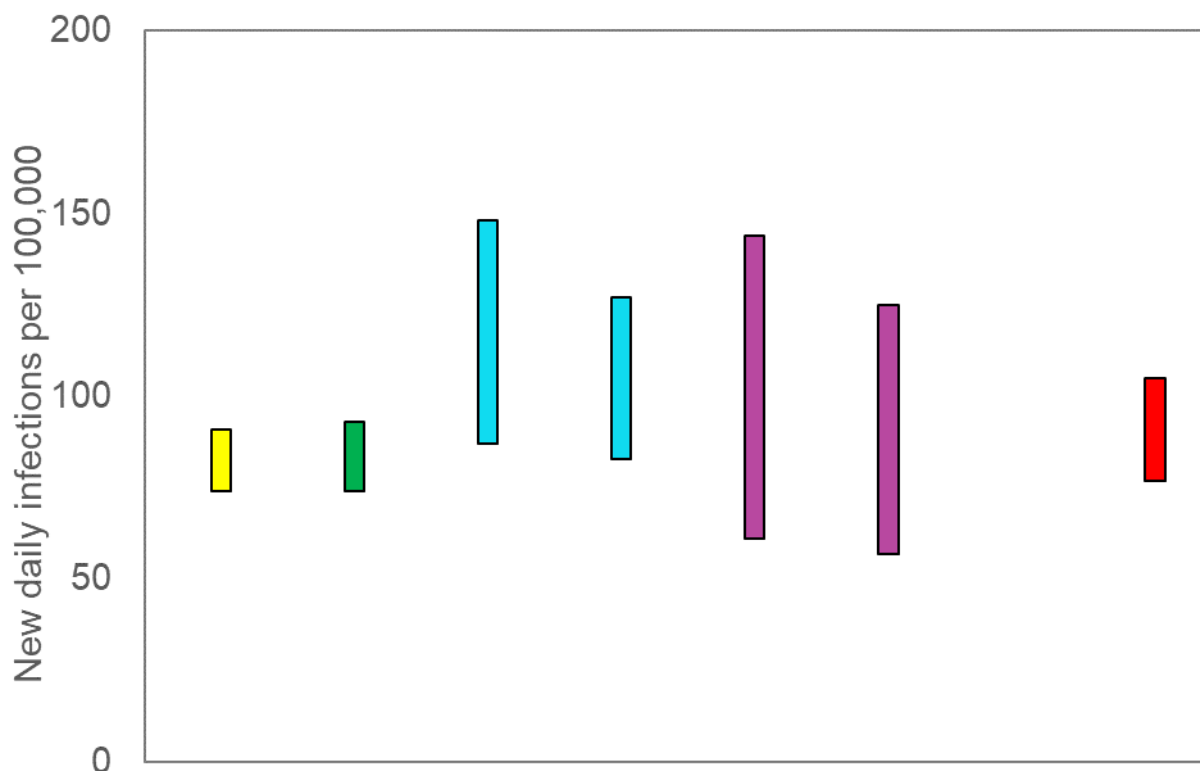


Source: EMRG

The various groups which report to the EMRG use different sources of data in their models to produce estimates of incidence (Figure 3). UKHSA’s consensus view across these methods, as at 12th October, was that the incidence of new daily infections in Scotland was between 77 and 105 new infections per 100,000. This equates to between 4,200 and 5,700 people becoming infected each day in Scotland. The upper limit has decreased since last week.

⁴ The cyan bars use Covid-19 test data and purple bars use multiple sources of data. The estimates produced by the Scottish Government are the two on the left. (Yellow uses confirmed cases from PHS and deaths from NRS; green uses wastewater data). The UKHSA consensus range is the right-most (red). Data to 25th October. R, incidence and growth rate as of 12th October.

Figure 3. Estimates of incidence for Scotland, as at 12th October, including 90% confidence intervals, produced by EMRG⁴.



Source: EMRG

The consensus from UKHSA for this week is that the growth rate in Scotland is between -3% and 0% per day as at 12th October. This is unchanged since last week.

What we know about how people’s contact patterns have changed

Average contacts have remained at a similar level in the last two weeks (comparing surveys pertaining to 30th September - 6th October and 14th October - 20th October) with a current level of 4.6 daily contacts as seen in Figure 4. Mean contacts within the work and home settings have decreased by around 16% and 6% respectively in the last two weeks. Contacts in the other setting (contacts outside home, school and work) have increased by 6% over the same period.

Figure 4. Mean Adult Contacts (truncated at 100) from SCS.

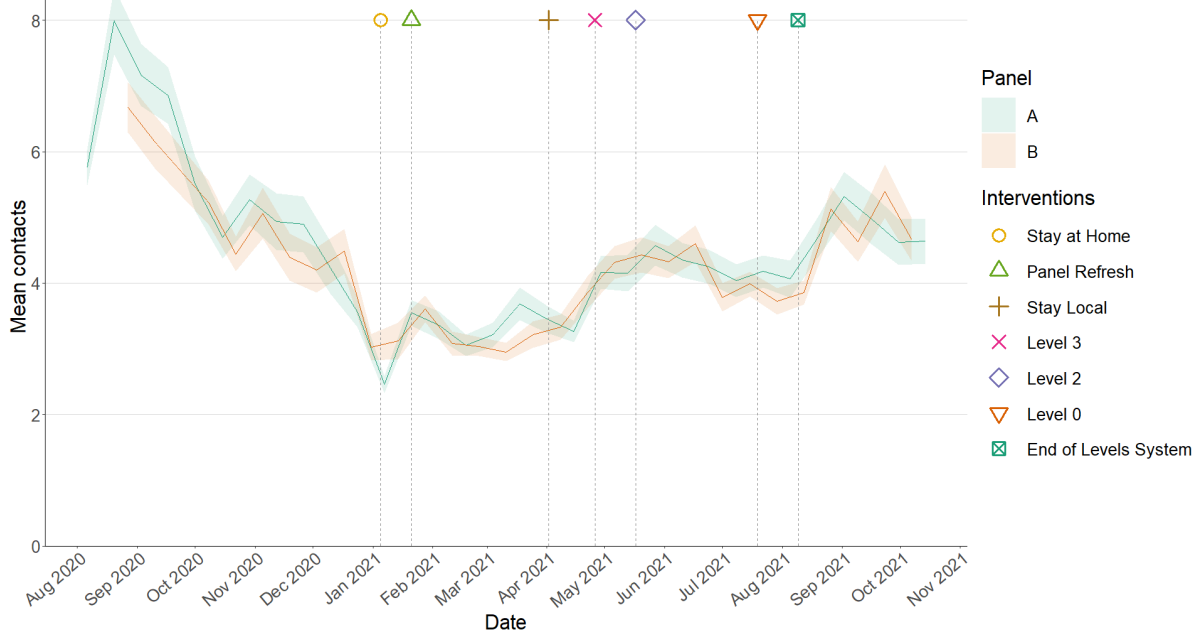
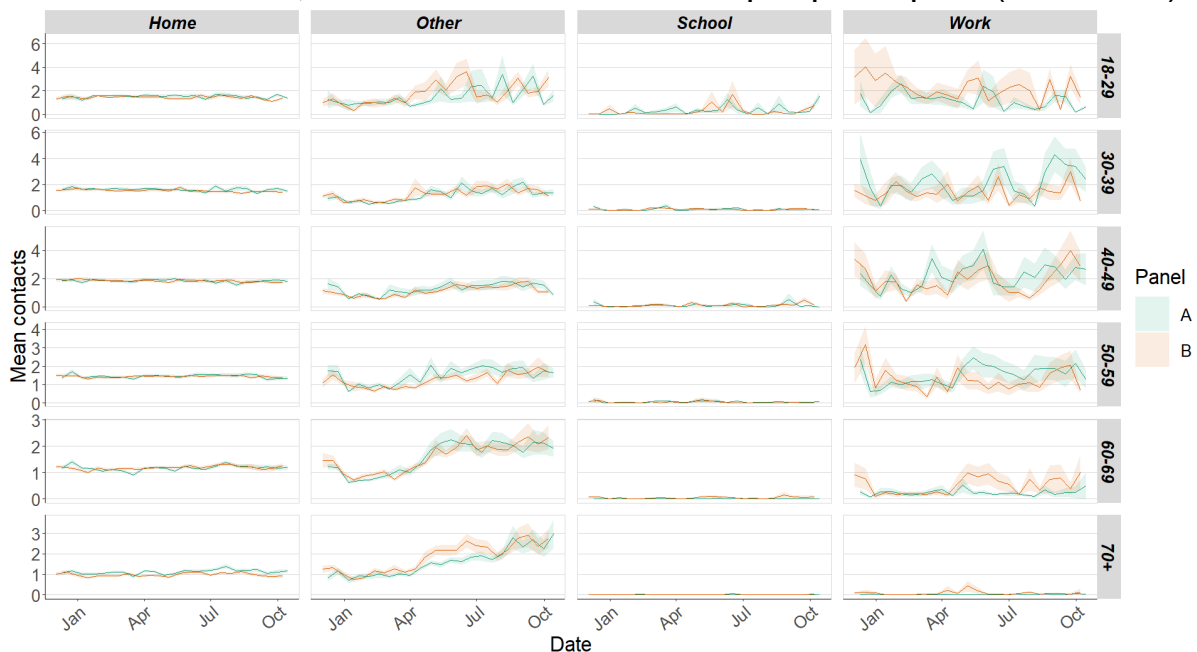


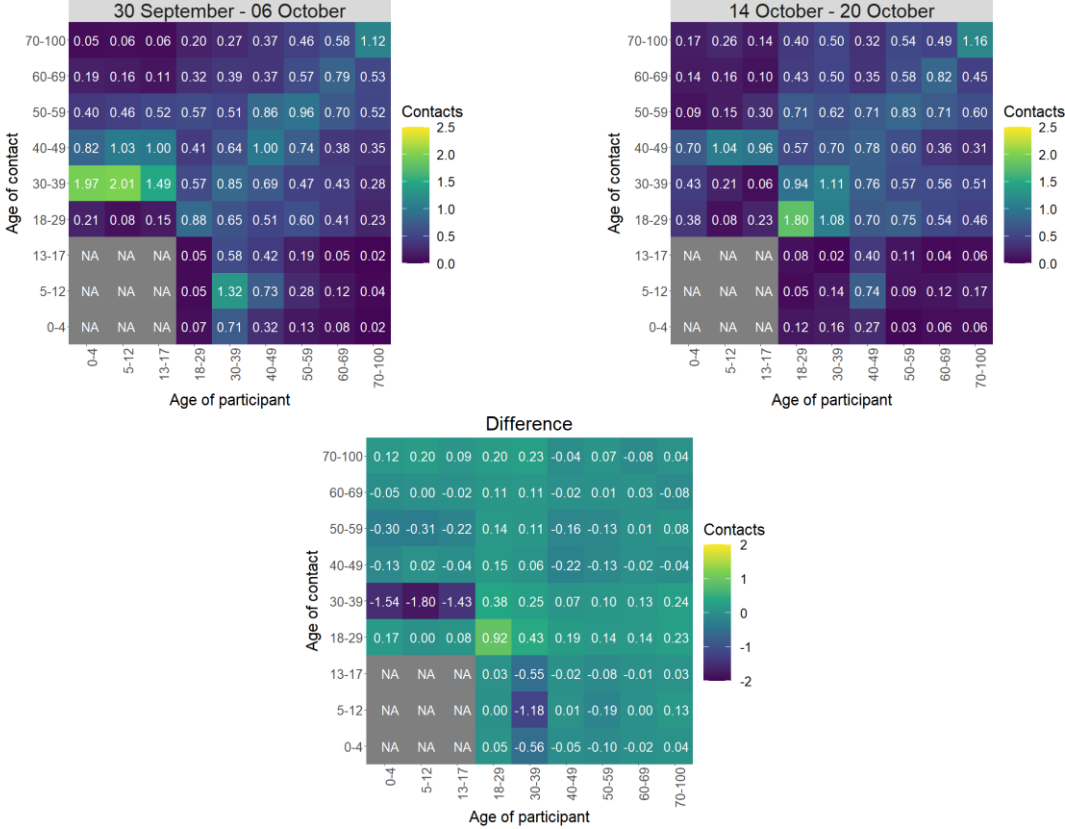
Figure 5 shows how contacts change across age group and setting. Those aged 70 and over and also individuals in the 18-29 age group reported an increase in overall contacts whereas all remaining age groups reported a decrease or remained at similar levels. The increase is largely driven by a rise in contacts within the work setting for the 18-29 age group and an increase in contacts within the other setting for those over 70.

Figure 5. Average (mean) contacts for each panel per day by setting for adults in Scotland, truncated to 100 contacts per participant (from SCS).



The heatmaps in Figure 6 show the mean overall contacts between age groups for the weeks relating to 30th September - 6th October and 14th October - 20th October and the difference between these periods. Those aged between 30-39 have reported the biggest decrease in interactions with those aged under 18 in the last two weeks whereas interactions between the 18-29 age group with each other have doubled in the last two weeks.

Figure 6. Overall mean contacts by age group for the weeks relating to 30th September - 6th October and 14th October - 20th October.



The biggest changes in the proportion of participants visiting different locations, though slight, is seen in those visiting a non-essential shop and also those visiting a pub or restaurant. Visits to a non-essential shop have increased from approximately 41% to 46% with individuals attending an pub or restaurant increasing from 47% to 52% in the last two weeks.

Figure 7. Locations visited by participants at least once for panel A and B (from SCS).

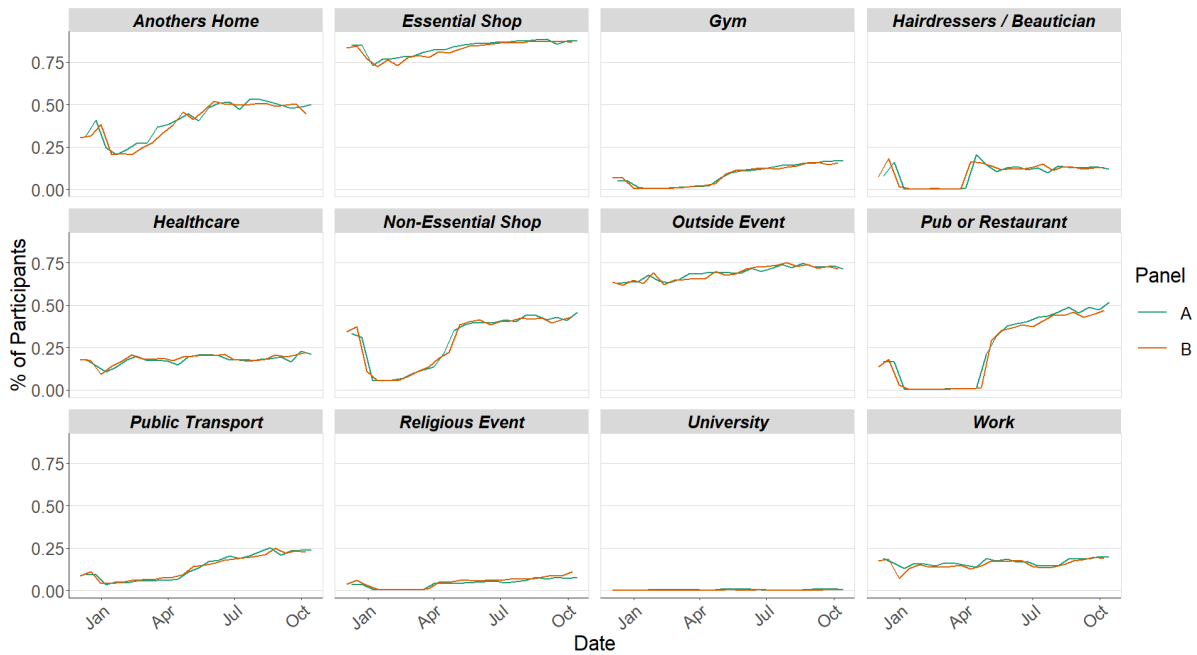


Figure 8 shows the proportion of participants that reported contacts indoors and outdoors for contacts individually reported for panel A. A contact can also be recorded as both indoor and outdoor. The proportion of contacts reported to have been indoors only has reduced slightly in the last two weeks from 68% to 66%.

Figure 8. Proportion of participants reported indoors and outdoors for contacts individually reported for panel A.

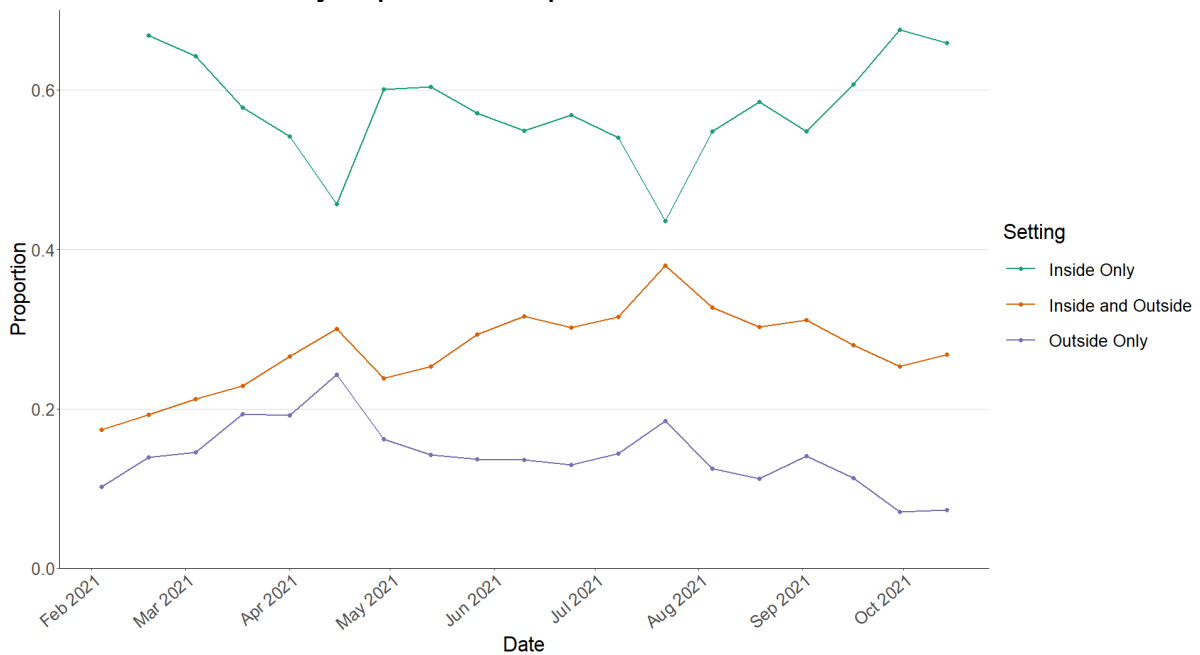
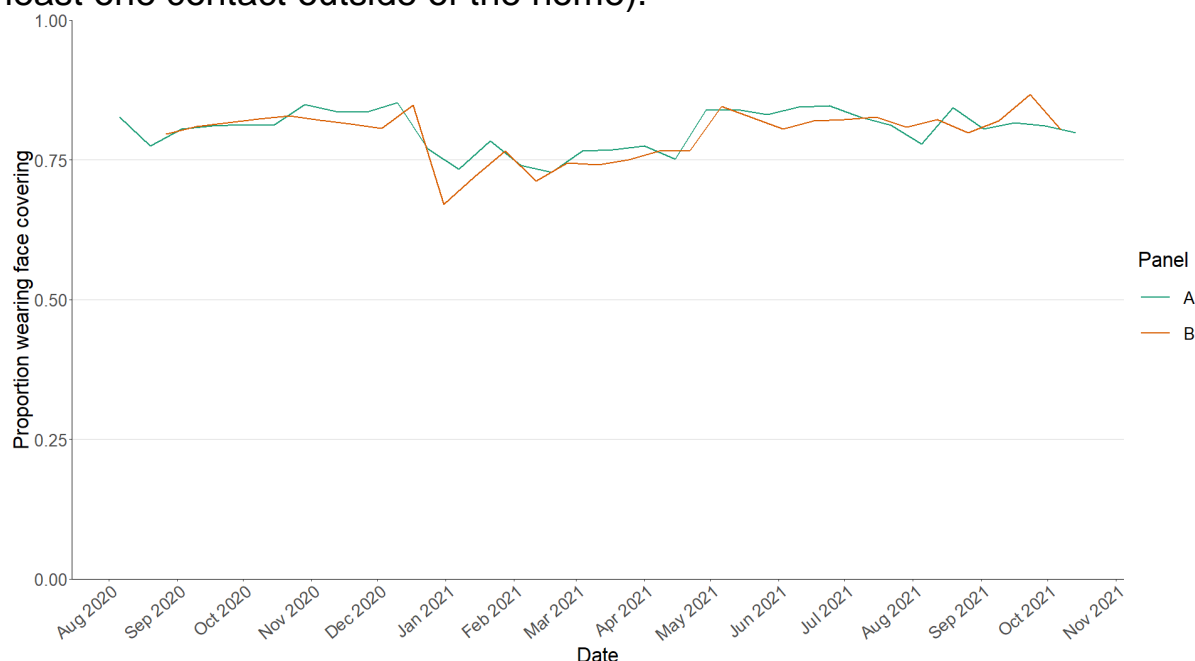


Figure 9 shows the number of people wearing a face covering where they have at least one contact outside of the home. This remains at a similar level to two weeks prior, currently at 80%.

Figure 9. Proportion of adults wearing a face coverings over time (with at least one contact outside of the home).



What the modelling tells us about estimated infections as well as Hospital and ICU bed demand

The Scottish Government assesses the impact of Covid-19 on the NHS in the next few weeks in terms of estimated number of infections. Figure 10 shows three projections over the three weeks to 14th November.

‘Central’ assumes that infections will rise or plateau at the current level, resulting from a small rise in transmission. ‘Worse’ assumes a larger rise in transmission from the current level. ‘Better’ assumes a small drop in transmission⁵. All three scenarios account for the end of the half-term period and the start of the COP 26 conference beginning in Glasgow on 31st October. Due to this, there is a large amount of uncertainty as to the potential impact on infections.

Contacts tend to be lower during half term and holidays. The modelling accounts for a potential increase in transmission from schools reopening after half-term.

⁵ All scenarios are based on current vaccine roll-out plans and efficacy assumptions. Data to 25th October.

Figure 10. Medium term projections of modelled total new daily infections, adjusting positive tests⁶ to account for asymptomatic and undetected infections, from Scottish Government modelling, based on positive test data reported up to 25th October.

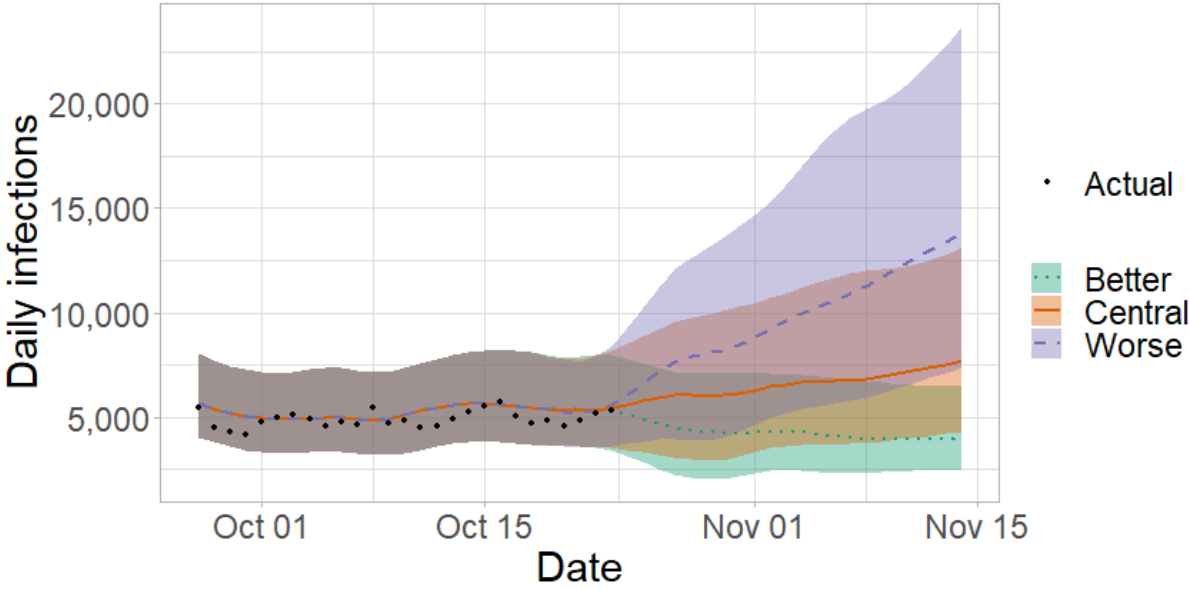


Figure 11 shows the impact of the projections on the number of people in hospital. The modelling includes all hospital stays, whereas the actuals only include stays up to 28 days duration that are linked to Covid-19.

There continues to be uncertainty over hospital occupancy and intensive care in the next three weeks.

⁶ The actual positive tests are adjusted to coincide with the estimated day of infection.

Figure 11. Medium term projections of modelled hospital bed demand, from Scottish Government modelling, based on positive test data reported up to 25th October.

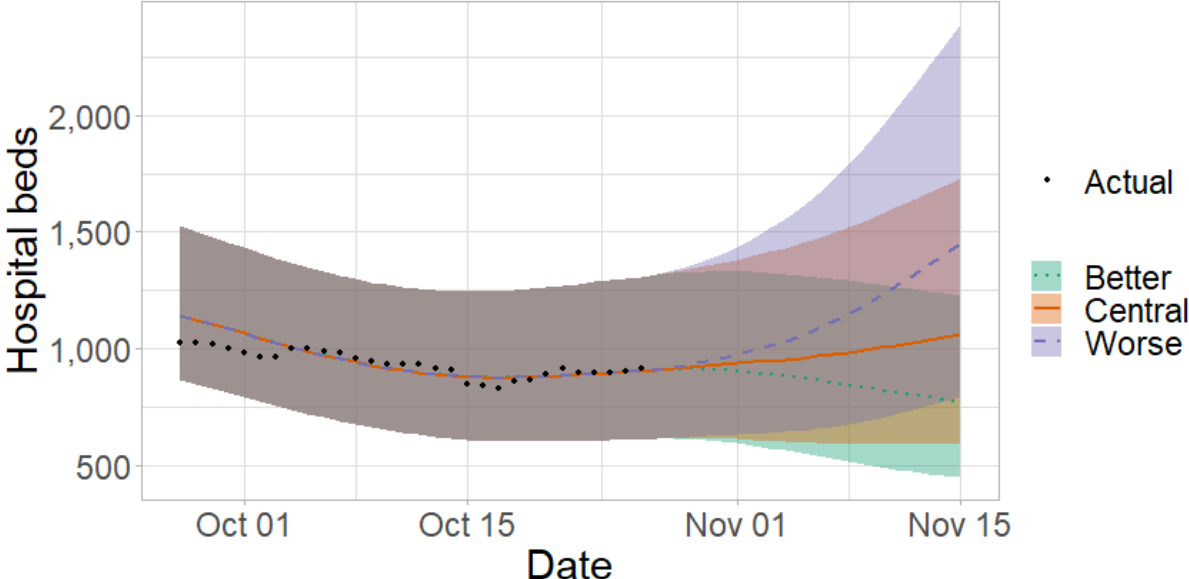
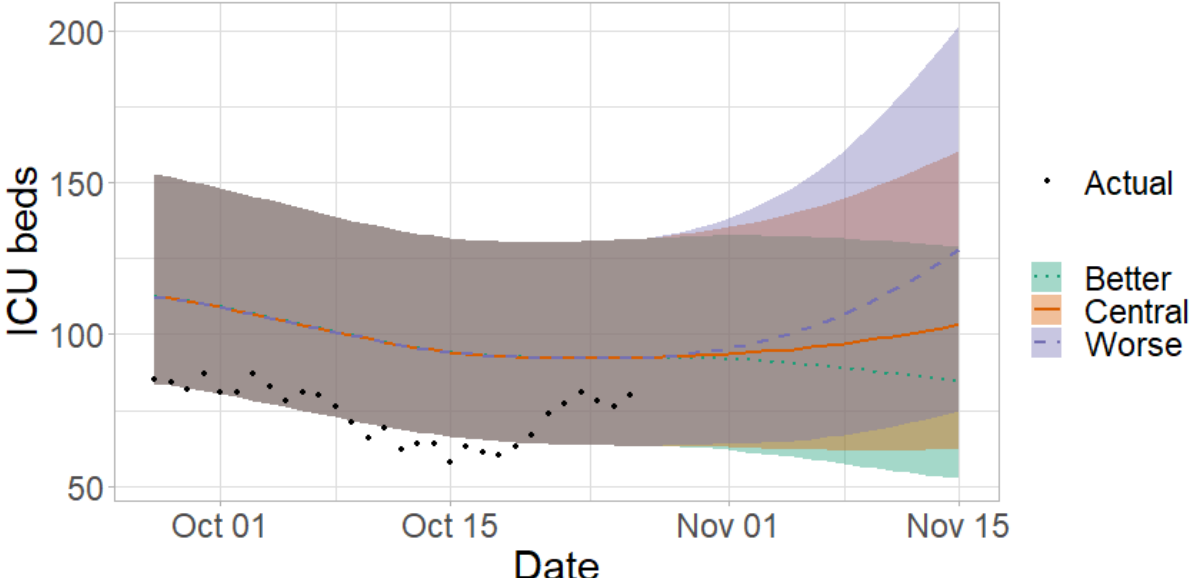


Figure 12 shows the impact of the projection on ICU bed demand.

Figure 12. Medium term projections of modelled ICU bed demand, from Scottish Government modelling⁷, based on positive test data reported up to 25th October.



A comparison of the actual data against historical projections is included in the Technical Annex.

⁷ Actual data does not include full numbers of CPAP. ICU bed actuals include all ICU patients being treated for Covid-19 including those over 28 days.

What the modelling tells us about projections of hospitalisations and deaths in the medium term

SPI-M produces projections of the epidemic⁸ (Figures 13 and 14), combining estimates from several independent models (including the Scottish Government's logistics modelling, as shown in Figures 10 to 12). These projections are not forecasts or predictions. They represent a scenario in which the trajectory of the epidemic continues to follow the trends that were seen in the data up to 25th October and **do not include the effects of any future policy or behavioural changes.**

The delay between infection, developing symptoms, the need for hospital care, and death means they cannot fully reflect the impact of behaviour changes in the two to three weeks prior to 25th October. Projecting forwards is difficult when the numbers of admissions and deaths fall to very low levels, which can result in wider credible intervals reflecting greater uncertainty. The interquartile range should be used, with judgement, as the projection from which estimates may be derived until the 15th November.

These projections include the potential impact of vaccinations over the next few weeks. Modelling groups have used their expert judgement and evidence from UKHSA, Scottish Universities & Public Health Scotland, and other published efficacy studies when making assumptions about vaccine effectiveness.

⁸ Three week projections are provided here: [Scientific evidence supporting the government response to coronavirus \(COVID-19\) - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/evidence/scientific-evidence-supporting-the-government-response-to-coronavirus-covid-19)

Figure 13. SPI-M medium-term projection of daily hospitalisations in Scotland, at 50% and 90% credible intervals.

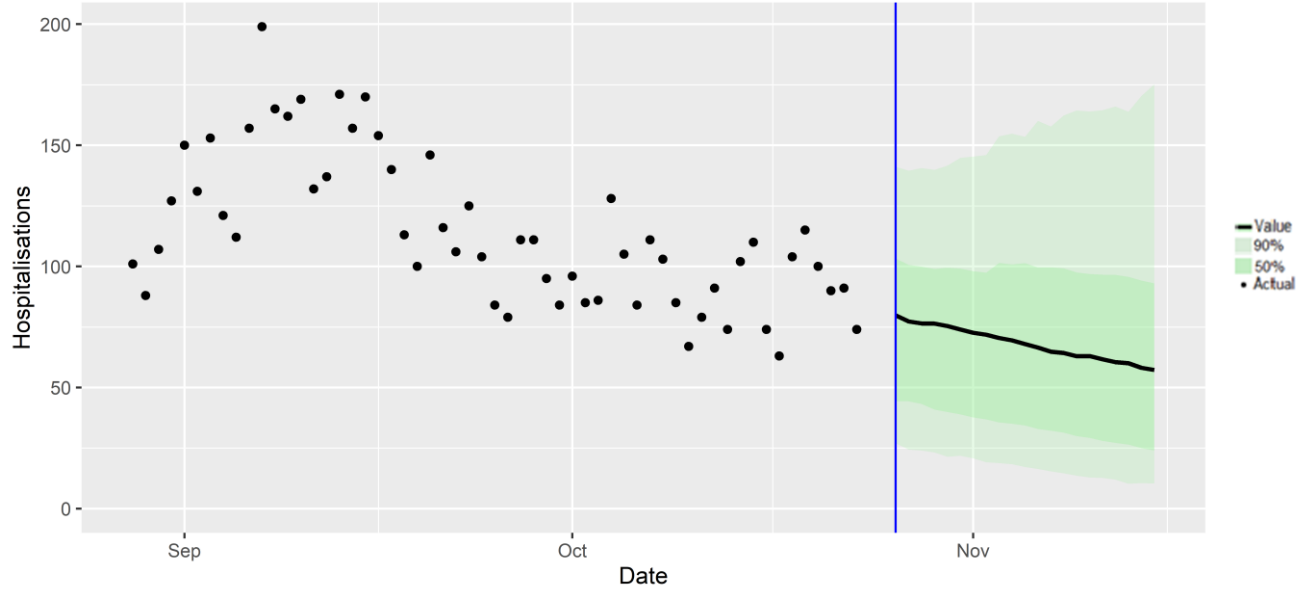
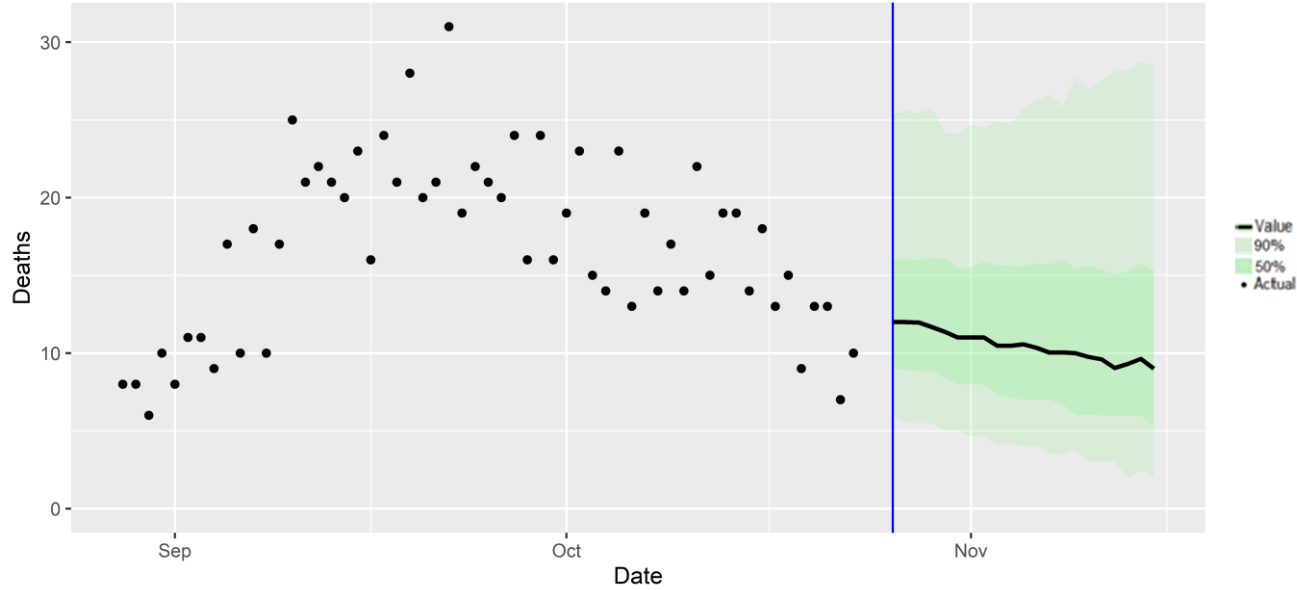


Figure 14. SPI-M medium-term projection of daily deaths in Scotland, at 50% and 90% credible intervals.



What we know about which local authorities are likely to experience high levels of Covid-19 in two weeks' time

We continue to use modelling based on Covid-19 cases and deaths using data to 18th October from several academic groups to give us an indication of whether a local authority is likely to experience high levels of Covid-19 in the future. This has been compiled via UKHSA into a consensus. In this an area is defined as a hotspot if the two week prediction of cases (positive tests) per 100K population is predicted to exceed a threshold, e.g. 500 cases.

This week, there is increased uncertainty in estimates due to recent changes in case trends.

Modelled rates of positive tests per 100K using data to 25th October (Figure 15) indicate that, for the week commencing 7th November 2021, there are 29 local authorities which are expected to exceed 50 cases per 100K with at least 75% probability⁹.

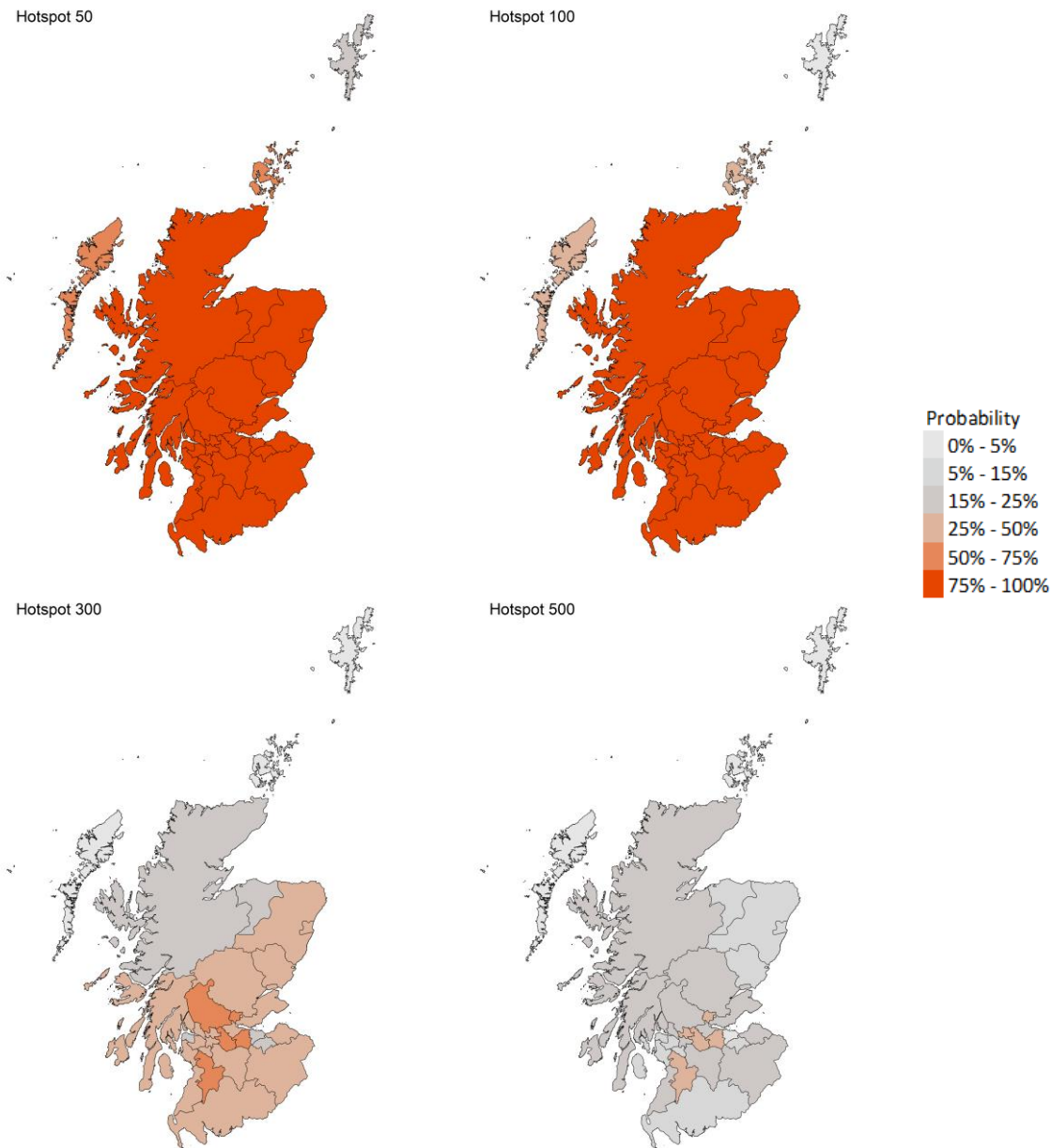
These 29 local authorities are also expected to exceed 100 cases per 100K with at least 75% probability.

There are no local authorities which are expected to exceed 300 cases per 100K with at least 75% probability¹⁰.

⁹ The exceptions are Na h-Eileanan Siar, Orkney Islands and Shetland Islands.

¹⁰ Values are included in Table 1 in the Technical Annex.

Figure 15. Probability of local authority areas exceeding thresholds of cases per 100K (7th to 13th November 2021), data to 25th October.



What can analysis of wastewater samples tell us about local outbreaks of Covid-19 infection?

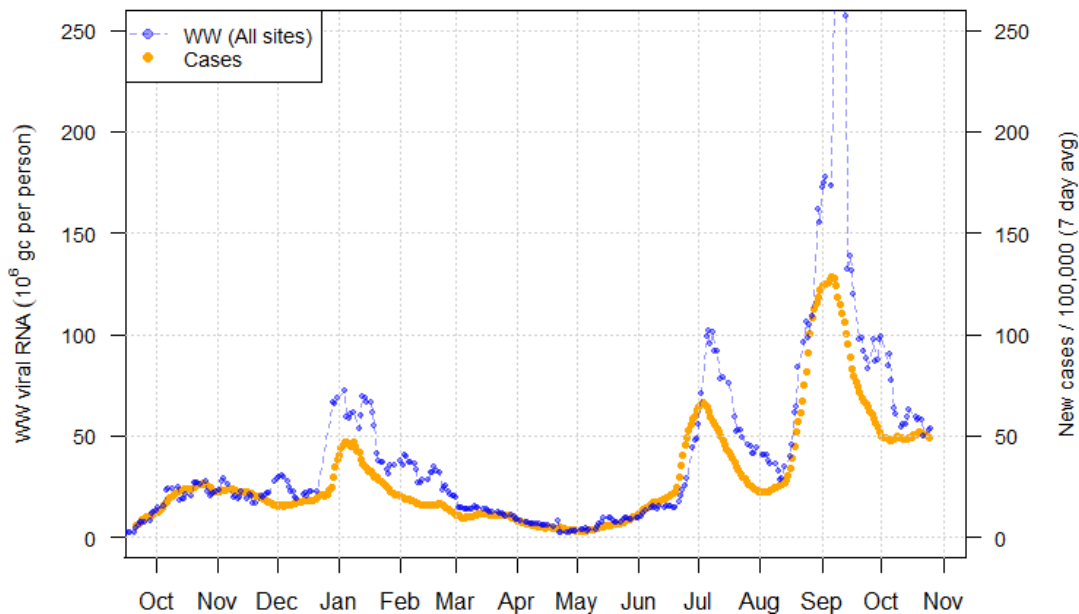
Levels of Covid-19 RNA in wastewater collected at a number of sites around Scotland are adjusted for population and local changes in intake flow rate and compared to 7 day average daily new case rates derived from Local Authority and Neighbourhood (Intermediate Zone) level

aggregate data. See Technical Annex in Issue 34 of these Research Findings for the methodology.

Nationwide, wastewater (WW) Covid-19 levels were similar or slightly lower than those seen last week (13th to 19th October), with a one-week average level ending on 26th October of around 54 million gene copies per person per day (Mgc/p/d). This brings levels in line with recent trends in case rates.

Figure 16 shows the national running average trend (over a 7-day period) for the full set of sampled sites, with a small number of unrealistically large outliers excluded. Wastewater Covid-19 levels exhibit a slow decrease since mid-October, reducing by around 7% in the last week. With the most recent readings, the ratio of WW levels to case numbers is now back at the historic rate of 1 Mgc/p/d corresponding to 1 new case per 100k inhabitants per day. WW Covid-19 levels are still high, similar to those early in the year or shortly after the July peak.

Figure 16. National running average trends in wastewater Covid-19 and daily new case rates (7 day moving average) as of 26th October¹¹.



¹¹ Anomalously high values, one in Seafield (Edinburgh) in mid-February (see Issue 40), one in Dunblane in mid-June, and two in Daldowie in January, were removed. For this graph, a wastewater RNA average using the last 7 days of data is computed at every sampling date.

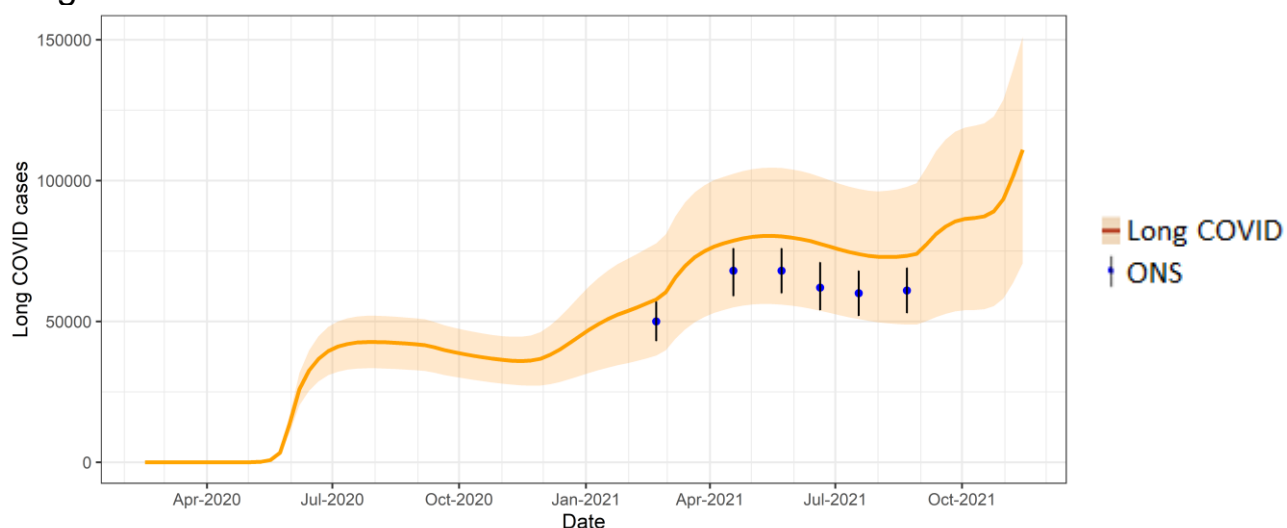
What estimates do we have of the number of people experiencing long Covid symptoms?

The Scottish Government is modelling the number of people likely to experience long Covid symptoms. This gives a projection of estimated self-reported long Covid rates in the future, based on Scottish Government medium term projection modelling, as set out in Figure 17.

This modelling estimates that at 14th November 2021 between 71,000 (1.3% of the population) and 151,000 (2.8%) people are projected to self-classify with long Covid for 12 weeks or more after their first suspected Covid infection in Scotland.

These are preliminary results, further data on rates of long Covid and associated syndromes as research emerges are required.

Figure 17. Estimates of self-classified long Covid prevalence at 12 weeks from 16th February 2020 to 14th November 2021 (showing 90% confidence interval). ONS estimates of self-reported long Covid with range also shown.



See the Technical Annex in issue 73 for information about the methodology.

What next?

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 R_t and the growth rate.

We may report on exceedance in future weeks when the background levels of Covid-19 reduces so that it can be useful in identifying outbreaks.

Technical Annex

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.

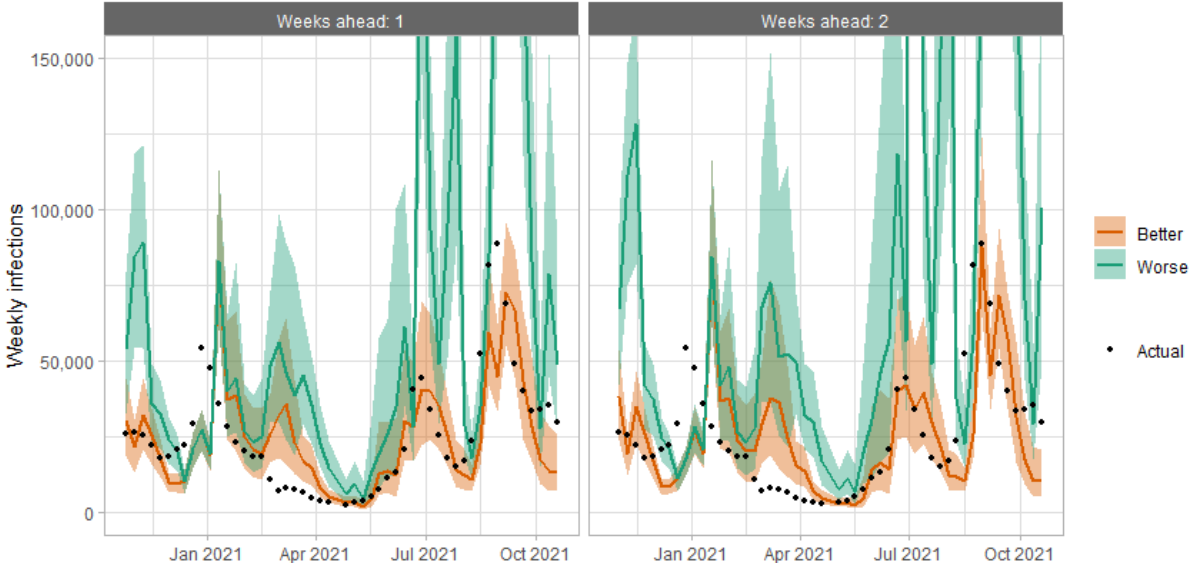
Modelling also allows us to make short-term forecasts of what may happen with a degree of uncertainty. These can be used in health care and other planning. The modelling in this research findings is undertaken using different types of data which going forward aims to both model the progress of the epidemic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

The delivery of the vaccination programme will offer protection against severe disease and death. The modelling includes assumptions about compliance with restrictions and vaccine take-up. Work is still ongoing to understand how many vaccinated people might still spread the virus if infected. As Covid-19 is a new disease there remain uncertainties associated with vaccine effectiveness. Furthermore, there is a risk that new variants emerge for which immunisation is less effective.

How the modelling compares to the real data as it emerges

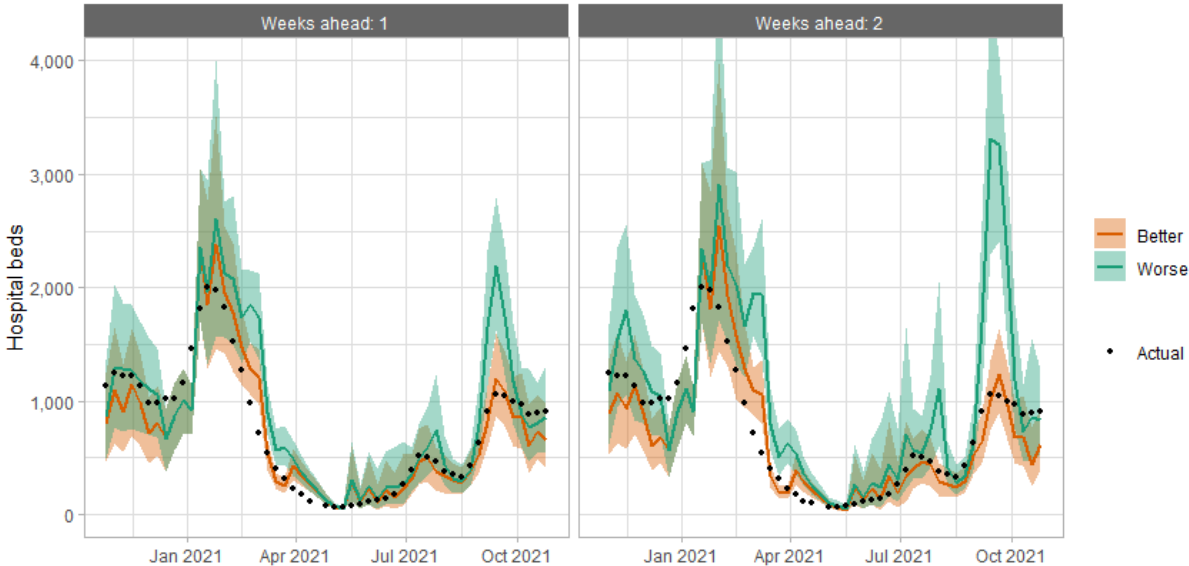
The following charts show the history of our modelling projections in comparison to estimates of the actual data. The infections projections were largely accurate during October to mid-December 2020 and from mid-January 2021 onwards. During mid-December 2020 to mid-January 2021, the projections underestimated the number of infections, due to the unforeseen effects of the new variant.

Figure 18. Infections projections versus actuals, for historical projections published between one and two weeks before the actual data came in.



Hospital bed projections have generally been more precise than infections estimates due to being partially based on already known information about numbers of current infections, and number of people already in hospital. The projections are for number of people in hospital due to Covid-19, which is slightly different to the actuals, which are number of people in hospital within 28 days of a positive Covid-19 test.

Figure 19. Hospital bed projections versus actuals, for historical projections published between one and two weeks before the actual data came in.



As with hospital beds, ICU bed projections have generally been more precise than infections. The projections are for number of people in ICU due to Covid-19. The actuals are number of people in ICU within 28 days of a positive Covid-19 test up to 20 January 2021, after which they include people in ICU over the 28 day limit.

Figure 20. ICU bed projections versus actuals, for historical projections published between one and two weeks before the actual data came in.

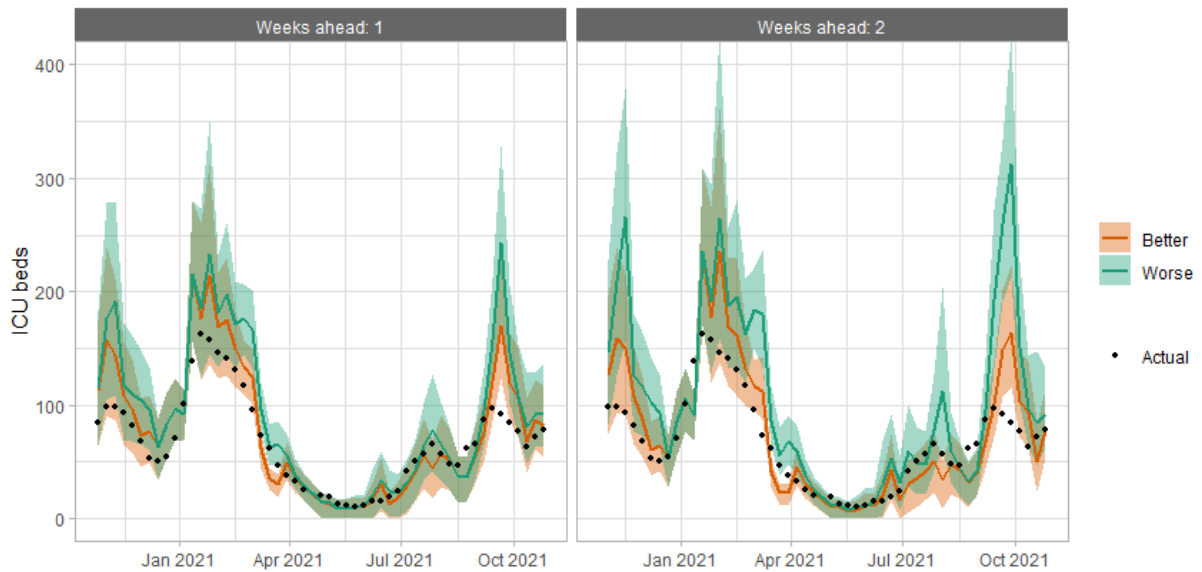


Table 1. Probability of local authority areas exceeding thresholds of cases per 100K (7th to 13th November 2021), data to 25th October.

Local Authority (LA)	Probability of exceeding (cases per 100K)			
	50	100	300	500
Aberdeen City	75-100%	75-100%	25-50%	5-15%
Aberdeenshire	75-100%	75-100%	25-50%	5-15%
Angus	75-100%	75-100%	25-50%	5-15%
Argyll and Bute	75-100%	75-100%	25-50%	15-25%
City of Edinburgh	75-100%	75-100%	15-25%	0-5%
Clackmannanshire	75-100%	75-100%	50-75%	25-50%
Dumfries & Galloway	75-100%	75-100%	25-50%	5-15%
Dundee City	75-100%	75-100%	25-50%	15-25%
East Ayrshire	75-100%	75-100%	50-75%	25-50%
East Dunbartonshire	75-100%	75-100%	25-50%	25-50%
East Lothian	75-100%	75-100%	25-50%	15-25%
East Renfrewshire	75-100%	75-100%	25-50%	5-15%
Falkirk	75-100%	75-100%	25-50%	15-25%
Fife	75-100%	75-100%	25-50%	15-25%
Glasgow City	75-100%	75-100%	25-50%	15-25%
Highland	75-100%	75-100%	15-25%	15-25%
Inverclyde	75-100%	75-100%	15-25%	5-15%
Midlothian	75-100%	75-100%	15-25%	5-15%
Moray	75-100%	75-100%	15-25%	5-15%
Na h-Eileanan Siar	50-75%	25-50%	0-5%	0-5%
North Ayrshire	75-100%	75-100%	25-50%	5-15%
North Lanarkshire	75-100%	75-100%	50-75%	25-50%
Orkney Islands	50-75%	25-50%	0-5%	0-5%
Perth and Kinross	75-100%	75-100%	25-50%	15-25%
Renfrewshire	75-100%	75-100%	25-50%	5-15%
Scottish Borders	75-100%	75-100%	25-50%	15-25%
Shetland Islands	15-25%	0-5%	0-5%	0-5%
South Ayrshire	75-100%	75-100%	25-50%	15-25%
South Lanarkshire	75-100%	75-100%	25-50%	15-25%
Stirling	75-100%	75-100%	50-75%	15-25%
West Dunbartonshire	75-100%	75-100%	25-50%	15-25%
West Lothian	75-100%	75-100%	50-75%	25-50%

What levels of Covid-19 are indicated by wastewater data?

Table 2 provides population weighted daily averages for normalised WW Covid-19 levels in the weeks beginning 13th and 20th October 2021, with no estimate for error. This is given in Million gene copies per person, which approximately corresponds to new cases per 100,000 per day. Coverage is given as percentage of LA inhabitants covered by a wastewater Covid-19 sampling site delivering data during this period¹².

Table 2. Average daily cases per 100k as given by WW data¹³.

Local authority (LA)	w/b 13th October	w/b 20th October	Coverage
Aberdeen City	55	51	80%
Aberdeenshire	66	80	49%
Angus	113	59	56%
Argyll and Bute	–	–	3%
City of Edinburgh	34	39	96%
Clackmannanshire	91	86	92%
Dumfries & Galloway	54	64	32%
Dundee City	84	62	100%
East Ayrshire	56	34	57%
East Dunbartonshire	48	58	99%
East Lothian	30	39	56%
East Renfrewshire	75	59	95%
Falkirk	64	42	69%
Fife	62	55	52%
Glasgow City	58	66	98%
Highland	52	44	37%
Inverclyde	45	49	92%
Midlothian	35	39	73%
Moray	84	52	14%
Na h-Eileanan Siar	9	–	0%
North Ayrshire	28	22	93%
North Lanarkshire	73	64	87%
Orkney Islands	–	19	34%
Perth and Kinross	139	85	38%
Renfrewshire	77	36	57%
Scottish Borders	20	28	56%
Shetland Islands	1	–	0%
South Ayrshire	59	32	84%
South Lanarkshire	64	59	82%
Stirling	39	19	63%
West Dunbartonshire	48	53	98%
West Lothian	65	87	85%

¹² Advancements in detection and interpretation practices allow us to identify when outlying results are anomalous rather than indicators of spikes in Covid-19 levels. Table 2 provides population weighted daily averages for normalised WW Covid-19 levels with the outliers removed. See Technical Annex in Issue 60 of these Research Findings for further details.

¹³ Coverage as at the week beginning 20th October 2021.

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