

Scottish Government Central Analysis Division

Coronavirus (Covid-19): modelling the epidemic in Scotland (Issue No. 94)

Background

This is a report on the Scottish Government modelling of the spread and level of Covid-19 in Scotland. This updates the previous publication on modelling of Covid-19 in Scotland published on 10th March 2022. 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.

Key Points

- The reproduction rate R in Scotland is currently estimated as being between 1.0 and 1.3, as at 1st March 2022. The lower and upper limits have increased since last week.
- The daily growth rate for Scotland is currently estimated as between -1 and 3% as at 1st March. The upper limit has increased since last week.
- The number of new daily infections for Scotland is estimated as being between 278 and 692 as at 1st March, per 100,000 people.
- Average contacts from the most recent Panel A cohort of the Scottish Contact Survey (week ending 9th March) indicate an average of 4.8 contacts.
- Mean contacts within the work and other setting (contacts outside home, school and work) have increased within the last two weeks by 18% and 36% respectively. Contacts within the home have decreased by 5% levels over the same period.
- Individuals within the youngest age groups (18-59) have all reported a rise in contacts within the last two weeks, with the 18-29 age group increasing by approximately 55%. Increases are largely driven by a rise in contacts in the work and other setting (contacts outside home,

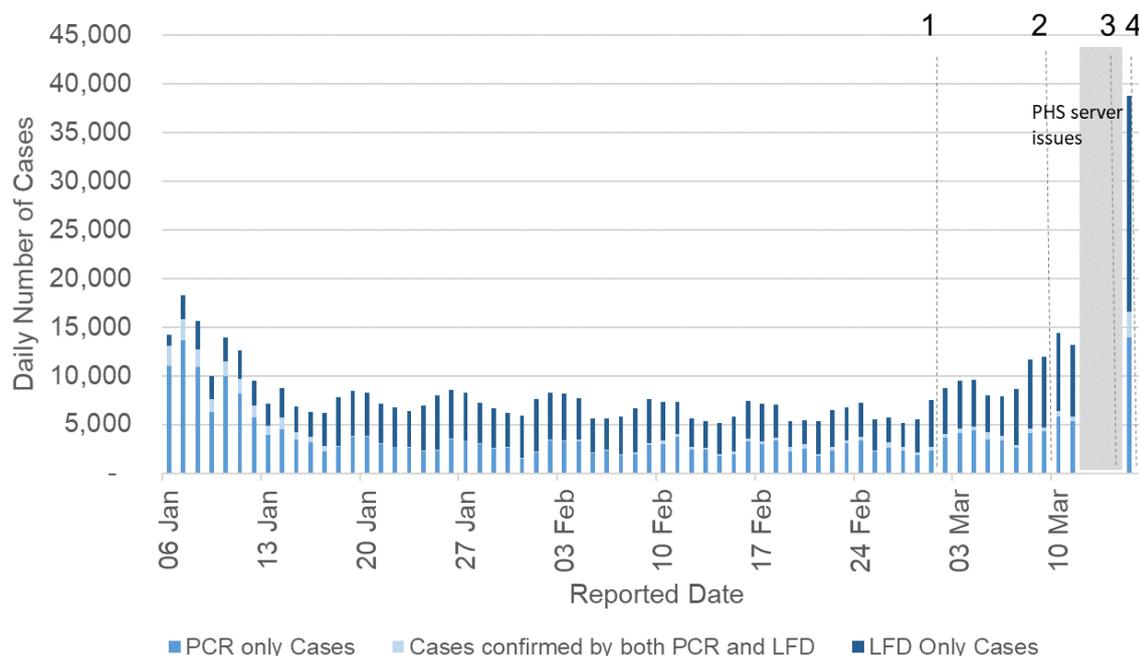
school and work). Those within the oldest age groups (60+) have decreased their contacts in the last two weeks.

- The 18-29 age group has increased interactions with all age groups within the last two weeks. Interactions between those aged 13-17 and individuals aged 40-49 have reported the biggest decrease.
- Visits to an outside event have shown the biggest increase, increasing from approximately 58% to 63% followed by visits to a pub or restaurant increasing from 45% to 49% in the last two weeks.
- The number of people wearing a face covering where they have at least one contact outside of the home has remained high at approximately 84%.
- Approximately 75% of individuals had taken at least one lateral flow test within the last 7 days for the survey pertaining to the 3rd March - 9th March, decreasing from 80% two weeks prior.
- Approximately 29% of individuals believe they have had Covid-19 at least once since March 2020.
- The future trajectory of infections, hospitalisations, hospital occupancy and deaths is still uncertain. We estimate that daily infections may be up to 49,000 in early April.
- Modelled rates of positive tests per 100K using data to 14th March indicate that, for the week commencing 27th March, all 29 of the local authorities included are expected to exceed 100 cases per 100K with at least 75% probability. These same 29 local authorities also have at least a 75% probability of exceeding 1000 cases per 100K.
- 21 of the 29 local authorities included are expected to exceed 2000 cases per 100K with at least 75% probability. The exceptions are Aberdeenshire, Angus, Argyll & Bute, Dundee, East Dunbartonshire, East Renfrewshire, Inverclyde and Moray.
- One local authority (North Ayrshire) is expected to exceed 3500 cases per 100K with at least 75% probability.
- Nationwide, wastewater Covid-19 RNA levels have increased rapidly. The week ending on 15th March saw levels of 206 million gene copies per person per day (Mgc/p/d), an increase of almost three times than two weeks prior (71 Mgc/p/d).

Recent cases

Figure 1 shows the number of Covid-19 cases (from either PCR or LFD) in Scotland between January and March 2022. 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: PCR and LFD positive daily and weekly case numbers by reporting date¹



R, growth rate and incidence are as of 1st March 2022 (dashed line 1). The Scottish Contact Survey uses data to 9th March 2022 (dashed line 2). The Scottish Government modelling of infections and hospitalisations, and the modelled rates of positive tests per 100K use data to 14th March (dashed line 3). The wastewater analysis uses data to 15th March 2022 (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

¹ Please note that Public Health Scotland experienced technical issues from 12th to 13th March, meaning that no cases could be reported on these dates and were instead added to case numbers by reporting date on 14th March. Additionally, the 15th March figure covers less than a 24 hour period and is likely to be an undercount. The Scottish Government modelling used data from a range of sources, some of which were affected by these issues.

symptoms, become sick, and either die or recover, there is a time lag in what our model can tell us about any change in the epidemic.

This week the Scottish Government presented two outputs to EMRG. The first uses the number of positive LFD or PCR tests, as published by PHS Scotland. The second uses wastewater data. These outputs are included in Figures 2 and 3.

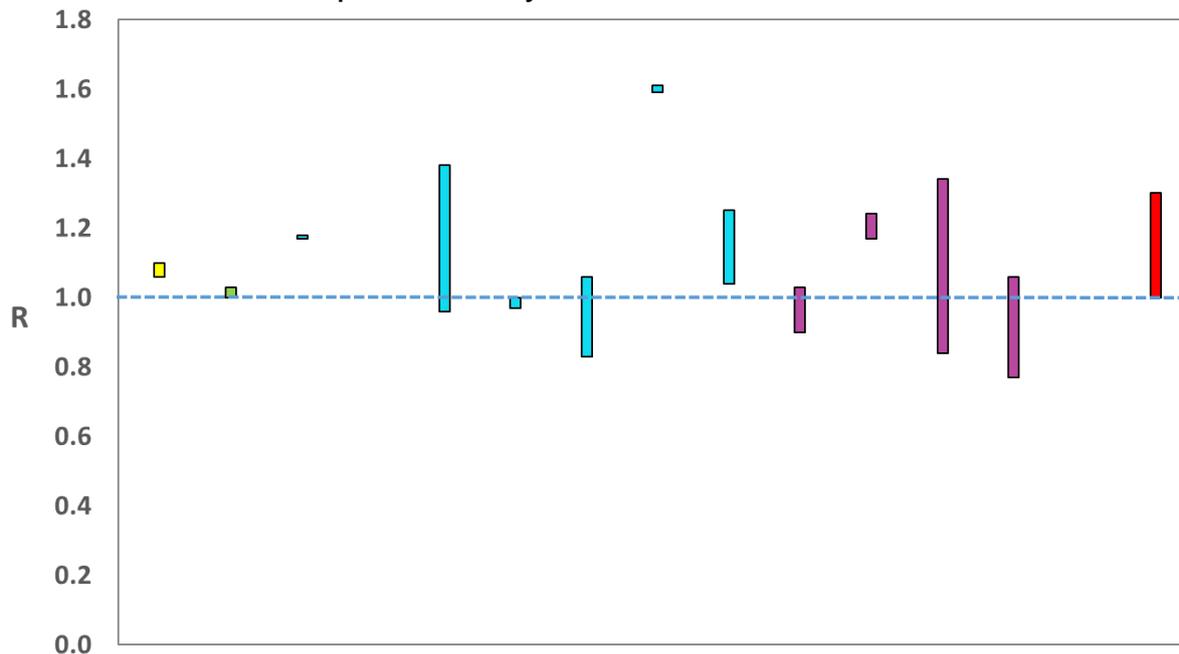
The R value and growth rates are estimated by several independent modelling groups based in universities and the UKHSA. Estimates are considered, discussed and combined at the Epidemiology Modelling Review Group (EMRG), which sits within the UKHSA. These are based on data to 14th March.

UKHSA's consensus view across these methods was that the value of R in Scotland² is between 1.0 and 1.3, as of 1st March 2022³ (Figure 2). The lower and upper limits have increased since last week. R is an indicator that lags by two to three weeks.

² Using data to 14th March.

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 1st March, including 90% confidence intervals, produced by EMRG⁴.



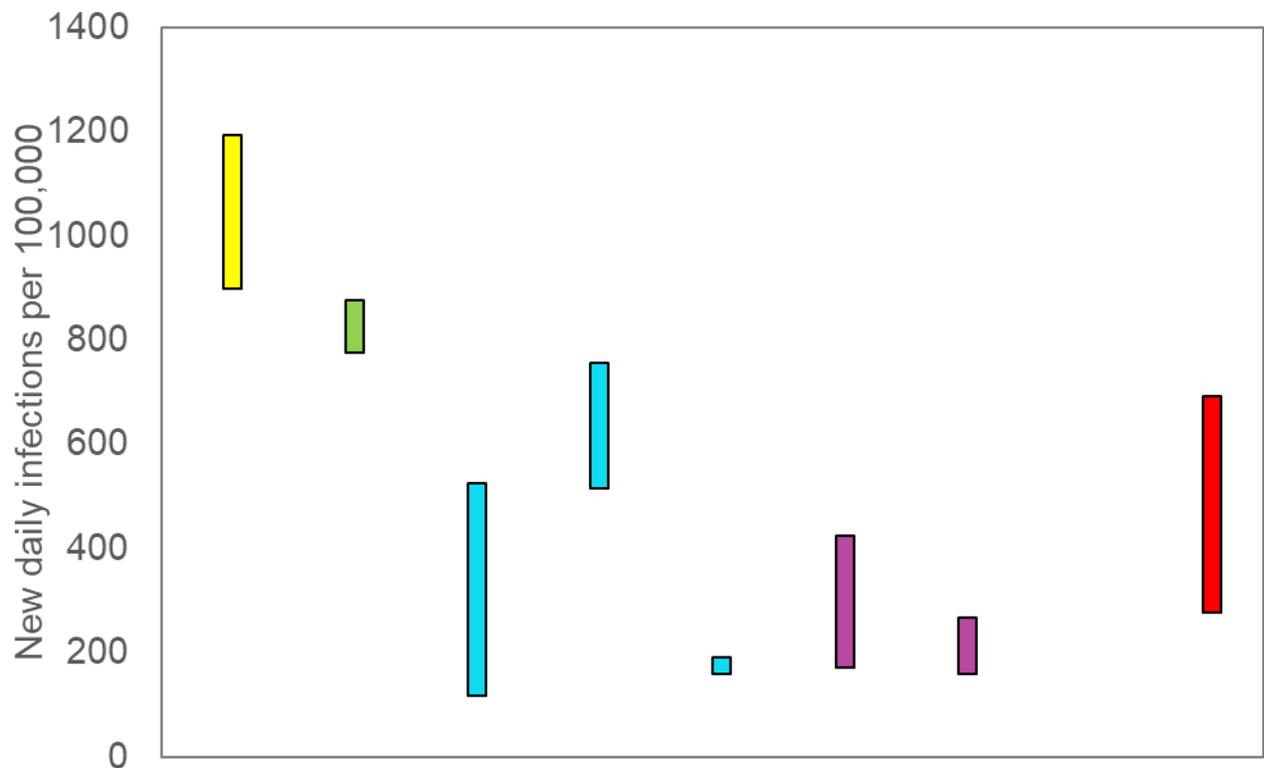
Source: EMRG

The consensus from UKHSA for this week is that the growth rate in Scotland is between -1% and 3% per day as at 1st March. The upper limit has increased since last week.

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 1st March, was that the incidence of new daily infections in Scotland was between 278 and 692 new infections per 100,000. This equates to between 15,200 and 37,800 people becoming infected each day in Scotland.

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; green uses wastewater data). The UKHSA consensus range is the right-most (red). Data to 14th March 2022. R and growth rate as of 1st March 2022.

Figure 3. Estimates of incidence for Scotland, as at 1st March, including 90% confidence intervals, produced by EMRG.



Source: EMRG

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

Average contacts from the most recent Panel A cohort of the Scottish Contact Survey (week ending 9th March) indicate an average of 4.8 contacts. This has increased by 28% compared to the previous Panel A of the survey (week ending 23rd February), as seen in Figure 4. Mean contacts within the work and other setting (contacts outside home, school and work) have increased within the last two weeks by 18% and 36% respectively. Contacts within the home have decreased by 5% over the same period.

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

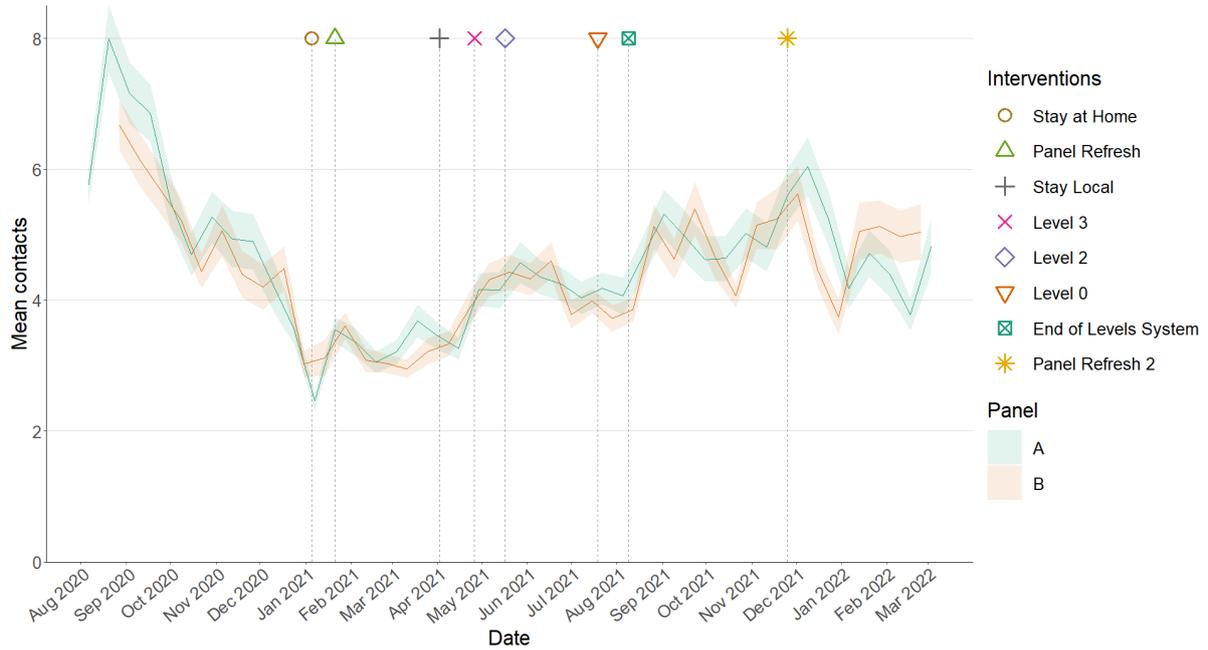
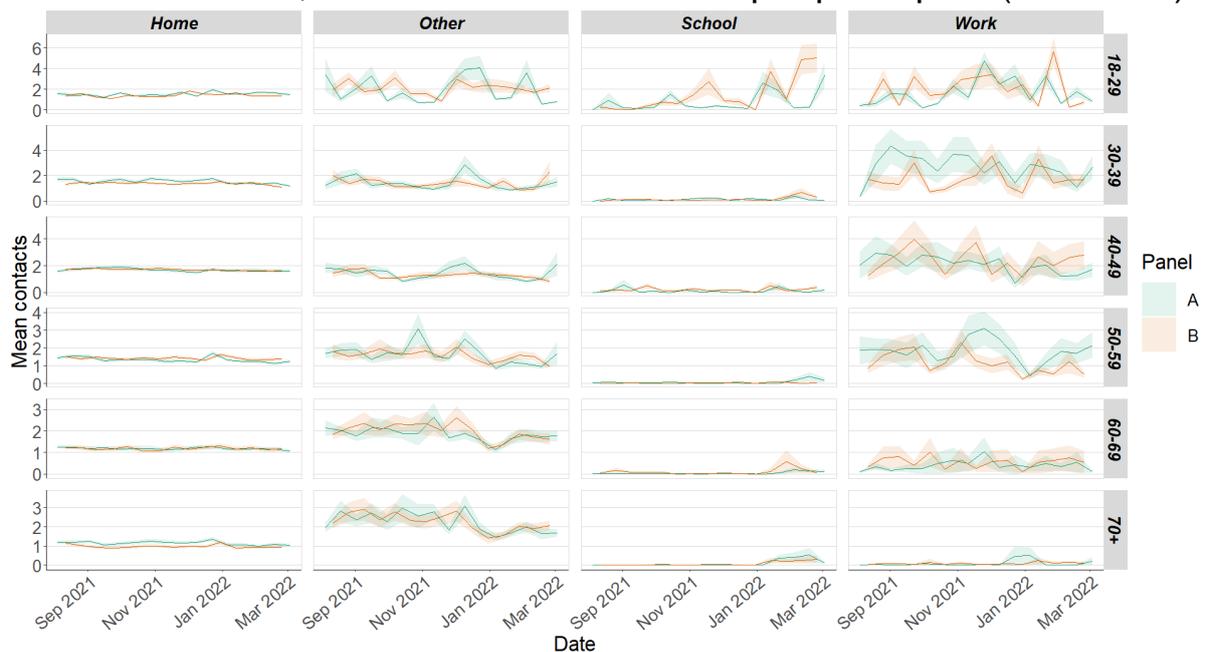


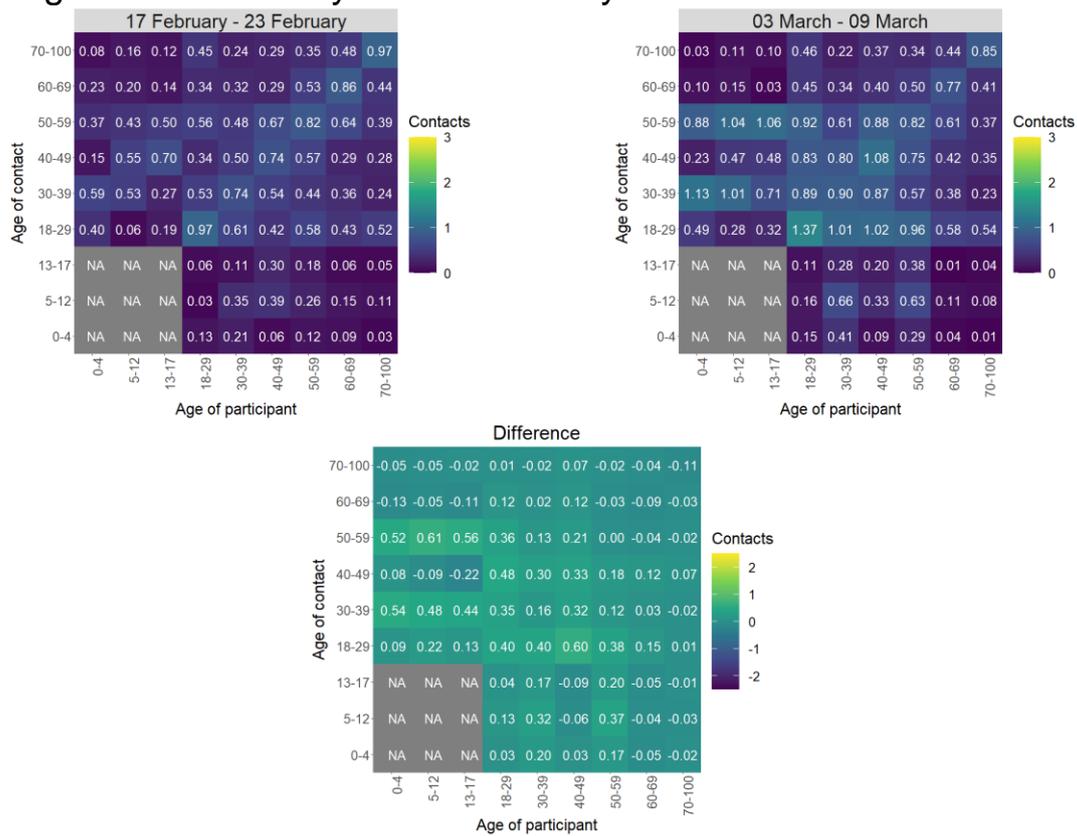
Figure 5 shows how contacts change across age group and setting. Individuals within the youngest age groups (18-59) have all reported a rise in contacts within the last two weeks, with the 18-29 age group increasing by approximately 55%. Increases are largely driven by a rise in contacts in the work and other setting (contacts outside home, school and work). Those within the oldest age groups (60+) have decreased their contacts in the last two weeks.

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 17th February - 23rd February and 3rd March - 9th March and the difference between these periods. The 18-29 age group has increased interactions with all age groups within the last two weeks. Interactions between those aged 13-17 and individuals aged 40-49 have reported the biggest decrease.

Figure 6: Overall mean contacts by age group before for the weeks relating to 17th February - 23rd February and 3rd March - 9th March.



The biggest changes in the proportion of participants visiting different locations is seen in those visiting an outside event and individuals visiting a pub or restaurant. Visits to an outside event have shown the biggest increase, increasing from approximately 58% to 63% followed by visits to a pub or restaurant increasing from 45% to 49% in the last two weeks as shown in Figure 7.

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

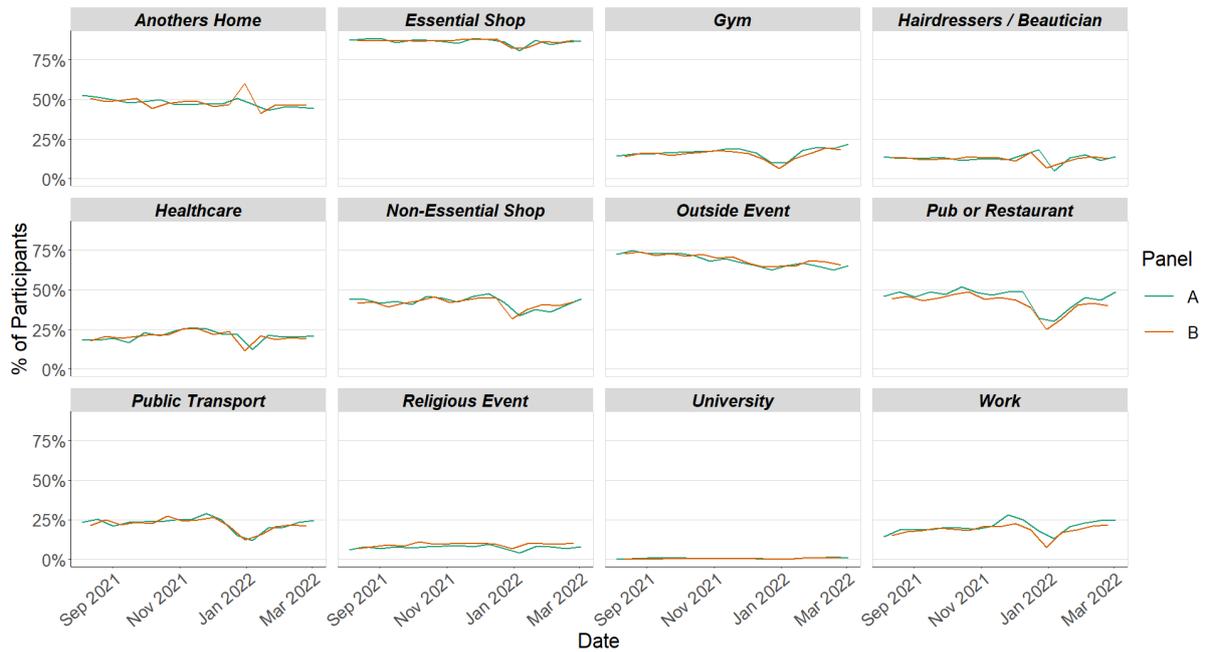


Figure 8 shows the number of people wearing a face covering where they have at least one contact outside of the home. This has remained high at approximately 84%.

Figure 8: Proportion of participants wearing a face coverings over time (with at least one contact outside of the home).



Approximately 75% of individuals had taken at least one lateral flow test within the last 7 days for the survey pertaining to the 3rd March - 9th March, decreasing from 80% two weeks prior as shown in Figure 9.

Figure 9: Proportion of participants taken a lateral flow in last 7 days

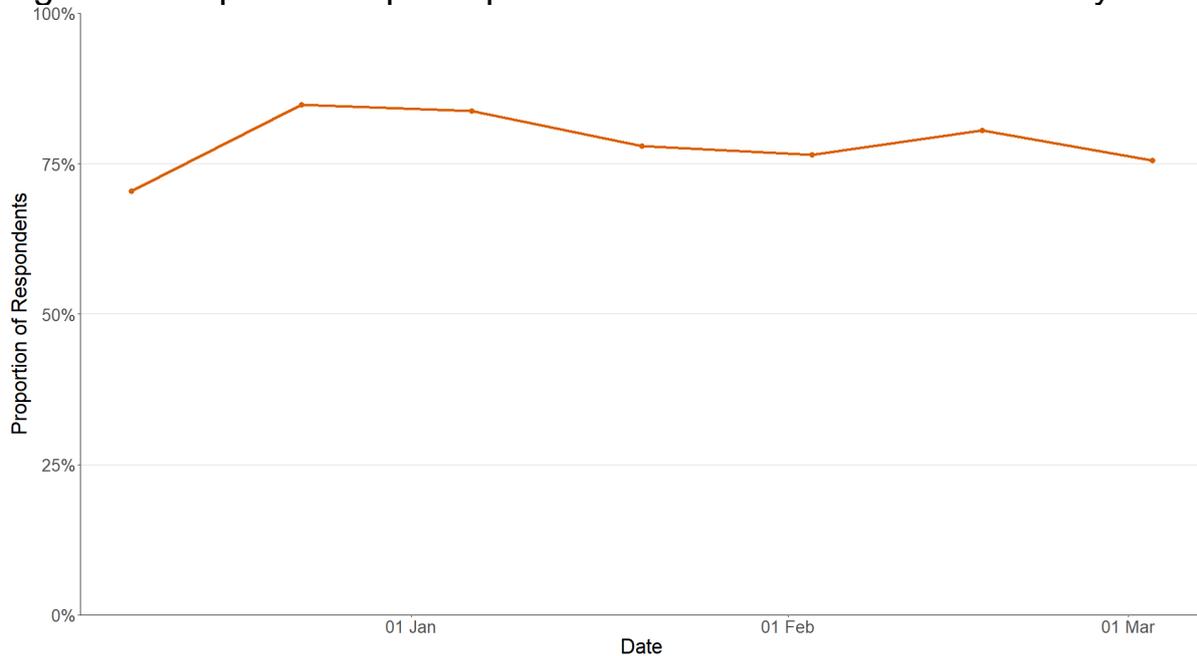
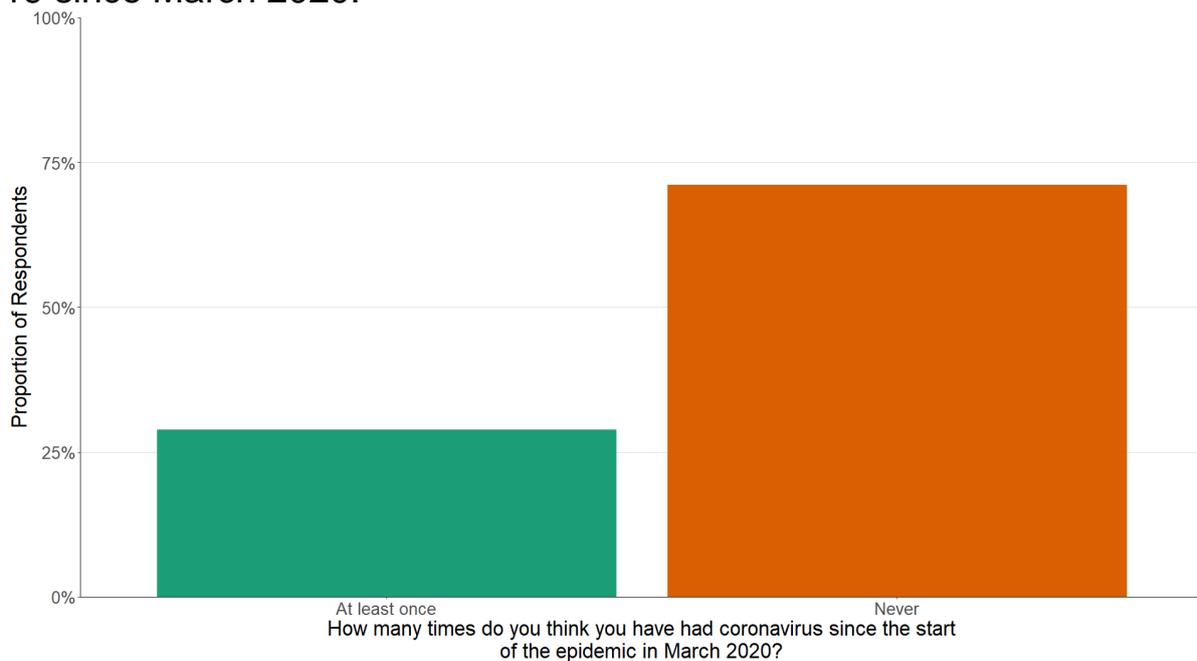


Figure 10 shows that approximately 29% of individuals believe they have had Covid-19 at least once since March 2020. Of those who think they have had Covid-19, 80% have had this confirmed through a test.

Figure 10: Proportion of participants who believe they have had Covid-19 since March 2020.



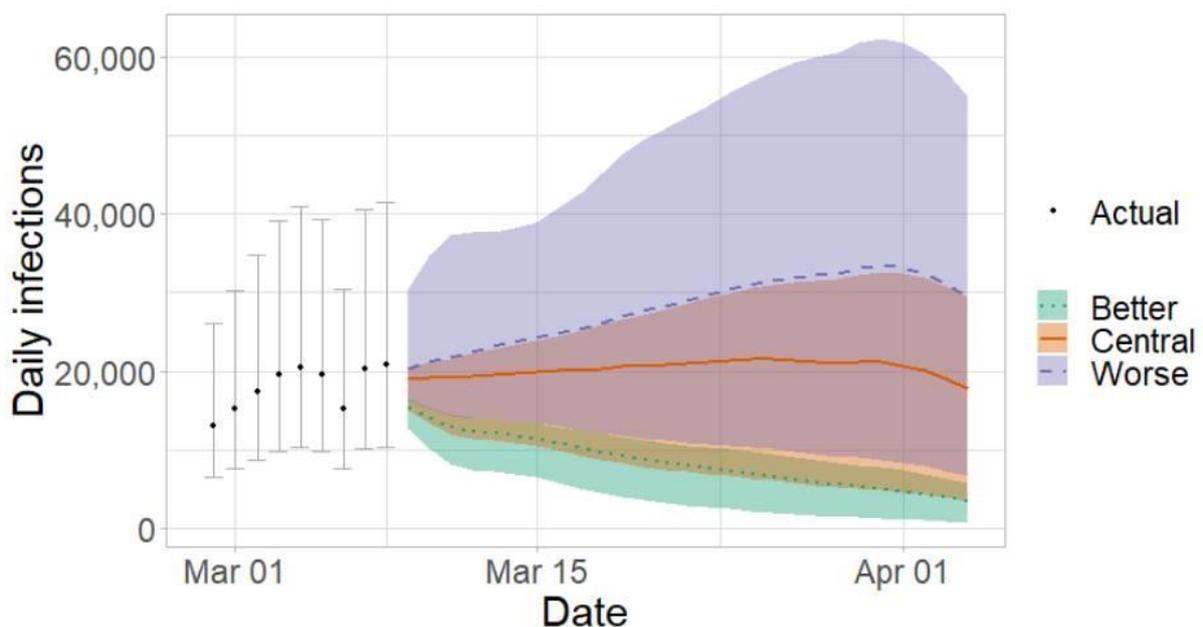
What the modelling tells us about estimated infections and hospitalisations

The Scottish Government assesses the impact of Covid-19 on the NHS in the next few weeks. Figures 11 - 13 show projections over three weeks.

These projections include the effect of booster take up. 'Central' assumes that transmissibility remains at current levels. 'Worse' assumes a higher transmissibility, whereas 'Better' assumes a lower transmissibility. These projections do not include the changes to restrictions announced on 15th March.

The future trajectory of infections is uncertain.

Figure 11. Medium term projections of modelled total new combined daily infections in Scotland, adjusting positive tests to account for asymptomatic and undetected infections, from Scottish Government modelling, based on positive test data reported up to 14th March



We estimate that daily infections may be up to 49,000 in early April.

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.

Figure 12. Medium term projections of modelled hospital bed demand, from Scottish Government modelling, based on positive test data reported up to 14th March.

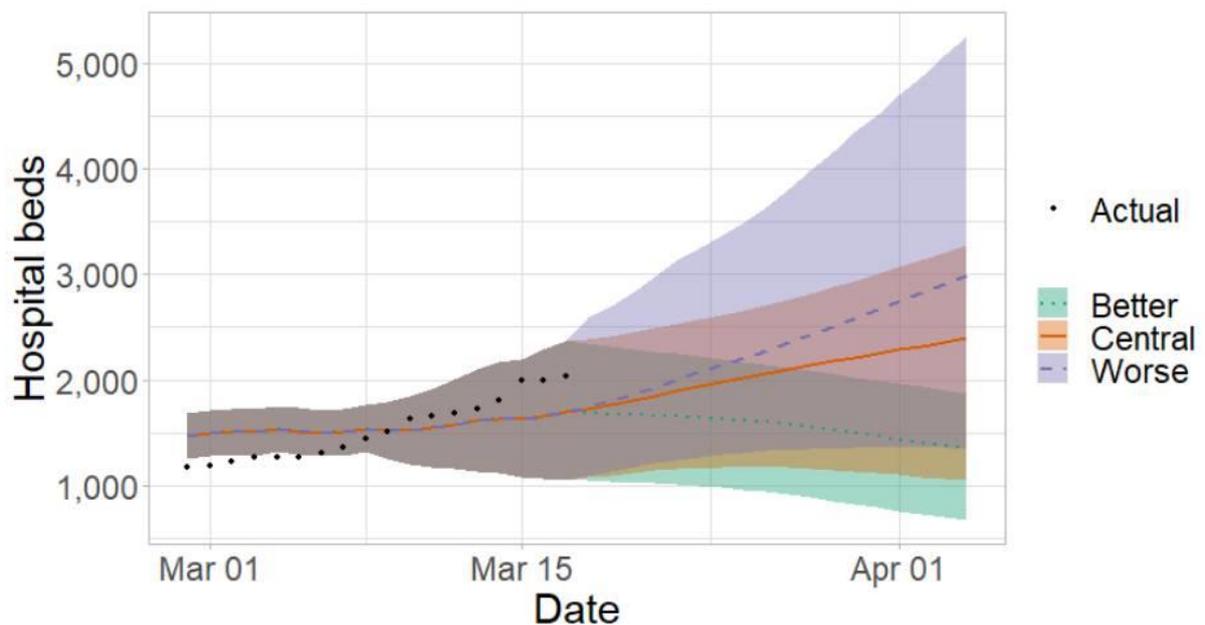
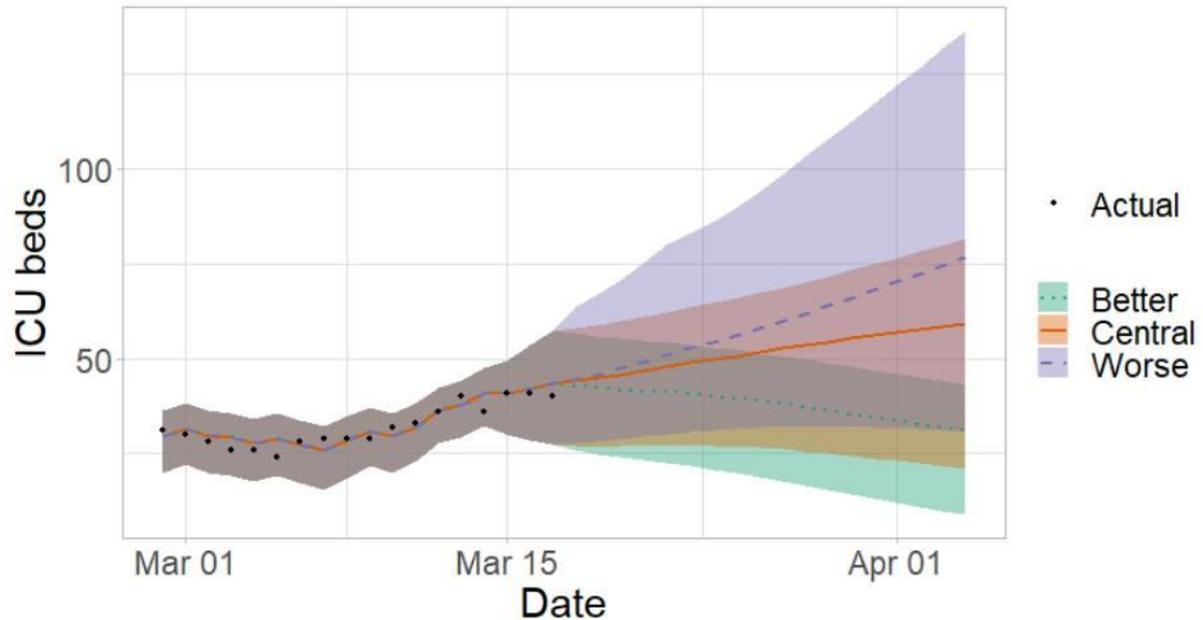


Figure 13 shows the impact of the projection on ICU bed demand.

Figure 13. Medium term projections of modelled ICU bed demand, from Scottish Government modelling, based on positive test data reported up to 14th March.



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

SPI-M-O produces projections of the epidemic (Figures 14 - 16), combining estimates from several independent models. 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 available to 14th March 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 14th March.

The 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.

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

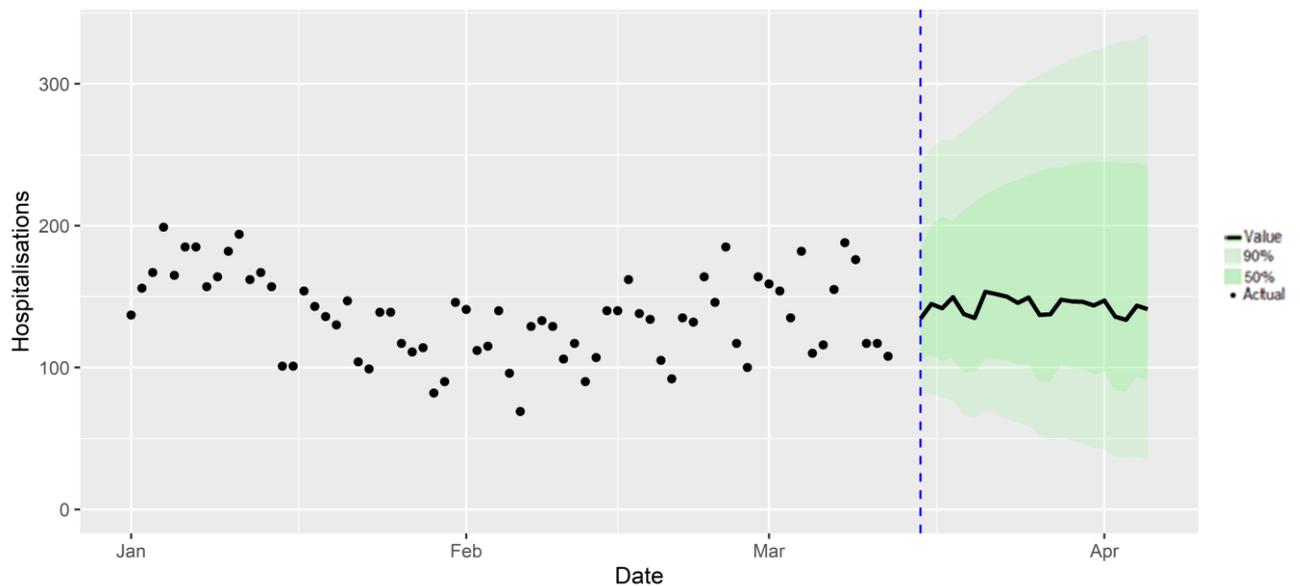
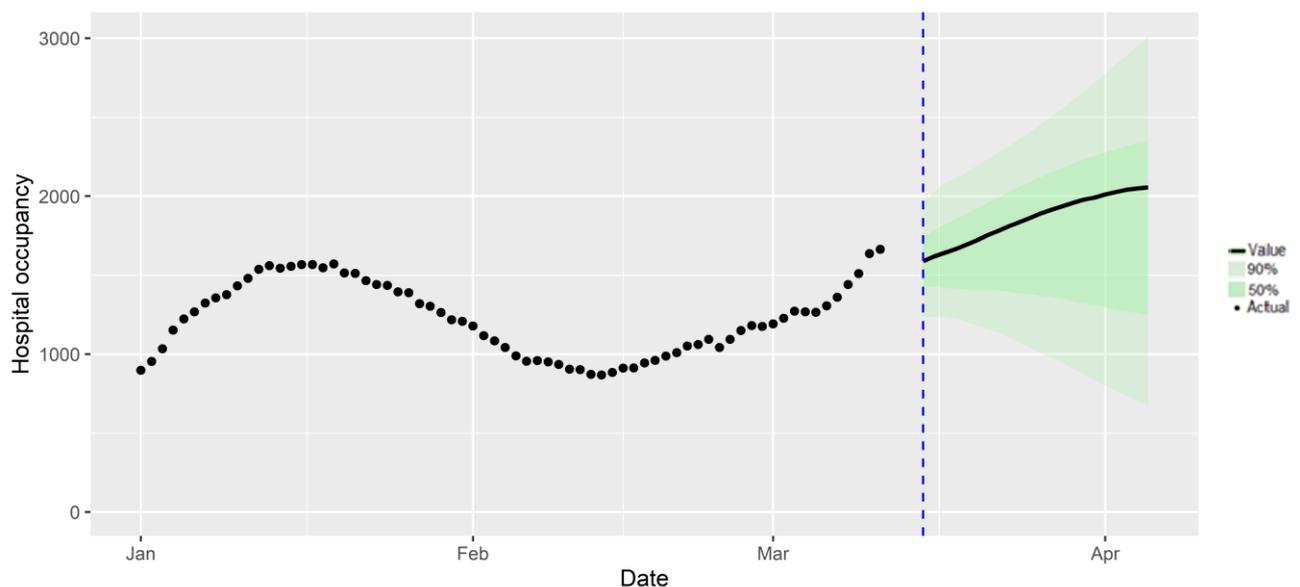


Figure 15 shows the SPI-M-O consensus on hospital occupancy. Hospital occupancy is determined by the combination of admissions and length of stay, the latter of which is difficult to model with confidence.

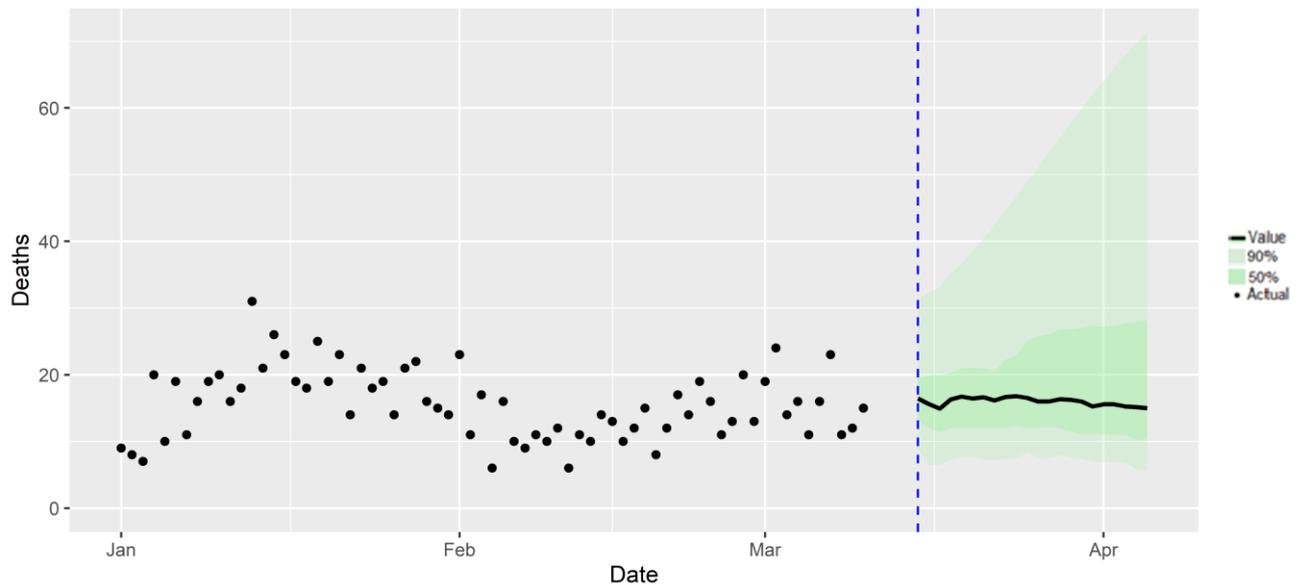
Figure 15. SPI-M-O medium-term projection of hospital occupancy in Scotland, at 50% and 90% credible intervals



Some models are struggling to fit to both the recent trends in Covid-19 hospital occupancy and admissions in Scotland. Producing reliable projections is challenging with the current trends in different data streams.

Figure 16 shows the SPI-M-O consensus on daily Covid-19 deaths.

Figure 16. SPI-M-O medium-term projection of daily Covid-19 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 14th March 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 not been compiled via UKHSA into a consensus this week and is based on one modelling group.

In less populated regions in which case numbers are small, there is a greater variation in model estimates, and hence increased uncertainty. This has led to us not including Na h-Eileanan Siar, Orkney Islands and Shetland Islands this week.

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.

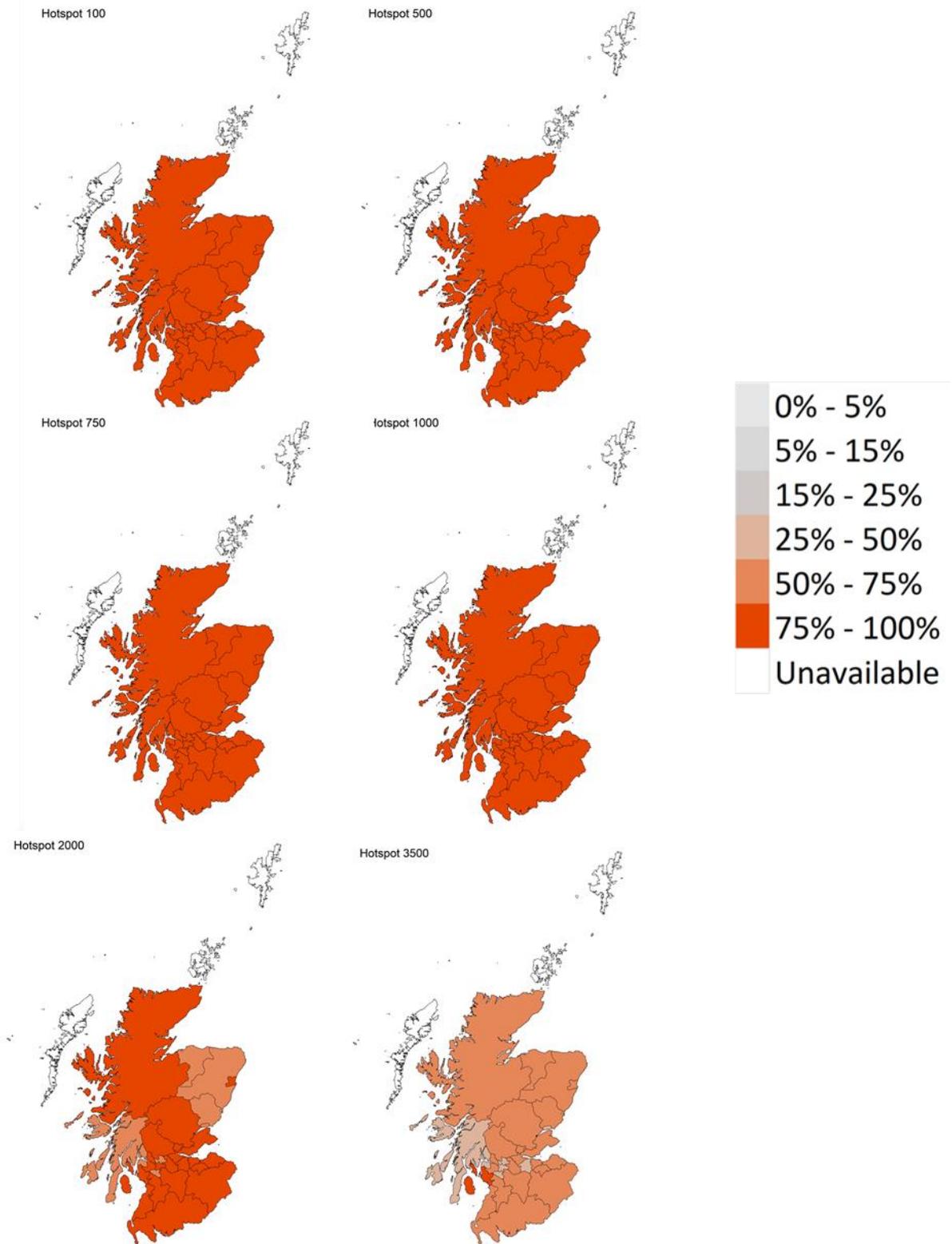
Modelled rates of positive tests per 100K using data to 14th March (Figure 17) indicate that, for the week commencing 27th March, all 29 of the local authorities included are expected to exceed 100 cases per 100K with at least 75% probability. These same 29 local authorities also have at least a 75% probability of exceeding 1000 cases per 100K.

21 of the 29 local authorities included are expected to exceed 2000 cases per 100K with at least 75% probability. The exceptions are Aberdeenshire, Angus, Argyll & Bute, Dundee, East Dunbartonshire, East Renfrewshire, Inverclyde and Moray.

One local authority (North Ayrshire) is expected to exceed 3500 cases per 100K with at least 75% probability.

We have not included the 50 threshold in Figure 17 this week due to the addition of some higher threshold levels. These thresholds levels are the same as for the 100 threshold. The full set of numbers are included in Table 1 in the Technical Annex.

Figure 17. Probability of local authority areas exceeding thresholds of cases per 100K (27th March to 2nd April 2022), data to 14th March.



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 (or ammonia levels where flow is not available). See Technical Annex in Issue 34 of these Research Findings for the methodology.

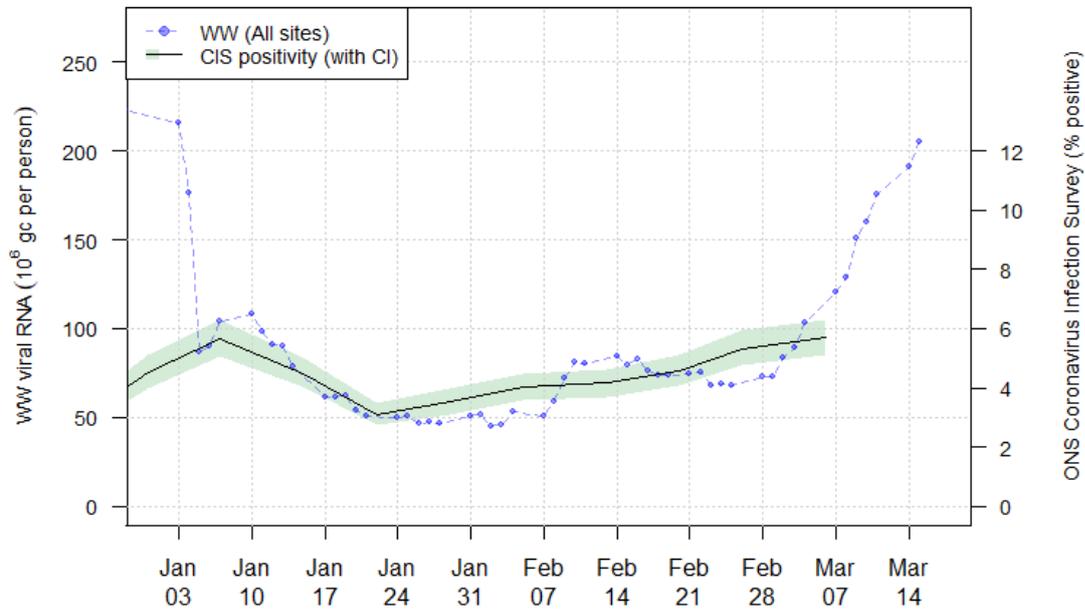
Nationwide, wastewater Covid-19 levels have increased rapidly. The week ending on 15th March saw levels of 206 million gene copies per person per day (Mgc/p/d), an increase of almost three times than two weeks prior (71 Mgc/p/d).

This week saw wastewater sampling levels increased compared to previous weeks, at 207 samples.

In Figure 18, we restrict plotting to the period after the end of 2021, at which point S-gene dropout testing data suggest that nearly all cases are from the Omicron variant. In this period, WW testing should have a consistent relationship with Covid-19 prevalence, assuming that the change in relationship is due to the new dominant variant and there is no shedding difference with Omicron BA.2. We also superimpose data from the ONS Coronavirus Infection Survey (CIS) to 5th March, with axis scaling chosen to match post-2021 levels in both datasets. Note that this scaling is not the same as that used in reports prior to 1 January 2022, where a scaling based on 2021 data was used.

In this graph, we see a rapid increase in WW Covid-19 levels starting from the end of February. This latest increase appears substantially more rapid than the increases seen in CIS and in WW RNA levels from late January, although the CIS does not cover the most recent time period and the WW Covid-19 levels show greater variability.

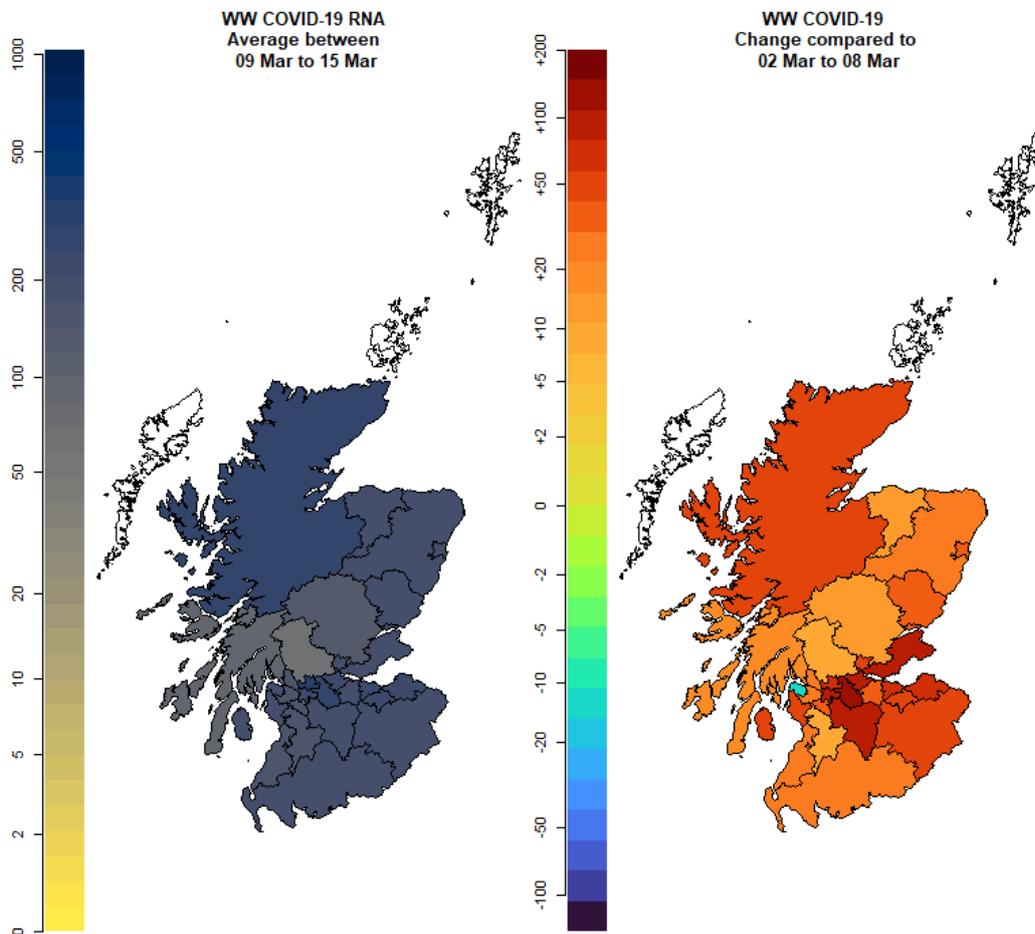
Figure 18. National running average trends in wastewater Covid-19 from 31st December 2021 to 15th March 2022⁵



The maps in Figure 19 show population weighted average WW viral Covid-19 levels for each local authority for the last week, with changes relative to the previous week. These show a clear increase in Covid-19 levels across much of Scotland.

⁵ For this graph, a wastewater RNA average using the last 7 days of data is computed at every sampling date. Prevalence estimates and 95% confidence intervals from the ONS Coronavirus Infection Survey are overlaid, with a scale chosen to approximately match wastewater COVID-19 levels in 2022.

Figure 19. Map showing wastewater Covid-19 levels (million gene copies/person/day) for each local authority for 9th March to 15th March and changes relative to 2nd March to 8th March.



Long Covid

A report on the rate of long Covid has not been included this week. We will report the long Covid projections again once updated estimates of self-reported long Covid prevalence amongst those infected with the less severe Omicron variant become available.

What next?

Modelling will continue to look at the impact of Omicron, particularly the variant BA.2. As the year progresses we will incorporate different models as and when it is appropriate to do so.

We hope to include our analysis on long Covid in future weeks.

UKHSA is considering a change in the frequency that Covid-19 estimates are published, to every two weeks from 1st April. This would mean that this *Modelling the Epidemic* publication would also move to every two weeks from 1st April. If you have any feedback about this, please contact UKHSA at enquiries@ukhsa.gov.uk.

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.

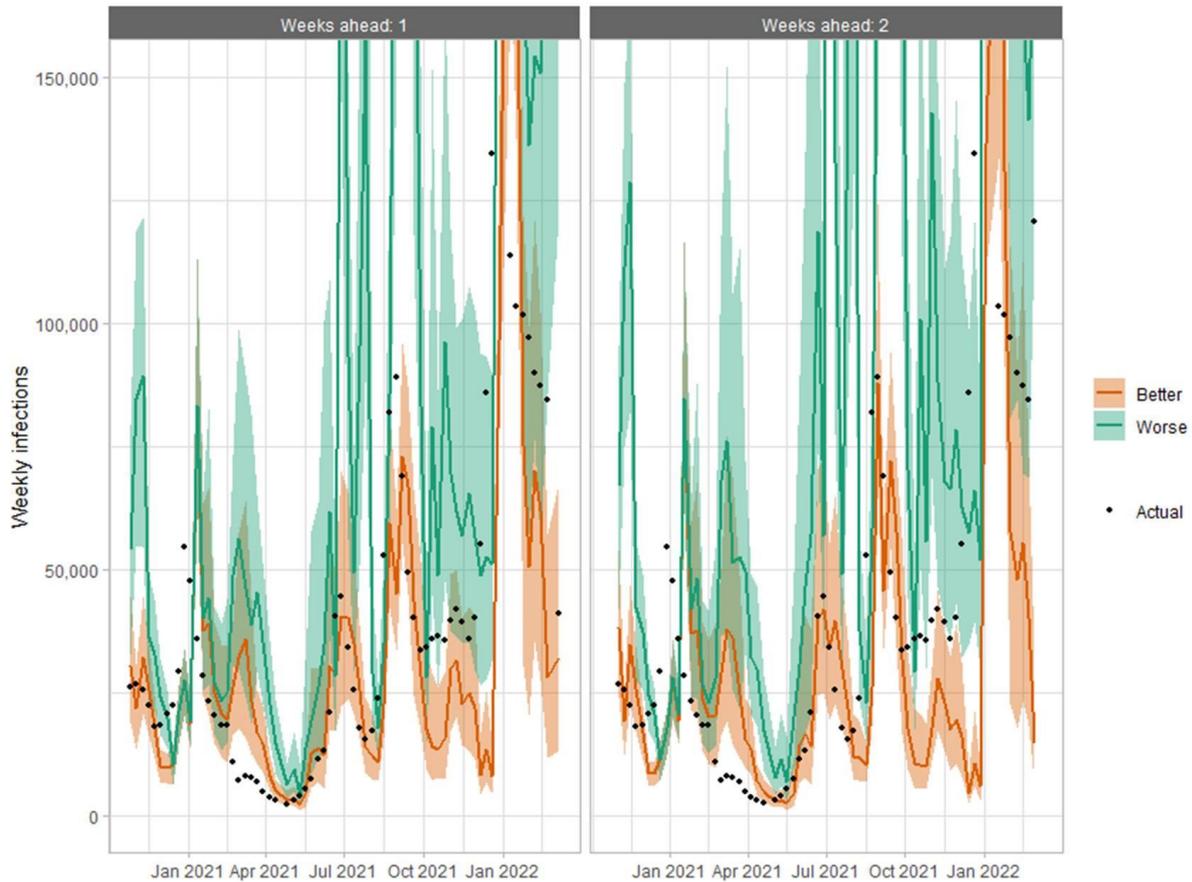
Modelling also allows us to make short-term forecasts of what may happen with a degree of uncertainty. These can be used in health care and other planning. The modelling in this research findings is undertaken using different types of data which going forward aims to both model the progress of the epidemic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

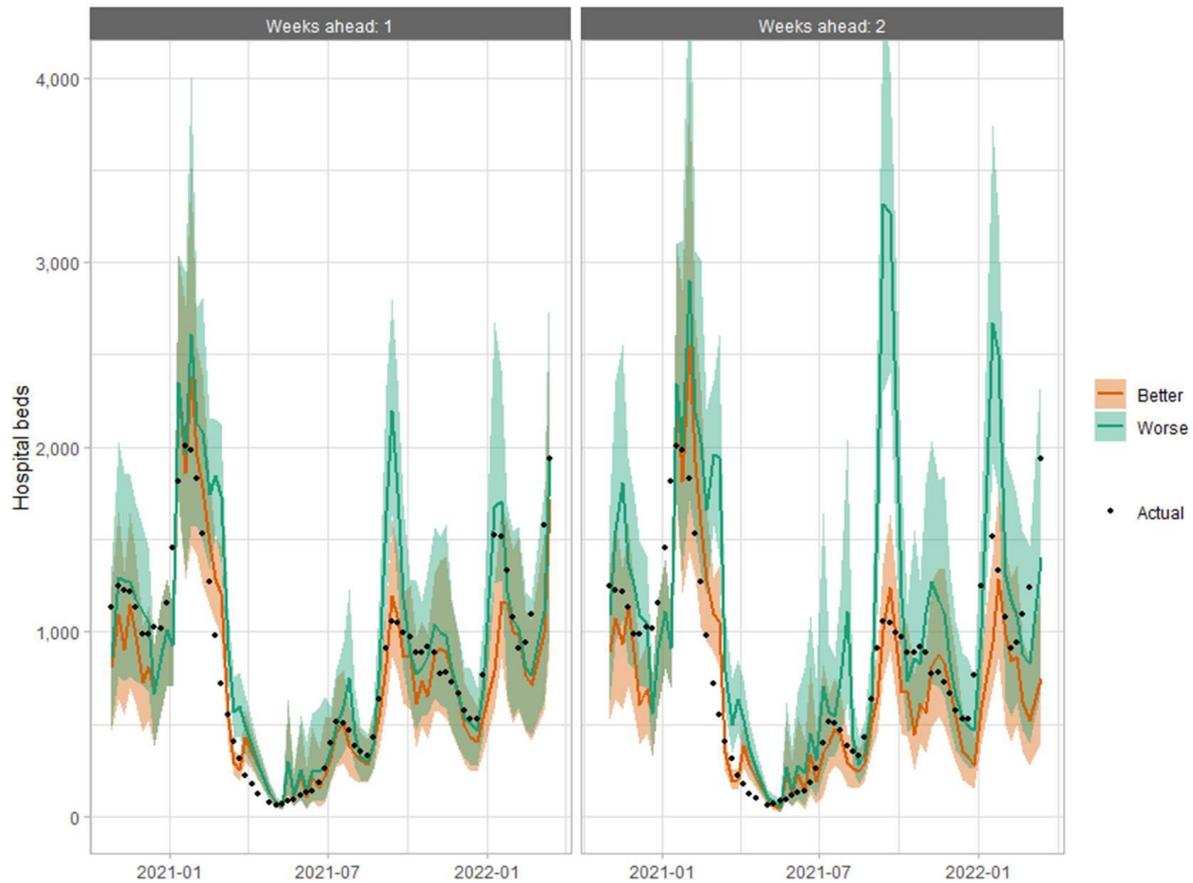
The following charts show the history of our modelling projections in comparison to estimates of the actual data. The infections projections were largely accurate from mid-January 2021 until mid-December 2021, from which point the projections have underestimated the number of infections, due to the unforeseen effects of the Omicron variant. The same is true for the hospital beds projections, however the ICU beds 24 projections have overestimated the actual figures since mid-December 2021, due to the lower severity of Omicron.

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



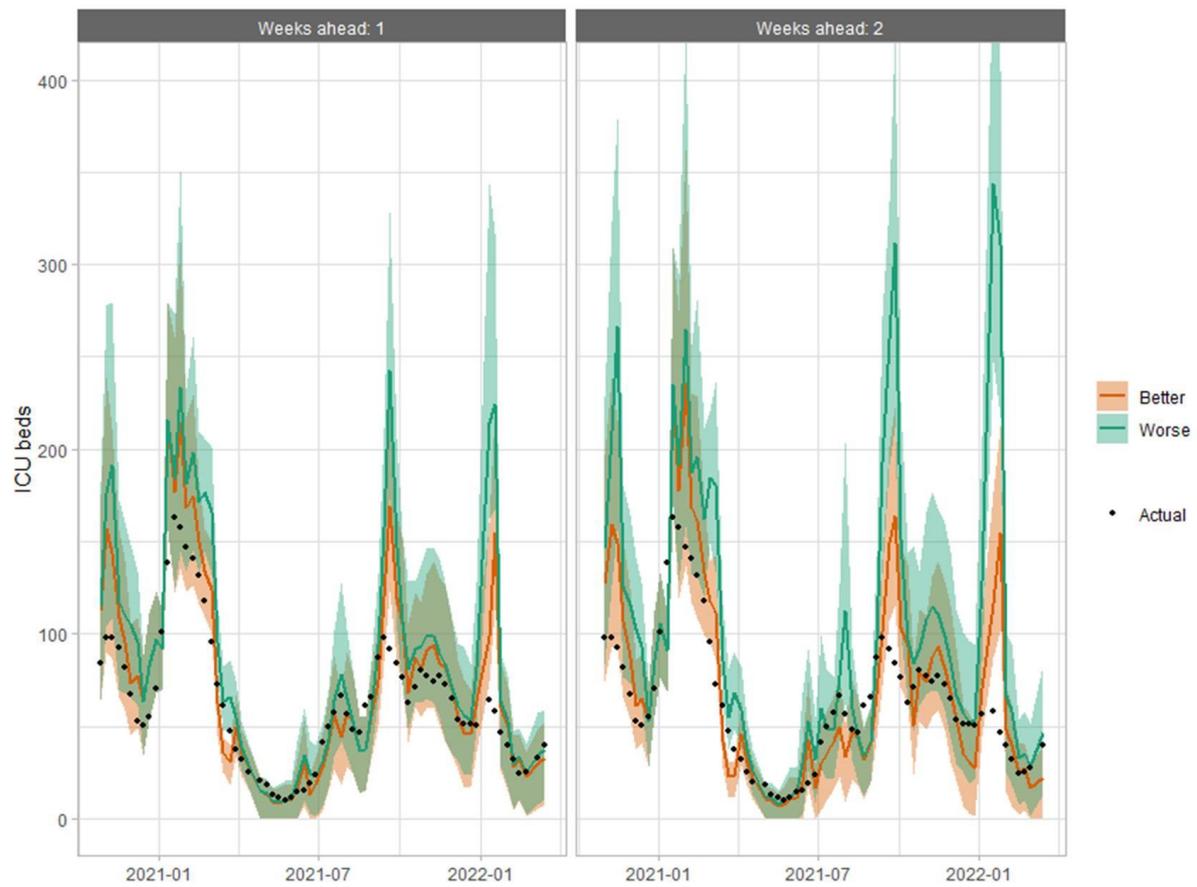
Hospital bed projections have generally been more precise than infections estimates due to being partially based on already known information about numbers of current infections, and number of people already in hospital. The projections are for number of people in hospital due to Covid-19, which is slightly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

Figure 21. 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 22. ICU bed projections versus actuals, for historical projections published between one and two weeks before the actual data came in.



Which local authorities are likely to experience high levels of Covid-19 in two weeks' time

Table 1. Probability of local authority areas exceeding thresholds of cases per 100K (20th March to 26th March 2022). Data to 7th March.

Local Authority	Probability of exceeding (cases per 100K)						
	50	100	100	500	1000	2500	3000
Aberdeen City	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Aberdeenshire	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	50-75%
Angus	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	50-75%
Argyll and Bute	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	25-50%
City of Edinburgh	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Clackmannanshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Dumfries & Galloway	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Dundee City	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	25-50%
East Ayrshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
East Dunbartonshire	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	25-50%
East Lothian	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
East Renfrewshire	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	25-50%
Falkirk	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Fife	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Glasgow City	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	25-50%
Highland	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Inverclyde	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	25-50%
Midlothian	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Moray	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%	50-75%
Na h-Eileanan Siar ⁶	-	-	-	-	-	-	-
North Ayrshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%
North Lanarkshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Orkney Islands ⁶	-	-	-	-	-	-	-
Perth and Kinross	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Renfrewshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Scottish Borders	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Shetland Islands ⁶	-	-	-	-	-	-	-
South Ayrshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
South Lanarkshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
Stirling	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
West Dunbartonshire	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	50-75%
West Lothian	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	25-50%

⁶ We have not been able to provide estimates for Na h-Eileanan Siar, Orkney Islands or Shetland Islands this week.

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 ending 8th March and 15th March 2022, with no estimate for error. This is given in Million gene copies per person per day. Coverage is given as percentage of inhabitants in each local authority covered by a wastewater Covid-19 sampling site delivering data during this period⁷.

Table 2. Average Covid-19 wastewater levels (Mgc/p/d)⁸.

Local authority (LA)	w/e 8 th March	w/e 15 th March	Coverage
Aberdeen City	144	196	99%
Aberdeenshire	151	186	44%
Angus	134	190	68%
Argyll and Bute	73	96	23%
City of Edinburgh	140	220	98%
Clackmannanshire	122	182	92%
Dumfries & Galloway	149	180	33%
Dundee City	164	206	100%
East Ayrshire	130	145	72%
East Dunbartonshire	190	296	99%
East Lothian	133	238	74%
East Renfrewshire	96	147	89%
Falkirk	125	244	96%
Fife	95	198	84%
Glasgow City	117	225	75%
Highland	199	268	48%
Inverclyde	188	179	98%
Midlothian	149	220	88%
Moray	165	186	55%
Na h-Eileanan Siar	118	–	0%
North Ayrshire	115	177	92%
North Lanarkshire	116	267	91%
Orkney Islands	208	–	0%
Perth and Kinross	107	124	45%
Renfrewshire	120	156	97%
Scottish Borders	122	194	59%
Shetland Islands	6	–	0%
South Ayrshire	130	171	88%
South Lanarkshire	96	205	90%
Stirling	53	66	63%
West Dunbartonshire	139	171	98%
West Lothian	132	181	95%

⁷ 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.

⁸ Coverage as for week ending 15th March 2022.

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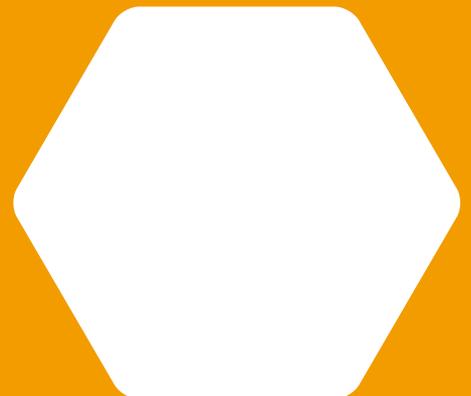
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