Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 74)

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 14th 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

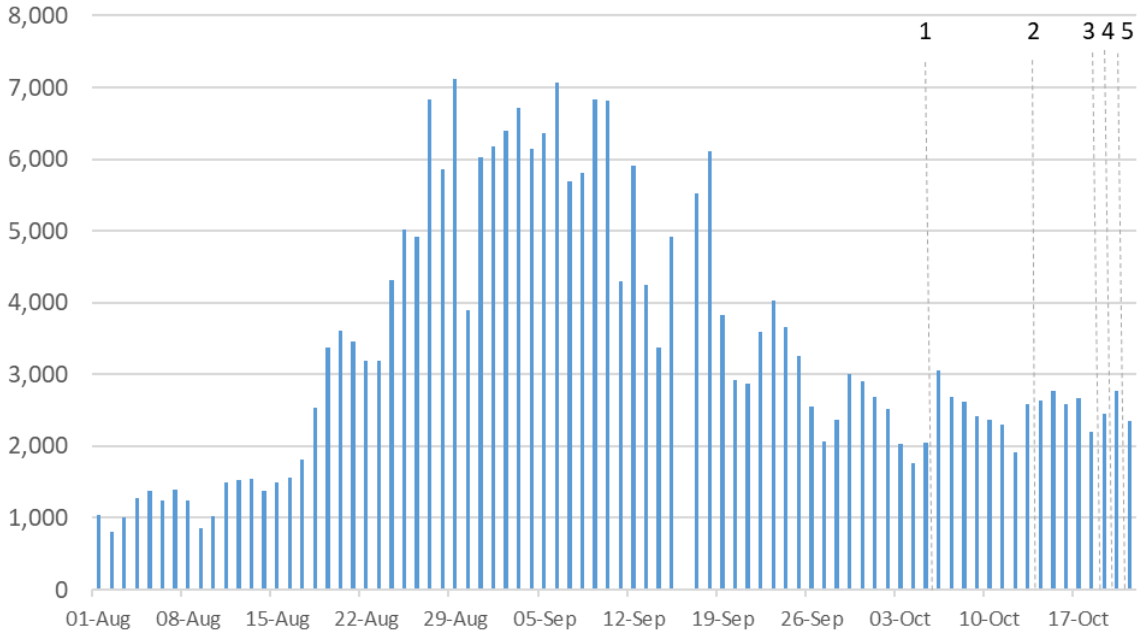
- The reproduction rate R in Scotland is currently estimated as being between 0.8 and 1.0, as of 5th October. This is unchanged from last week.
- The number of new daily infections for Scotland is estimated as being between 77 and 114, per 100,000 people. The lower and upper limits have decreased since last week.
- The growth rate for Scotland is currently estimated as between -3% and 0%. This is unchanged from last week.
- Average contacts have decreased by approximately 14% in the last two weeks (comparing surveys pertaining to 23rd September - 29th September and 7th October - 13th October) with a current level of 4.7 daily contacts.

- Mean contacts within the work setting have decreased by around 48% whereas contacts in the other setting (contacts outside home, school and work) have increased by 11% in the last two weeks. Contacts within the home have remained at a similar level 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 those under 18 has shown the biggest increase.
- The proportion of individuals visiting another's home decreased from approximately 51% to 44% whilst individuals visiting a pub or restaurant rose from 45% to 47% in the last two weeks.
- The proportion of contacts reported to have been indoors only has remained at similar level to two weeks prior, currently at 66%.
- The number of people wearing a face covering where they have at least one contact outside of the home has fallen from 87% to 80% in the last two weeks.
- Hospital and ICU occupancies are in a gradual fall or 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 18th October indicate that, for the week commencing 31st October 2021, there are 28 local authorities which are expected to exceed 50 cases per 100K with at least 75% probability. There are 23 local authorities which are 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, after the decrease observed last week (5th to 11th October 2021), levels of Covid in wastewater have remained consistent.
- Modelling of long Covid estimates that on 7th November 2021 between 1.2% and 2.6% 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 20th October 2021[1]



R, growth rate and incidence are as of 5th October (dashed line 1). The Scottish Contact Survey uses data to 13th October (dashed line 2). The medium term projections and modelled rates of positive tests per 100K use data to 18th October (dashed line 3). Wastewater analysis uses data to 19th October (dashed line 4). The Scottish Government modelling of infections, hospitalisations and ICU beds, the long Covid analysis use data to 20th October (dashed line 5).

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.

[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.

We use the Scottish Contact Survey (SCS) to inform a modelling technique based on the number of contacts between people. Over time, 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 5th October[2] in Scotland was between 0.8 and 1.0 (see Figure 2)[3].

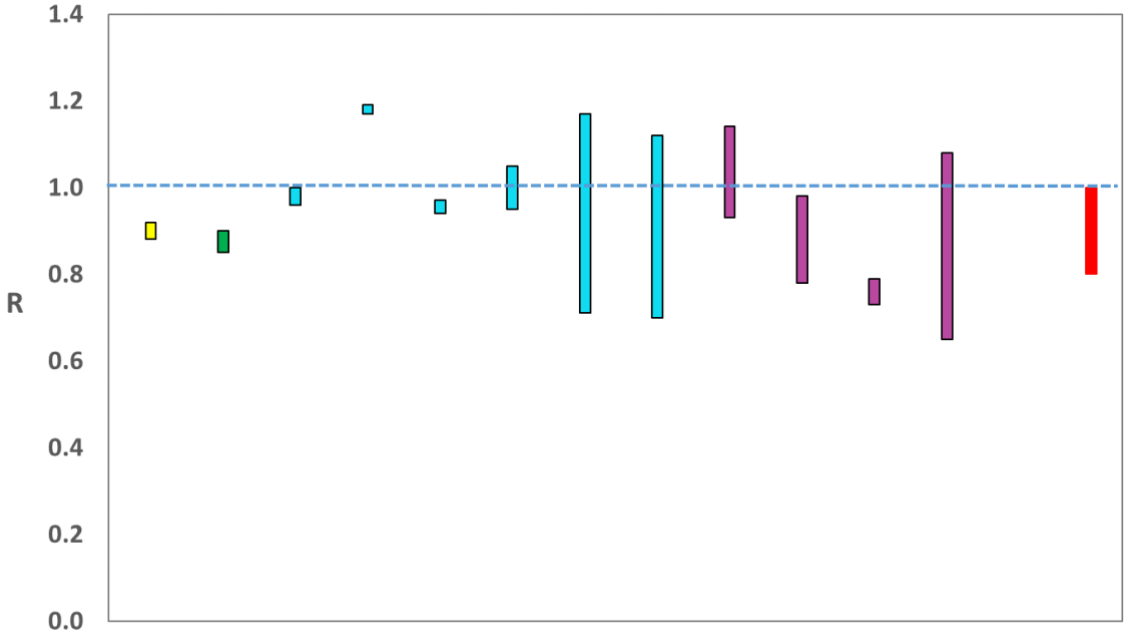
R is an indicator that lags by two to three weeks and therefore should not be expected to reflect recent fluctuations.

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 18th 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 5th October, including 90% confidence intervals, produced by EMRG[4].

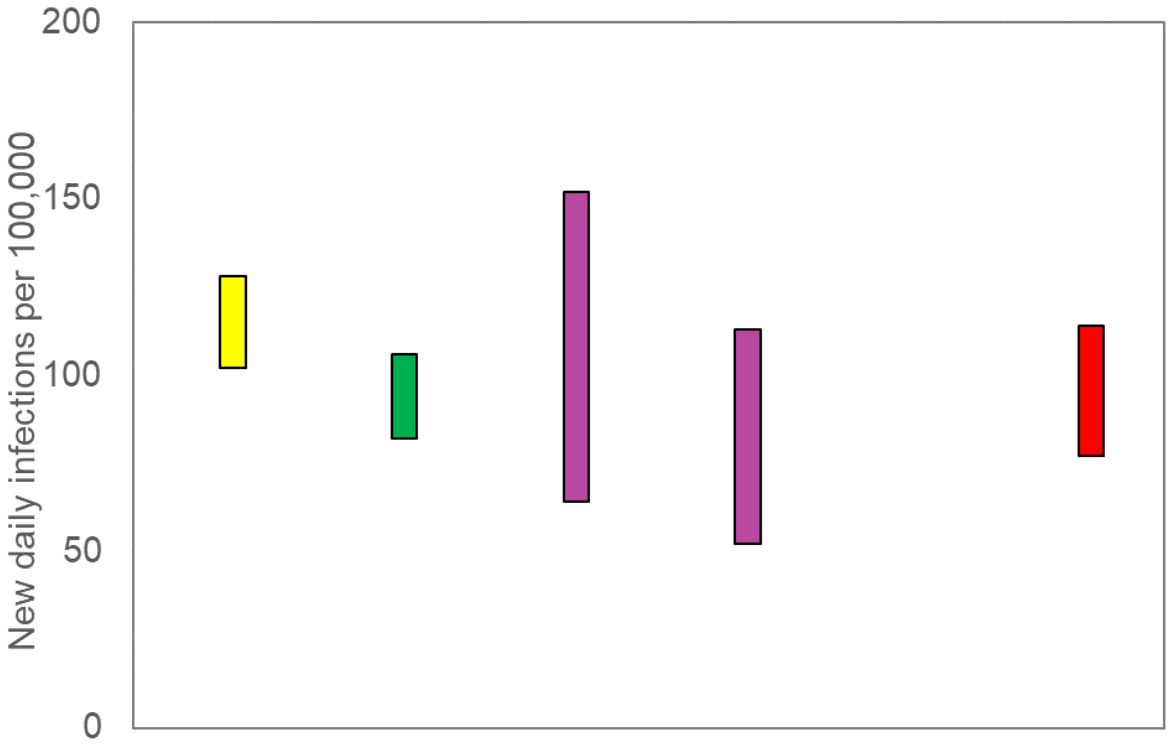


Source: EMRG

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 5th October, was that the incidence of new daily infections in Scotland was between 77 and 114 new infections per 100,000. This equates to between 4,200 and 6,200 people becoming infected each day in Scotland. The lower and upper limits have 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 18th October. R, incidence and growth rate as of 5th October.

Figure 3. Estimates of incidence for Scotland, as at 5th October, including 90% confidence intervals, produced by EMRG[4].



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 5th October. The lower and upper limits are unchanged since last week.

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

Average contacts have decreased by approximately 14% in the last two weeks (comparing surveys pertaining to 23rd September - 29th September and 7th October - 13th October) with a current level of 4.7 daily contacts as seen in Figure 4. Mean contacts within the work have decreased by around 48% whereas contacts in the other setting (contacts outside home, school and work) have increased by 11% in the last two weeks. Contacts within the home have remained at a similar level over the same period.

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

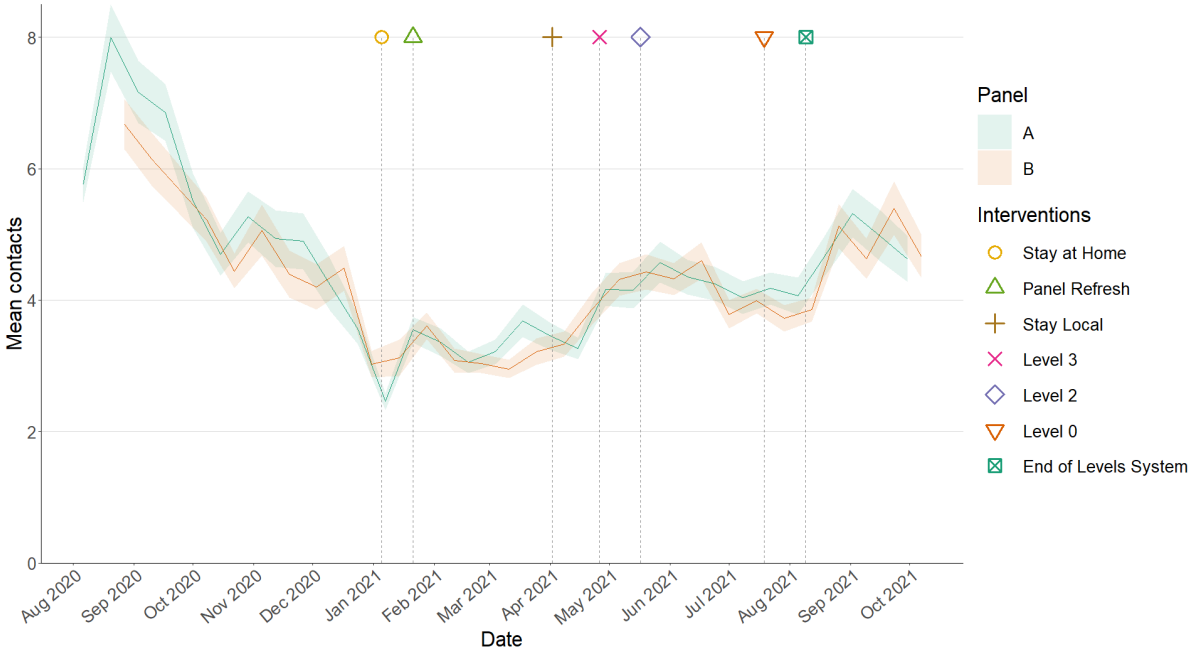
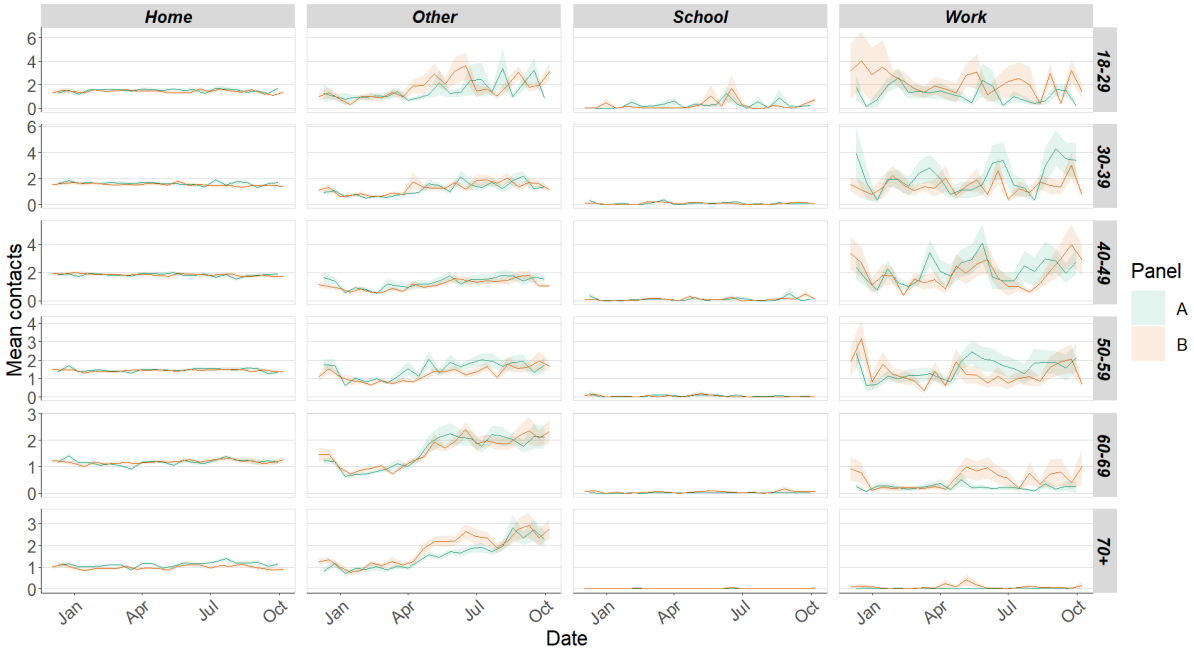


Figure 5 shows how contacts change across age group and setting. Those aged 60 and over reported an increase in overall contacts whereas all remaining age groups reported a decrease. The decreases are largely driven by a reduction in contacts within the work setting.

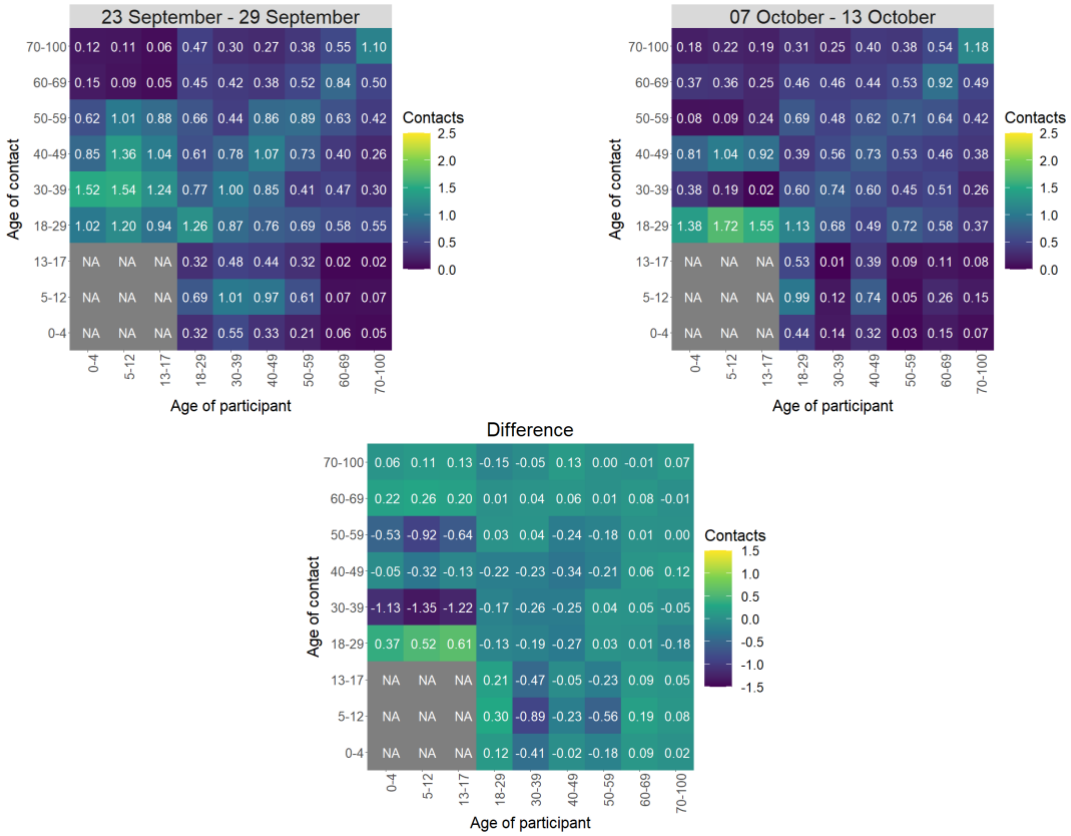
Figure 5. Average (mean) contacts for each panel per day by setting for adults in Scotland, truncated to 100 contacts per participant (from SCS).



The heatmaps in Figure 6 show the mean overall contacts between age groups for the weeks relating to 23rd September - 29th September and 7th October - 13th 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 under 18's has shown the biggest increase.

Figure 6. Overall mean contacts by age group before for the weeks relating to 23rd September - 29th September and 7th October - 13th October.



The biggest differences are seen with those visiting a another's home and also individuals visiting a pub or restaurant (Figure 7). The proportion of individuals visiting another's home decreased from approximately 51% to 44% while individuals visiting a pub or restaurant rose from 45% to 47% in the last two weeks.

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

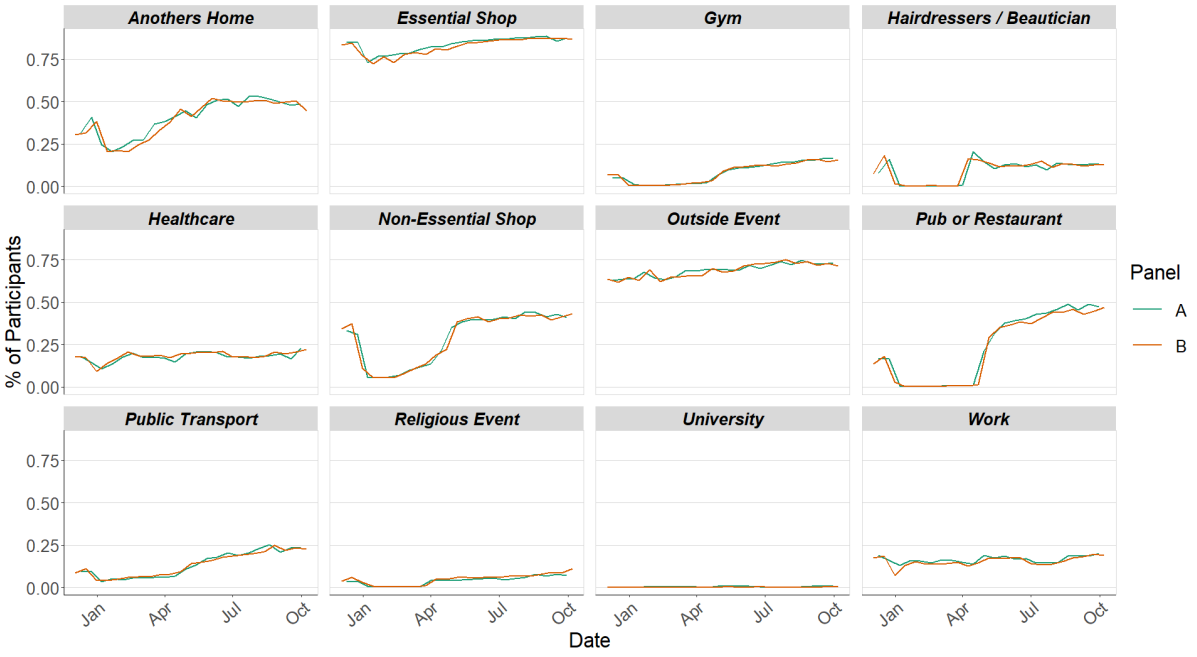


Figure 8. Proportion of participants reported indoors and outdoors for contacts individually reported for panel B. The proportion of contacts reported to have been indoors only has remained at similar level to two weeks prior, currently at 66%.

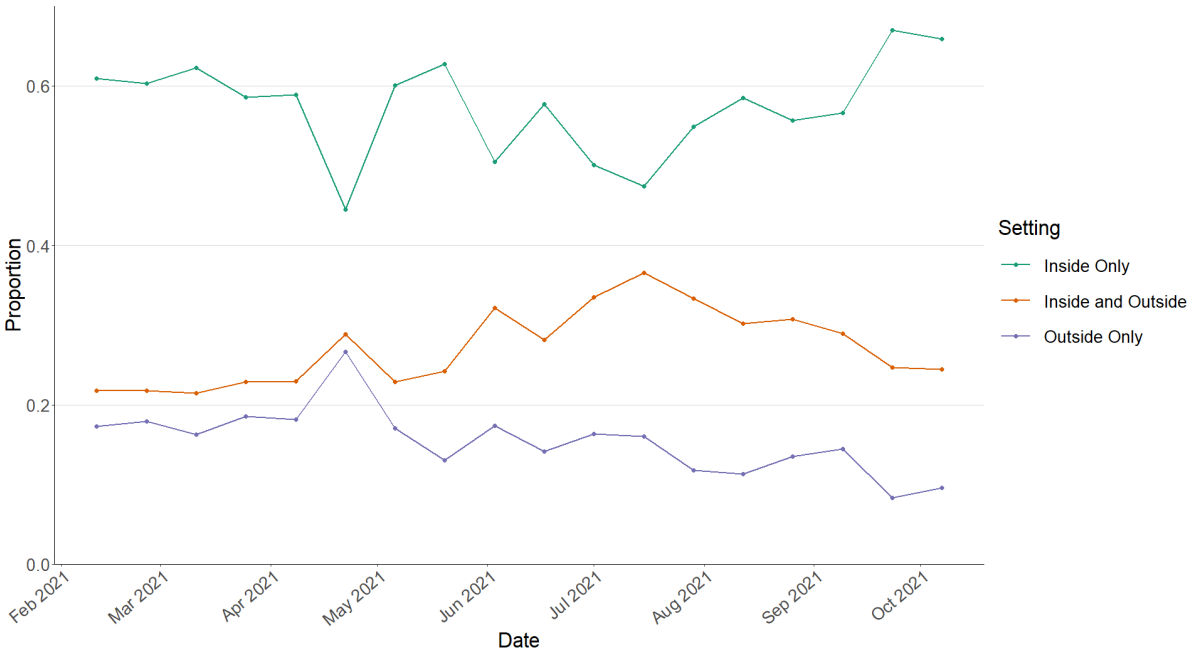
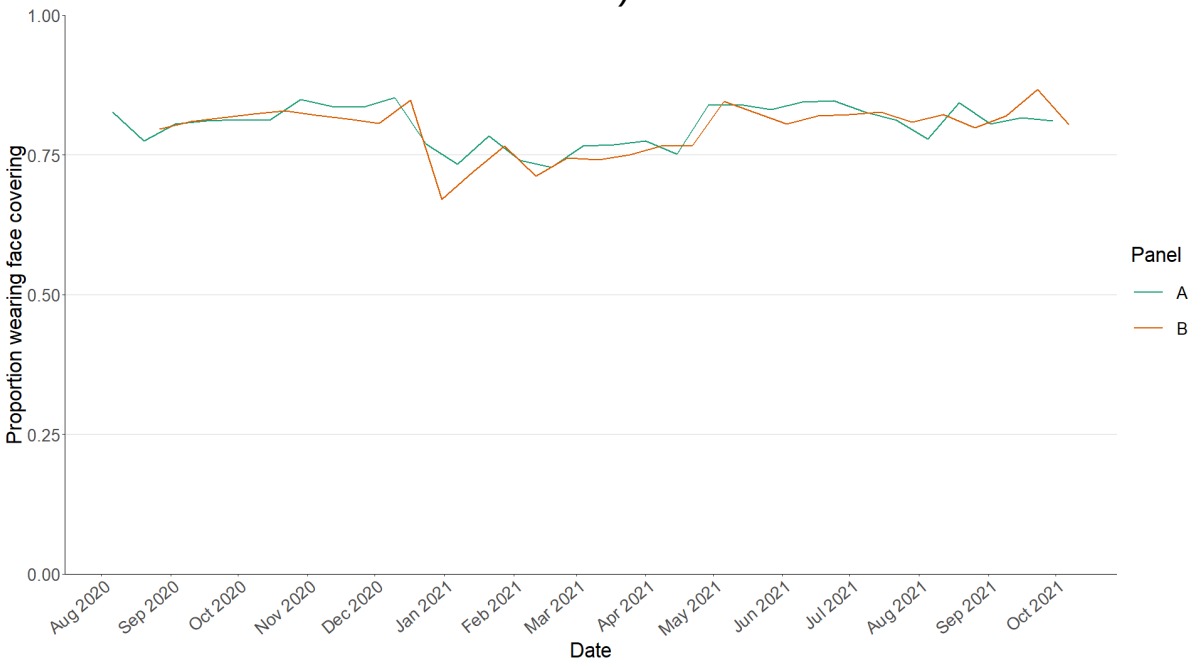


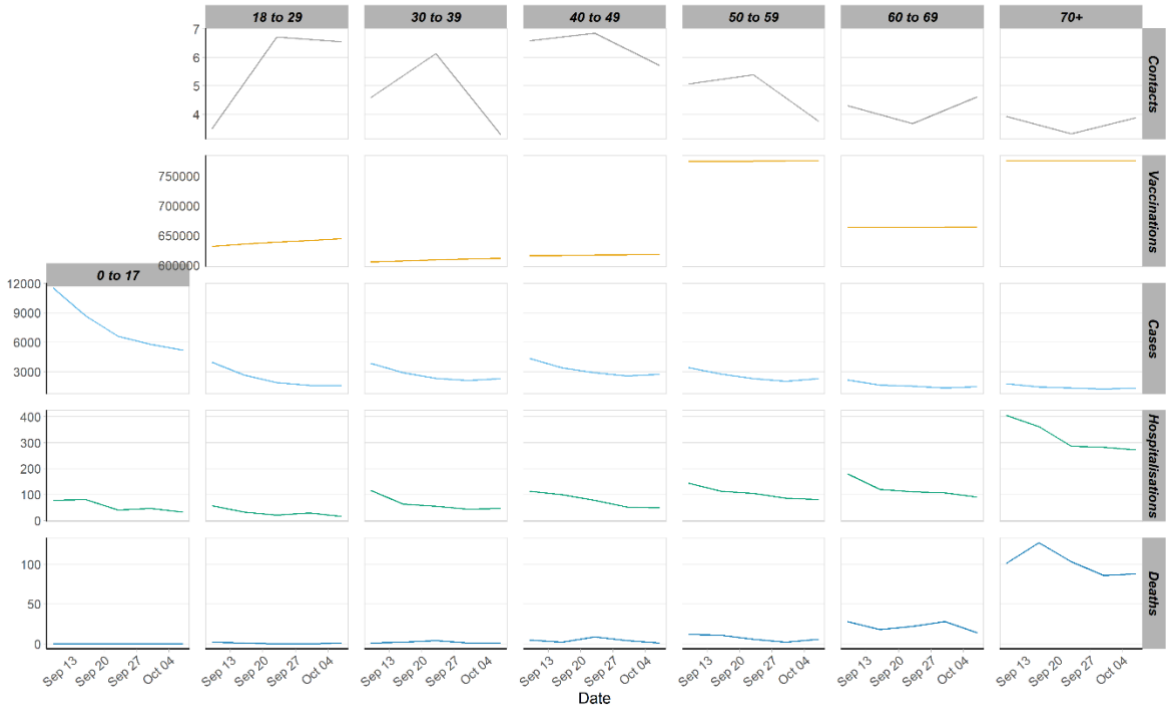
Figure 9 shows the number of people wearing a face covering where they have at least one contact outside of the home. This has fallen from 87% to 80% in the last two weeks.

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



From Figure 10, it can be seen that the oldest age group has lower levels of contacts and higher vaccinations than the youngest age group, they also have the lowest weekly case number comparatively to the younger age group. Despite that they have higher weekly hospitalization levels to that seen with the younger age groups.

Figure 10. Average contacts for Panel B, weekly cases, covid-19 hospital admissions and deaths[5] and cumulative vaccinations by age band[6]



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 11 shows three projections over the three weeks to 7th 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 transmission[7]. All three scenarios account for the end of the half-term period and the start of the COP 26 conference beginning in Glasgow 31st October. Due to this, there is a large amount of uncertainty as to the potential impact on infections.

As noted earlier, 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] Deaths, Cases and Hospitalisations from PHS COVID-19 daily cases in Scotland dashboard.
[6] Vaccination and contact data for the 0-17 age cohort is not presented due to the vast majority of this age group not being offered vaccinations and the SCS excluding contacts between children.
[7] All scenarios are based on current vaccine roll-out plans and efficacy assumptions. Data to 20th October.

Figure 11. Medium term projections of modelled total new daily infections, adjusting positive tests[8] to account for asymptomatic and undetected infections, from Scottish Government modelling, based on positive test data reported up to 20th October. The chart on the right hand side is a cut out of the one on the left but with the y axis maximum set to 20,000.

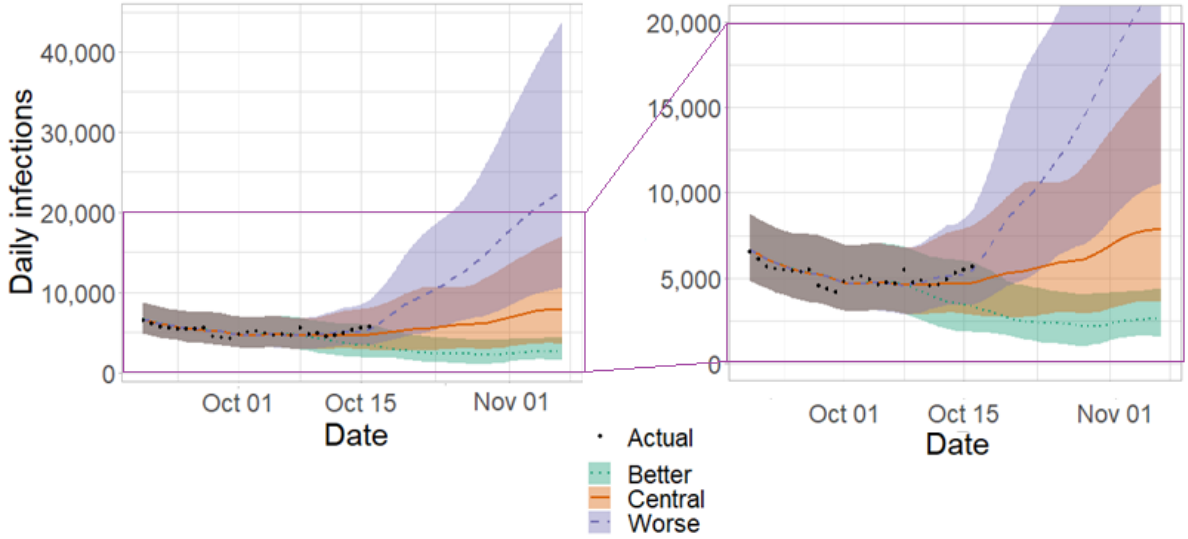


Figure 12 shows the impact of the projections on the number of people in hospital. The modelling includes all hospital stays, whereas the actuals only include stays up to 28 days duration that are linked to Covid-19.

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

[8] The actual positive tests are adjusted to coincide with the estimated day of infection.

Figure 12. Medium term projections of modelled hospital bed demand, from Scottish Government modelling, based on positive test data reported up to 20th October.

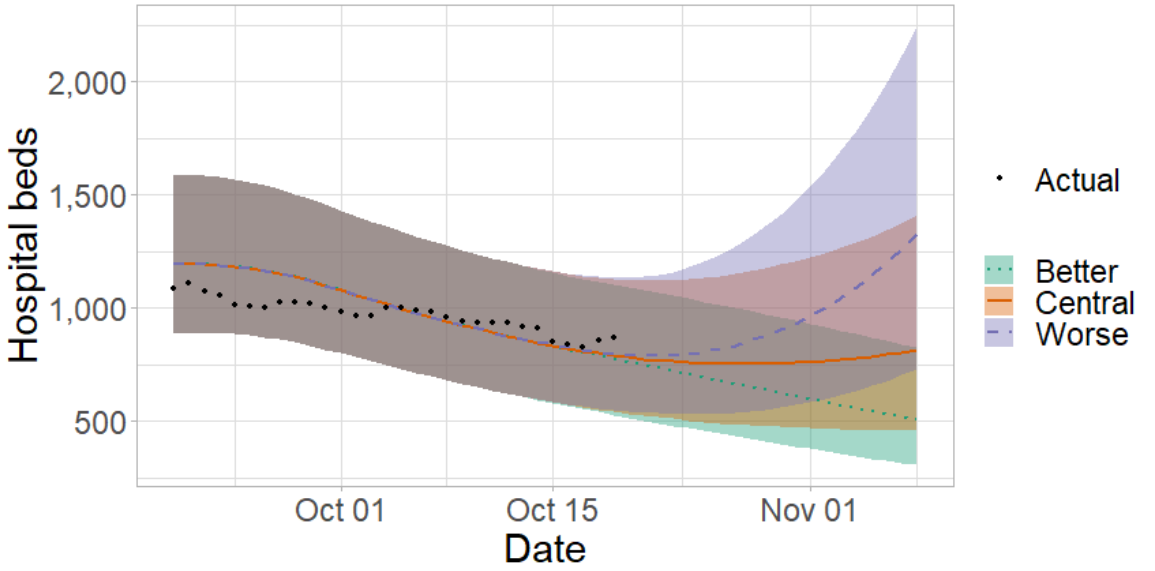
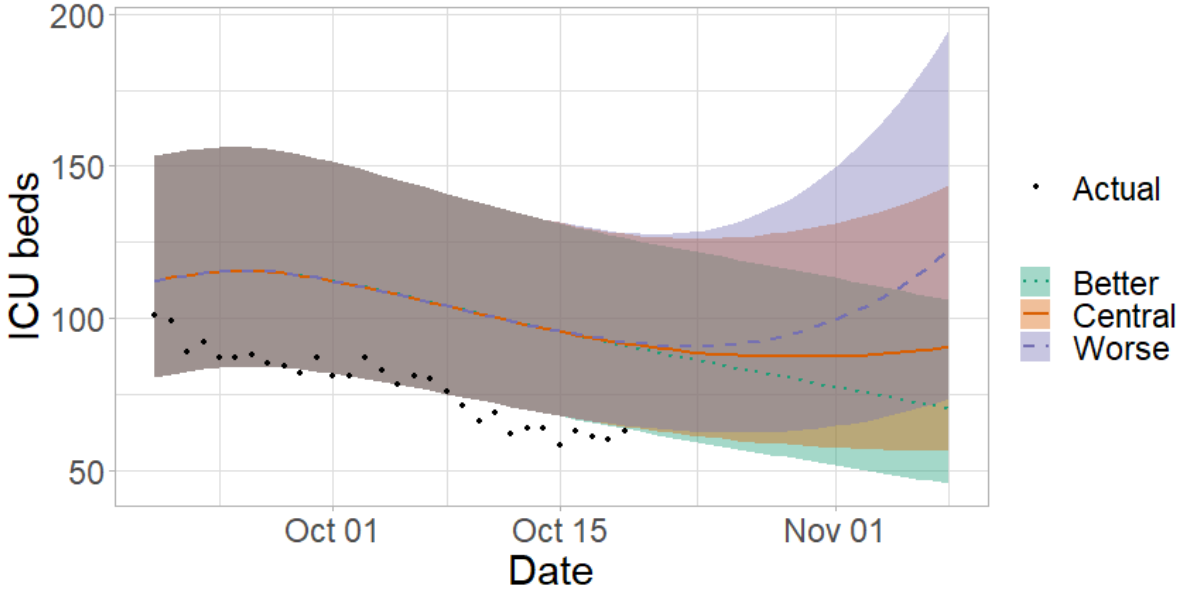


Figure 13 shows the impact of the projection on ICU bed demand.

Figure 13. Medium term projections of modelled ICU bed demand, from Scottish Government modelling[9], based on positive test data reported up to 20th October.



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

[9] 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 epidemic[10] (Figures 14 and 15), combining estimates from several independent models (including the Scottish Government's logistics modelling, as shown in Figures 11 to 13). 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 18th 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 18th 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 9th 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.

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

Figure 14. SPI-M medium-term projection of daily hospitalisations in Scotland, at 50% credible intervals[11].

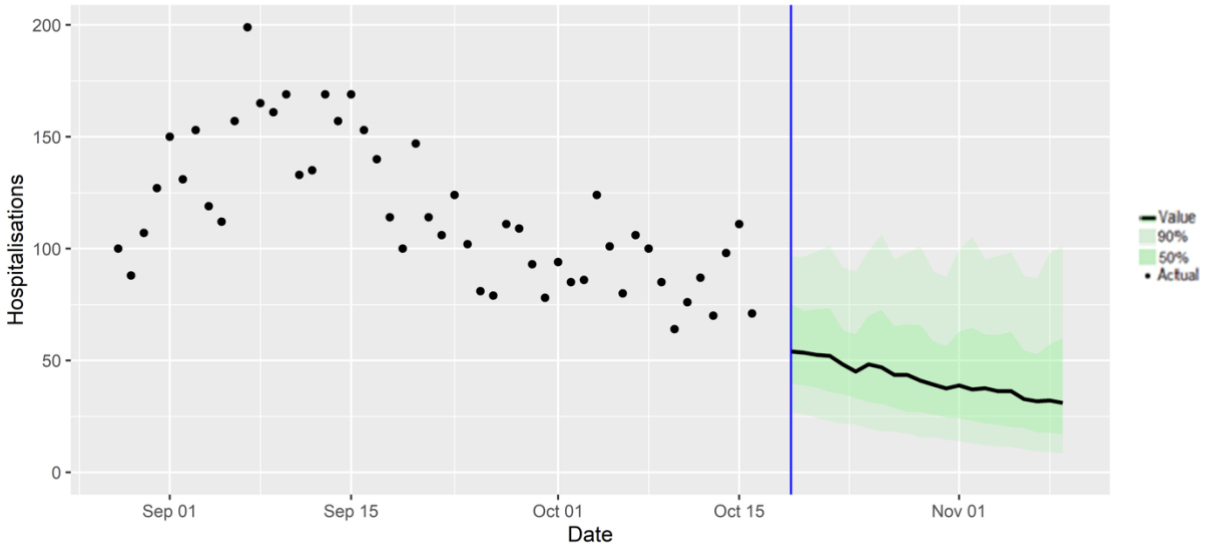
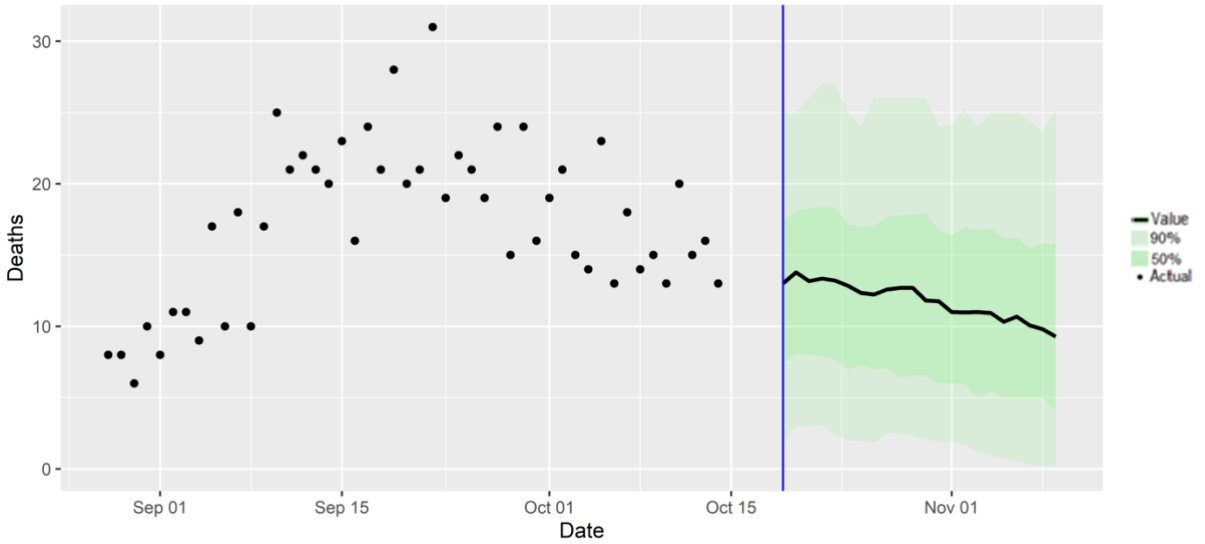


Figure 15. SPI-M medium-term projection of daily deaths in Scotland, at 50% credible intervals.



[11] This week we are only showing the interquartile range of the projections for both hospitalisations and deaths. SPI-M-O agreed that the interquartile range represented their consensus view of the likely trajectory of the epidemic in Scotland this week.

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.

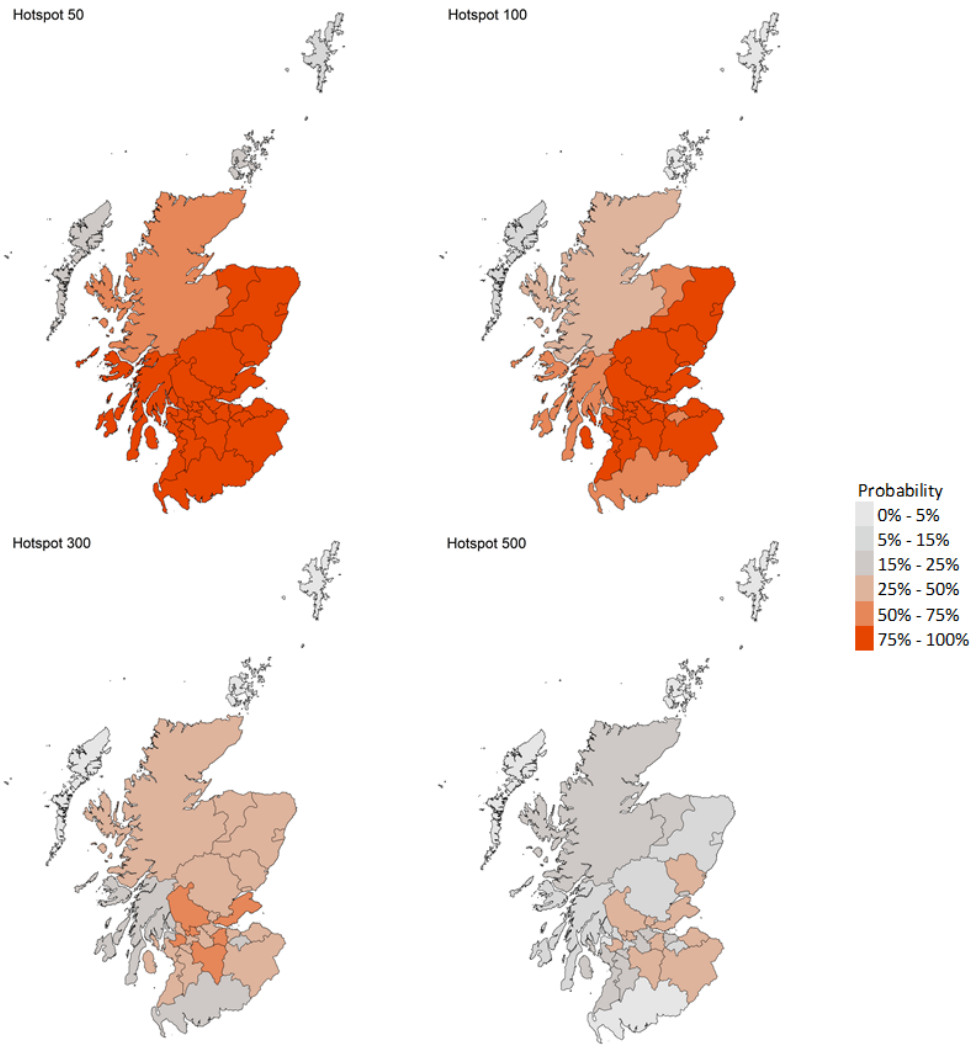
Modelled rates of positive tests per 100K using data to 18th October (Figure 16) indicate that, for the week commencing 31st October 2021, there are 28 local authorities which are expected to exceed 50 cases per 100K with at least 75% probability[12].

There are 23 local authorities which are 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[13].

[12] The exceptions are Na h-Eileanan Siar, Orkney Islands, Shetland Islands and Highland.
[13] Values are included in Table 1 in the Technical Annex. Note that fewer modelling groups have contributed to the local authority consensus than usual this week.

Figure 16. Probability of local authority areas exceeding thresholds of cases per 100K (31st October to 6th November 2021), data to 18th October.



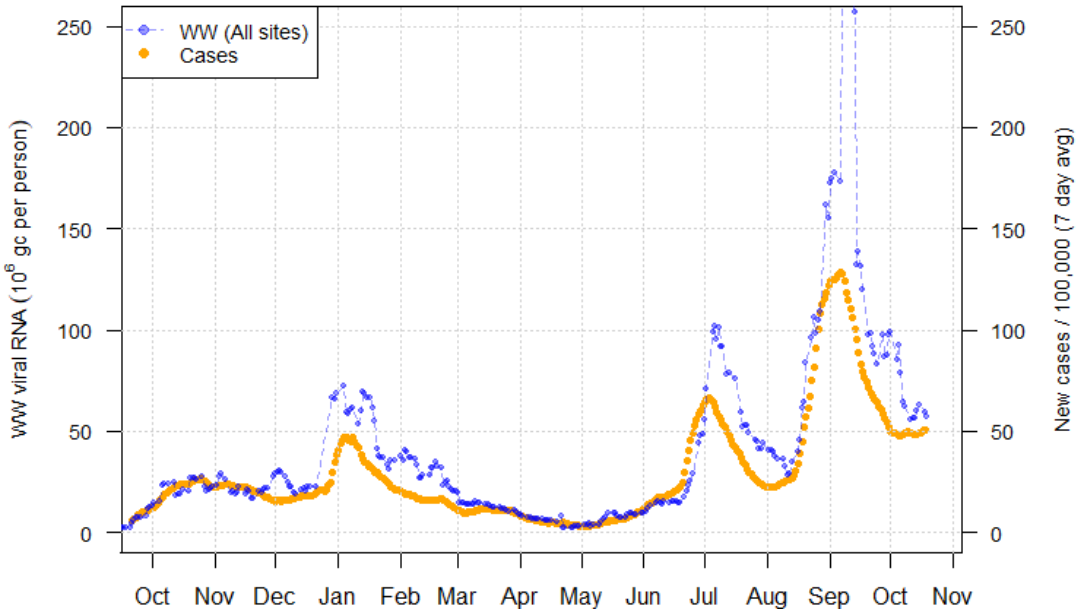
What can analysis of wastewater samples tell us about local outbreaks of Covid-19 infection?

Levels of Covid-19 RNA in wastewater (WW) 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, levels of wastewater Covid-19 remained at a similar level to the previous week, around 56 million gene copies per person per day (Mgc/p/d) in the week ending 19th October 2021. This is in line with the numbers of cases that can be seen in the same time period.

Figure 17 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. Covid-19 levels have stabilised. As also seen last week, the ratio of WW levels to case numbers is now closer to 1 Mgc/p/d corresponding to 1 new case per 100K inhabitants per day, a relationship that historically has been seen at most times, except during peaks. Wastewater Covid levels are now similar to those during the winter peak in early January.

Figure 17. National running average trends in wastewater Covid-19 and daily new case rates (7 day moving average), with samples taken up until 19th October 2021[14].



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

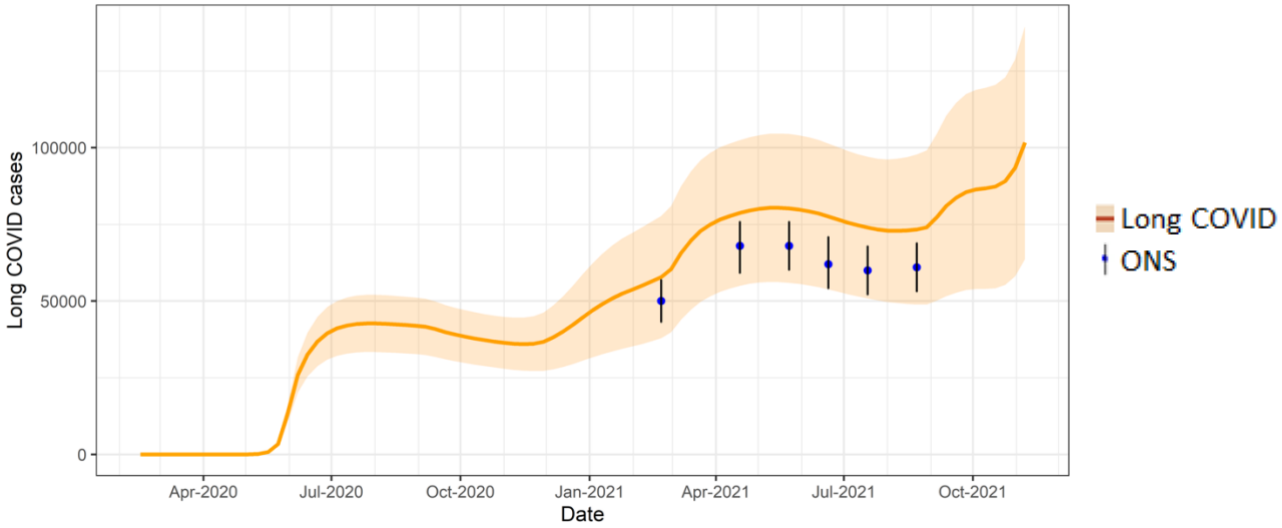
The Scottish Government is modelling the number of people likely to experience long Covid symptoms. This gives a projection of estimated self-reported long Covid rates in the future, based on Scottish Government medium term projection modelling, as set out in Figure 18.

This modelling estimates that at 7th November 2021 between 64,000 (1.2% of the population) and 140,000 (2.6%) people are projected to self-classify with long Covid for 12 weeks or more after their first suspected Covid infection in Scotland.

[14] 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.

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

Figure 18. Estimates of self-classified long Covid prevalence at 12 weeks from 16th February 2020 to 7th 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.

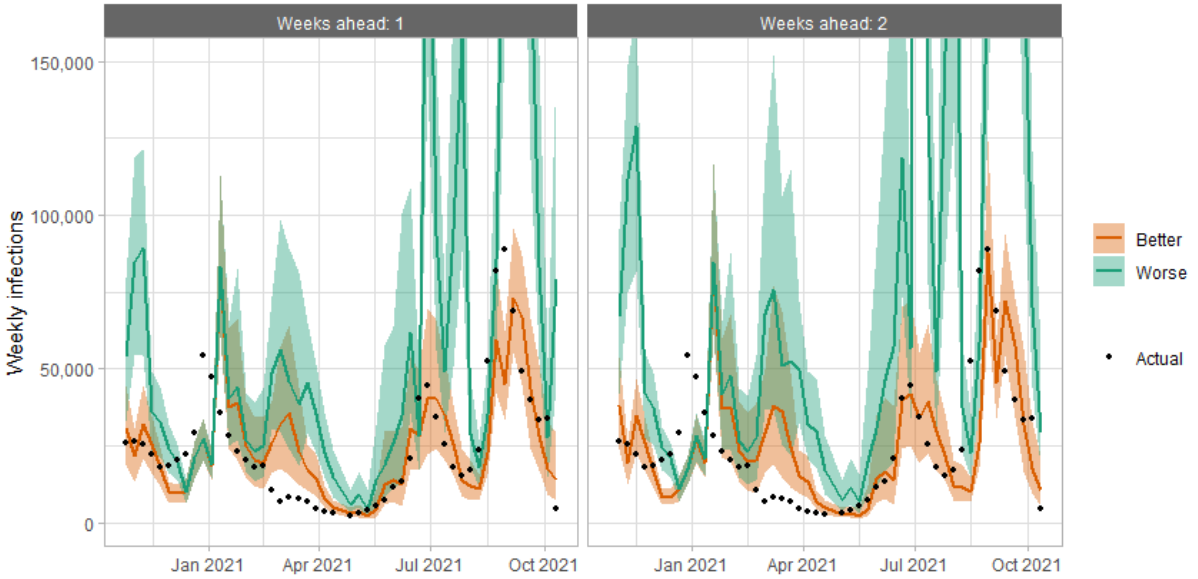
Modelling also allows us to make short-term forecasts of what may happen with a degree of uncertainty. These can be used in health care and other planning. The modelling in this research findings is undertaken using different types of data which going forward aims to both model the progress of the epidemic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

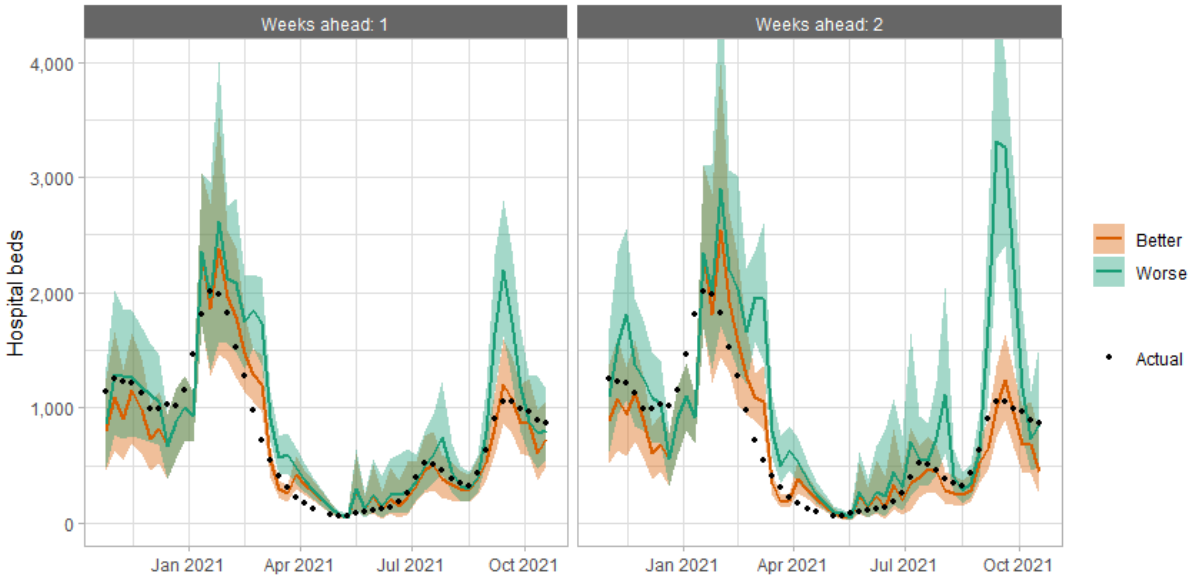
The following charts show the history of our modelling projections in comparison to estimates of the actual data. The infections projections were largely accurate during October to mid-December 2020 and from mid-January 2021 onwards. During mid-December 2020 to mid-January 2021, the projections underestimated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

Figure 19. 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 20. 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 21. ICU bed projections versus actuals, for historical projections published between one and two weeks before the actual data came in.

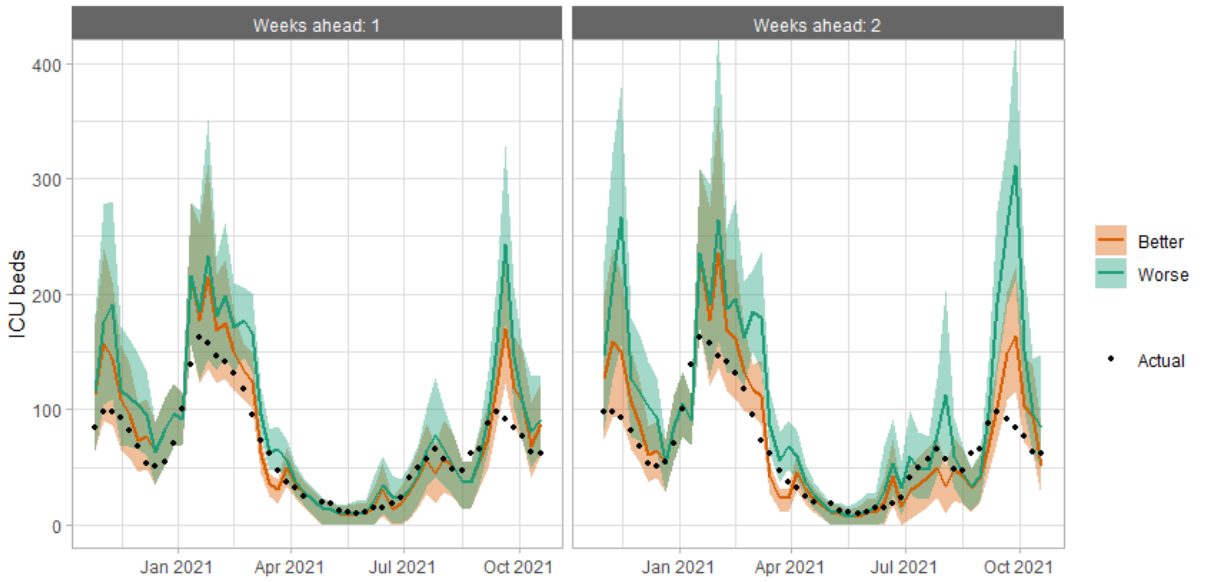


Table 1. Probability of local authority areas exceeding thresholds of cases per 100K (31st October to 6th November 2021), data to 18th October.

	Probability of exceeding (cases per 100K)			
Local Authority (LA)	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%	25-50%
Argyll and Bute	75-100%	50-75%	15-25%	5-15%
City of Edinburgh	75-100%	75-100%	25-50%	15-25%
Clackmannanshire	75-100%	75-100%	25-50%	25-50%
Dumfries & Galloway	75-100%	50-75%	15-25%	0-5%
Dundee City	75-100%	75-100%	25-50%	15-25%
East Ayrshire	75-100%	75-100%	25-50%	15-25%
East Dunbartonshire	75-100%	75-100%	50-75%	25-50%
East Lothian	75-100%	75-100%	25-50%	25-50%
East Renfrewshire	75-100%	75-100%	25-50%	15-25%
Falkirk	75-100%	75-100%	25-50%	15-25%
Fife	75-100%	75-100%	50-75%	25-50%
Glasgow City	75-100%	75-100%	25-50%	5-15%
Highland	50-75%	25-50%	25-50%	15-25%
Inverclyde	75-100%	50-75%	15-25%	0-5%
Midlothian	75-100%	50-75%	15-25%	5-15%
Moray	75-100%	50-75%	25-50%	15-25%
Na h-Eileanan Siar	15-25%	5-15%	0-5%	0-5%
North Ayrshire	75-100%	75-100%	25-50%	15-25%
North Lanarkshire	75-100%	75-100%	25-50%	15-25%
Orkney Islands	15-25%	0-5%	0-5%	0-5%
Perth and Kinross	75-100%	75-100%	25-50%	5-15%
Renfrewshire	75-100%	75-100%	50-75%	25-50%
Scottish Borders	75-100%	75-100%	25-50%	25-50%
Shetland Islands	5-15%	0-5%	0-5%	0-5%
South Ayrshire	75-100%	75-100%	25-50%	15-25%
South Lanarkshire	75-100%	75-100%	50-75%	25-50%
Stirling	75-100%	75-100%	50-75%	25-50%
West Dunbartonshire	75-100%	75-100%	25-50%	5-15%
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 6th and 13th 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 period[15].

Table 2. Average daily cases per 100k as given by WW data[16].

Local authority (LA)	w/b 6th October	w/b 13th October	Coverage
Aberdeen City	40	55	80%
Aberdeenshire	66	65	48%
Angus	77	84	43%
Argyll and Bute	–	–	0%
City of Edinburgh	35	38	96%
Clackmannanshire	35	91	92%
Dumfries & Galloway	63	56	32%
Dundee City	77	84	100%
East Ayrshire	46	56	72%
East Dunbartonshire	95	46	99%
East Lothian	33	34	65%
East Renfrewshire	36	75	89%
Falkirk	72	64	59%
Fife	62	56	79%
Glasgow City	72	58	98%
Highland	33	46	37%
Inverclyde	31	45	92%
Midlothian	47	40	88%
Moray	72	47	55%
Na h-Eileanan Siar	–	10	21%
North Ayrshire	41	27	84%
North Lanarkshire	62	73	81%
Orkney Islands	12	–	0%
Perth and Kinross	49	69	38%
Renfrewshire	45	77	57%
Scottish Borders	29	20	39%
Shetland Islands	1	–	0%
South Ayrshire	46	59	77%
South Lanarkshire	47	64	62%
Stirling	–	39	63%
West Dunbartonshire	95	46	48%
West Lothian	117	66	77%

[15] 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.
[16] Coverage as at the week beginning 13th October 2021.

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.

This document is also available from our website at www.gov.scot.
ISBN: 978-1-80201-550-8

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

Produced for
the Scottish Government
by APS Group Scotland
PPDAS963346 (10/21)
Published by
the Scottish Government,
October 2021

ISBN 978-1-80201-550-8

Web Publication

PPDAS963346 (10/21)