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Scottish Government Central Analysis Division

Coronavirus (Covid-19): modelling the epidemic in Scotland (Issue No. 100)

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 12th May 2022. The estimates in this document provide an overview of the situation regarding the virus and help the Scottish Government, the health service and the wider public sector plan ahead.

This edition of the research findings focuses on the epidemic as a whole, looking at estimates of R and growth rate as well as local measures of change in the epidemic.

Key Points

- The reproduction rate R in Scotland is currently estimated as being between 0.7 and 0.9, as at 10th May. The lower and upper limits are unchanged since last publication.
- The daily growth rate for Scotland is currently estimated as between -5% and -2% as at 10th May. The lower and upper limits have both increased since last publication.
- Average contacts from the most recent wave of the Scottish Contact Survey (12th May - 18th May) indicate an average of 5.0 contacts. This has remained at a similar level compared to the previous wave of the survey.
- Mean contacts within the work setting have decreased in the last two weeks by 26% whereas contacts within the other setting (contacts outside home, school and work) have increased by 33%. Contacts within the home have remained at a similar level over the same period.
- Those within the 18-29 age group have reported the biggest increase in contacts, by approximately 40%. This increase is largely driven by

a rise in contacts within the other setting. Those within the 30-39 and 50-59 age group reported a decrease in contacts, by at least 12%.

- The biggest increase in interactions has been between for those between the 18-29 age group.
- The biggest change in the proportion of participants visiting different locations is seen in those visiting a non-essential shop, increasing from 49% to 53% in the last two weeks.
- The percentage of people wearing a face covering where they have at least one contact outside of the home has decreased from 59% to 48% since the last wave of the survey.
- 40% of people had taken at least one lateral flow test in the previous 7 days, decreasing from 51% in the previous wave of the survey.
- Analysis by the Edinburgh University Roslin Institute indicates that there remains a substantial variation in geographical risk of infection when considering the average recorded census age and booster vaccination uptake.
- The data show a continued decline in reported tests but stabilisation of the overall positivity, which may be indicative that infection incidence is stabilising. It is however worth noting the recent rise in LFD positivity in the least deprived deciles, resulting in an “inversion” in LFD positivity with respect to deprivation, compared to for the first time in the epidemic, aside from a small deviation in around April 2022. However, with the small numbers of positives being reported, it is too early to say if this is a meaningful trend.
- The distribution of lateral flow/LFD tests being reported continues to vary substantially by both age and deprivation status, with many fewer tests reported in younger adults across all deciles of deprivation, and for children in more deprived deciles. The high level of LFD positivity in the latter category is marked, and when compared to the high number of positives amongst the least deprived, consistent with under ascertainment being concentrated (and in turn higher circulation than the cases data suggest) in particular groups.
- Nationwide, wastewater Covid-19 RNA levels in the past two weeks have had a similar average level as in our previous report. In the two weeks from 11th to 24th May, the medial level of Covid-19 in WW was 76 million gene copies per person per day (Mgc/p/d), compared to 82 Mgc/p/d previously. There is no significant difference between the two weeks.

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 SARS-CoV-2 the causative agent of 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 change in the epidemic.

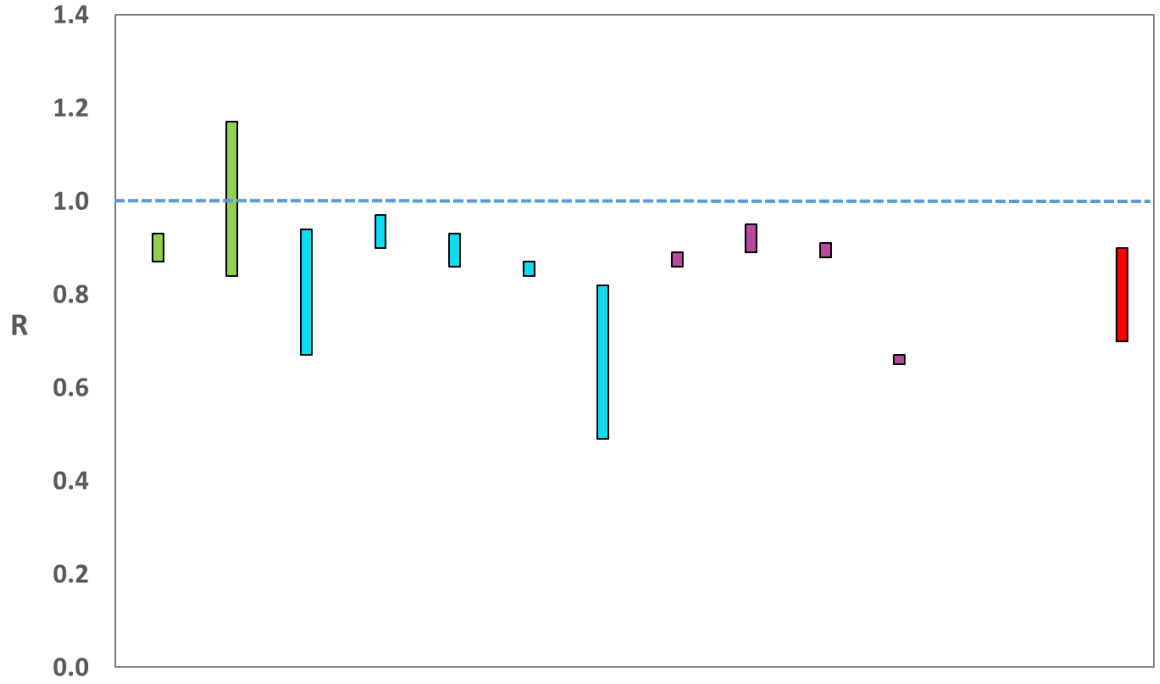
The Scottish Government presents outputs from two models (Epidemia and Covasim) to the Epidemiology Modelling Review Group (EMRG), both using wastewater derived data. These outputs are included in Figure 1.

The R value and growth rates are also estimated by several independent modelling groups based in universities and the UKHSA. Estimates are considered, discussed and combined at EMRG, which sits within the UKHSA. These are based on data to 9th May.

The consensus view of the UKHSA across these methods was that the value of R in Scotland is between 0.7 and 0.9, as of 10th May 2022[1] (Figure 1). The lower and upper limits are unchanged since last publication. R is an indicator that lags by two to three weeks.

[1] 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 1. Estimates of R_t for Scotland, as of 10th May, including 90% confidence intervals, produced by EMRG[2].



Source: EMRG

The consensus from UKHSA for this week is that the growth rate in Scotland is between -5% and -2% per day as at 26th April. The lower and upper limits have increased since last publication.

UKHSA was unable to form a consensus view on the incidence of new daily infections in Scotland as at 10th May.

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

Prior to the Covid-19 pandemic, the average daily contacts for adults in the UK were reported to be 10.8 from the UK-wide POLYMOD study3. Average contacts from the most recent wave of the Scottish Contact Survey (12th May - 18th May) indicate an average of 5.0 contacts as seen in Figure 2, less than half the level pre-pandemic. Since the commencement of this survey (August 2020), average contacts have not reached pre-pandemic levels

[2] The cyan bars use Covid-19 test data and purple bars use multiple sources of data. The estimates produce by the Scottish Government are the two green bars on the left. The UKHSA consensus range is the right-most (red). Data to 25th April. R and growth rate as of 26th April.

[3] The UK POLYMOD figures from https://bmcmedicine.biomedcentral.com/track/pdf/10.1186/s12916-020-01597-8

Mean contacts within the work setting have decreased in the last two weeks by 26% whereas contacts within the other setting (contacts outside home, school and work) have increased by 33%. Contacts within the home have remained at a similar level over the same period.

Figure 2: Mean contacts per day for adults in Scotland (truncated to 100 contacts per participant)[4]

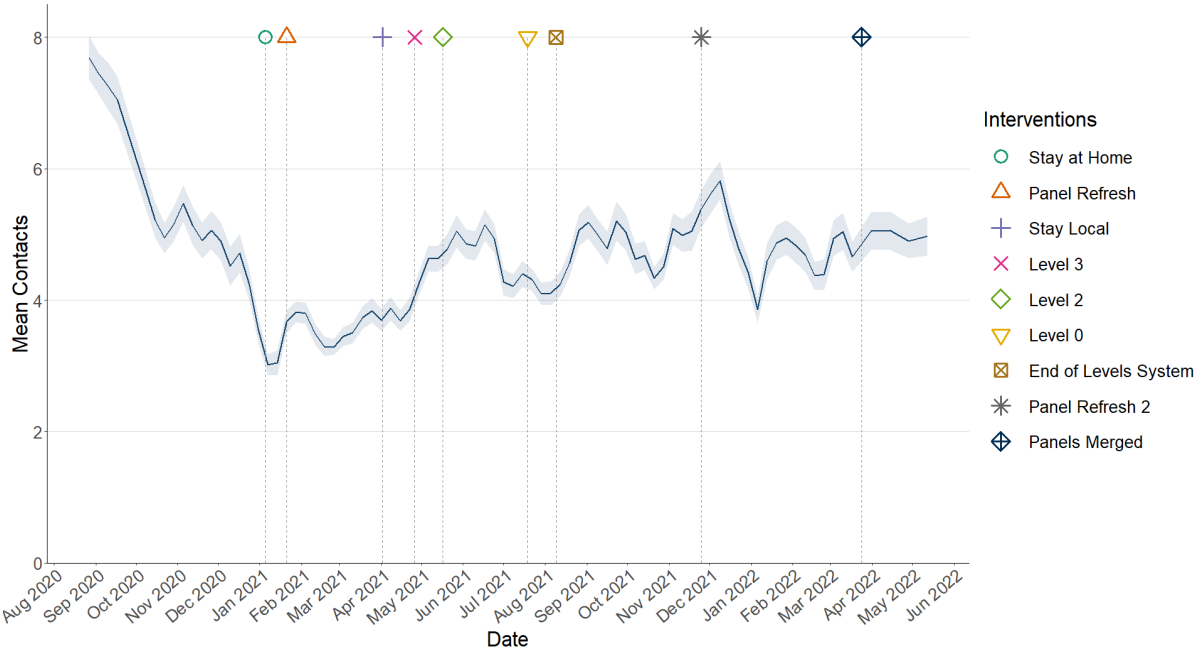
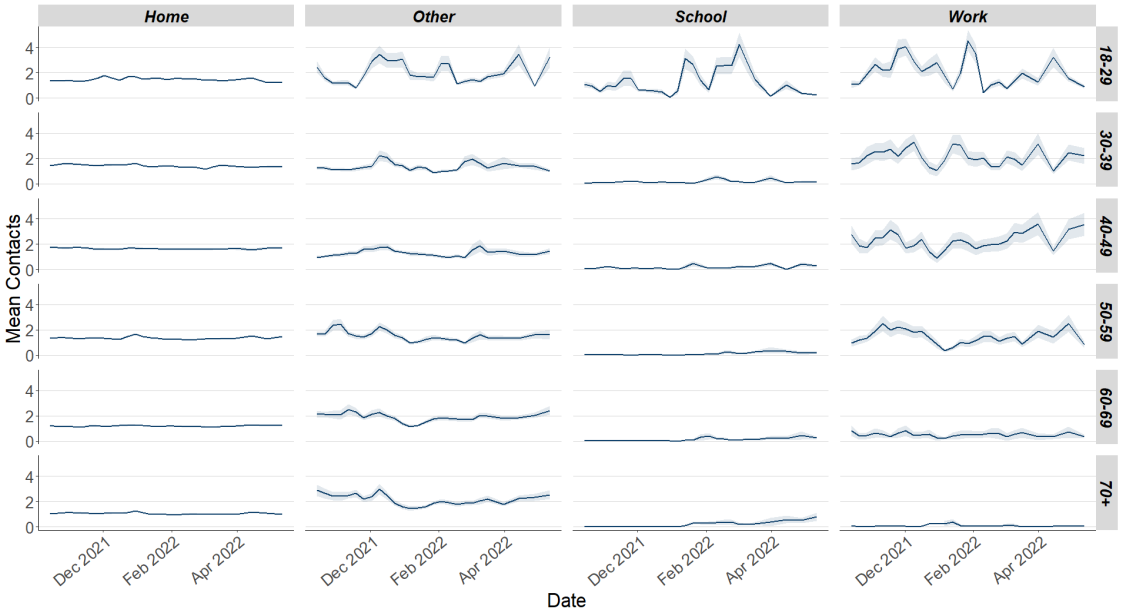


Figure 3 shows how contacts change across age group and setting. Those within the 18-29 age group have reported the biggest increase in contacts, by approximately 40%. This increase is largely driven by a rise in contacts within the other setting. Those within the 30-39 and 50-59 age group reported a decrease in contacts, by at least 12%.

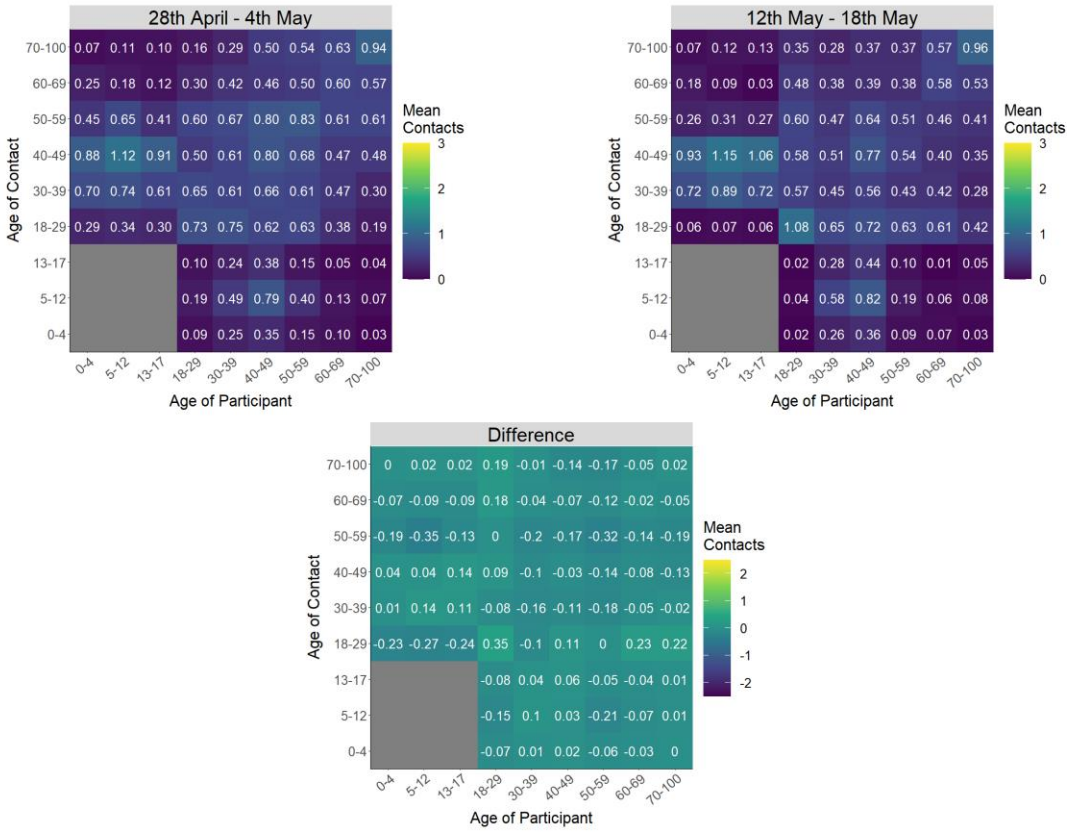
[4]From the 31st March 2022, panels A and B were merged into one survey and are run fortnightly. These data points are reported as at the first day of the survey round. Further details of this are presented in the Technical Annex of issue 99.

Figure 3: Mean contacts per day for adults in Scotland (truncated to 100 contacts per participant) by age group and setting.



The heatmaps in Figure 4 show the mean overall contacts between age groups for the surveys relating to 28th April - 4th May and 12th May - 18th May and the difference between these periods. The biggest increase in interactions has been between the 18-29 age group with each other.

Figure 4: Mean contacts per day between age groups (truncated to 100 contacts per participant)



The biggest changes in the proportion of participants visiting different locations is seen in those visiting a non-essential shop. This increased from 49% to 53% in the last two weeks as shown in Figure 5.

Figure 5: Locations visited by participants at least once

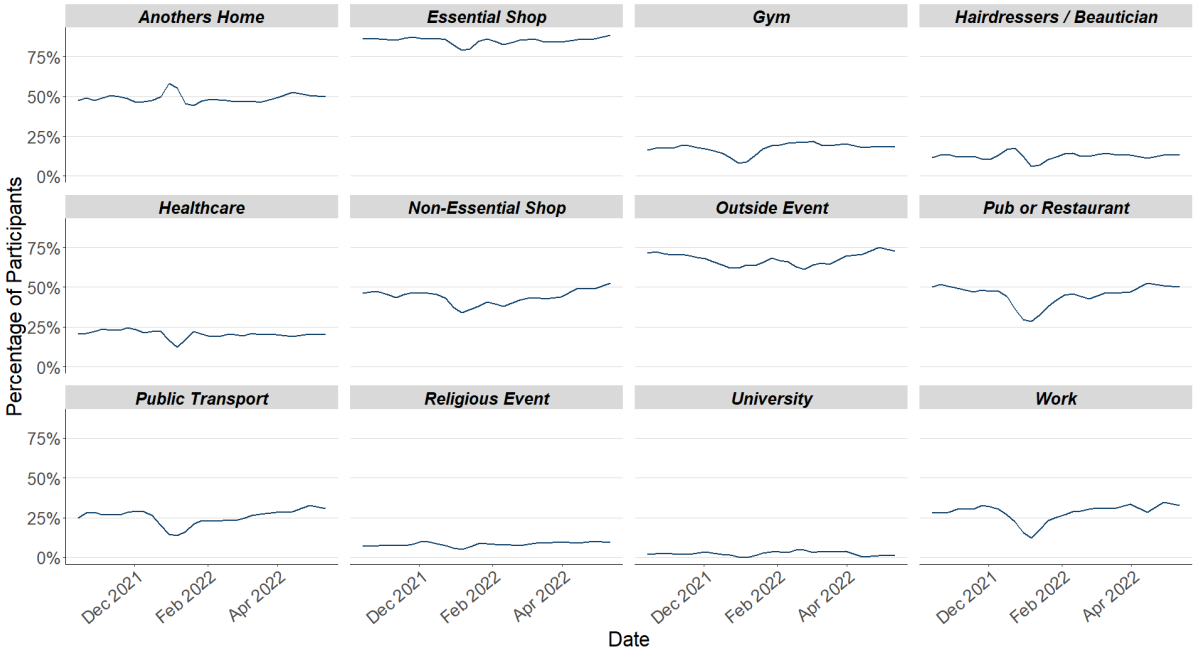
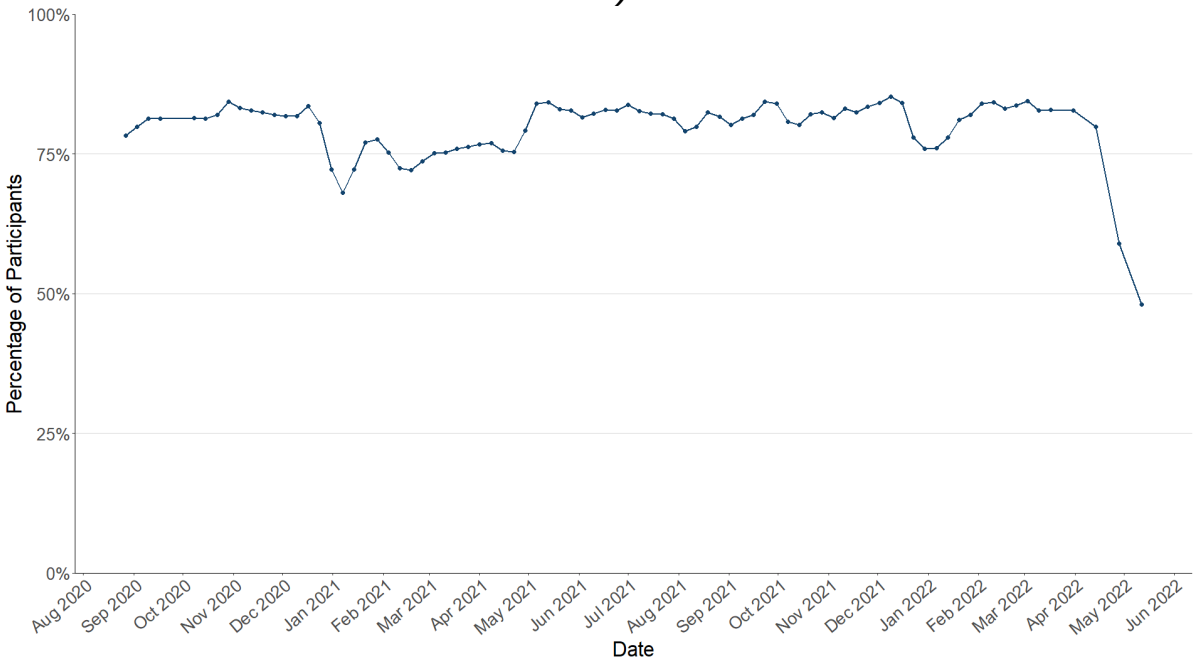


Figure 6 shows the percentage of people wearing a face covering where they have at least one contact outside of the home. This has decreased from 59% to 48% since the last wave of the survey.

Figure 6: Percentage of participants wearing a face covering (with at least one contact outside of the home)



In the survey pertaining to 12th May - 18th May, 40% of people had taken at least one lateral flow test in the previous 7 days, decreasing from 51% in the previous wave of the survey pertaining to the 28th April - 4th May.

Figure 7: Percentage of participants who had taken at least one lateral flow test in the last 7 days

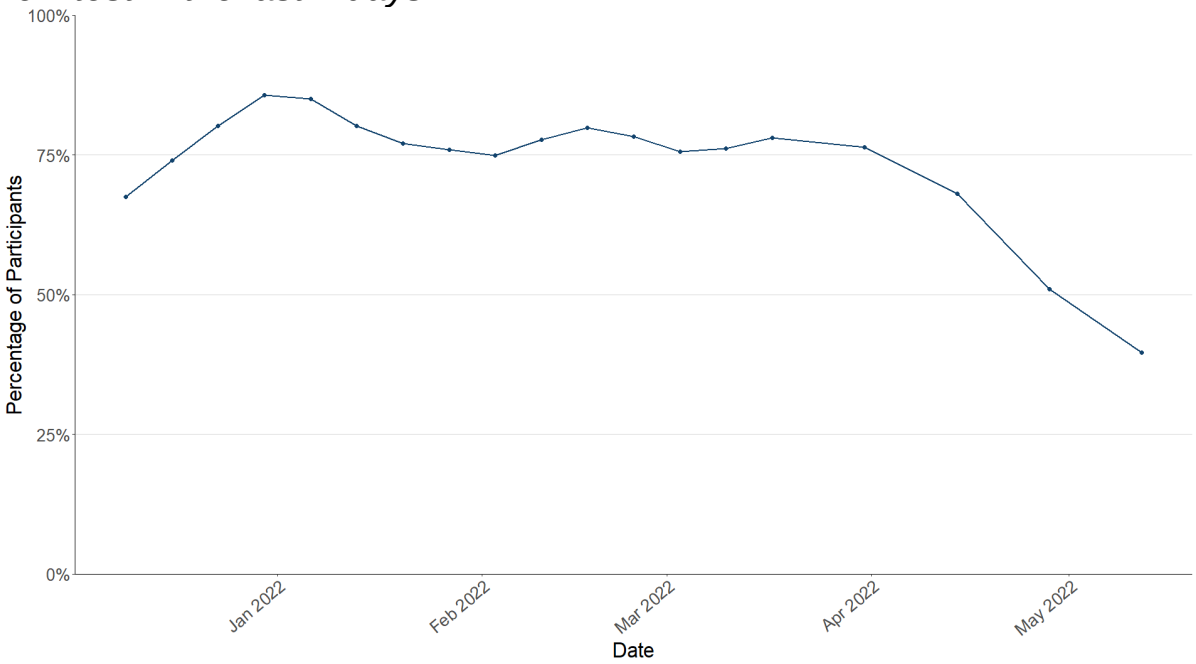
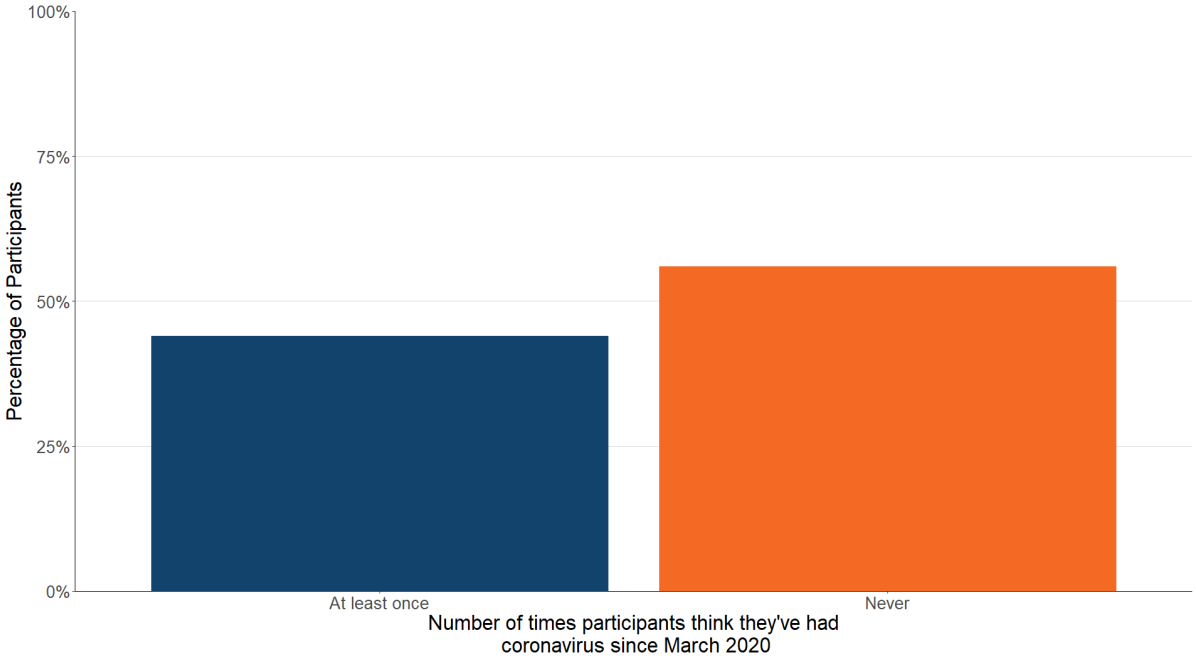


Figure 8 shows that 44% of participants believe they have had Covid-19 at least once since March 2020. Of those who think they have had Covid-19, 94% have had this confirmed through a test.

Figure 8: Percentage of participants who believe they have had Covid-19 since March 2020



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

We are not including the Scottish Government medium-term projections on infections, or hospital and ICU occupancy this issue.

SPI-M-O produces projections of the epidemic (Figures 9 - 10), 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 10th May 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 10th May. 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.

The number of deaths have fallen to very low levels in Scotland. Projecting forwards is difficult when numbers fall to very low levels, therefore projections for deaths in Scotland are not provided this week. However the consensus view is that the number of deaths in Scotland will remain low over the next six weeks.

Figure 9. SPI-M-O medium-term projection of daily hospitalisations in Scotland, at 50% and 90% credible intervals.

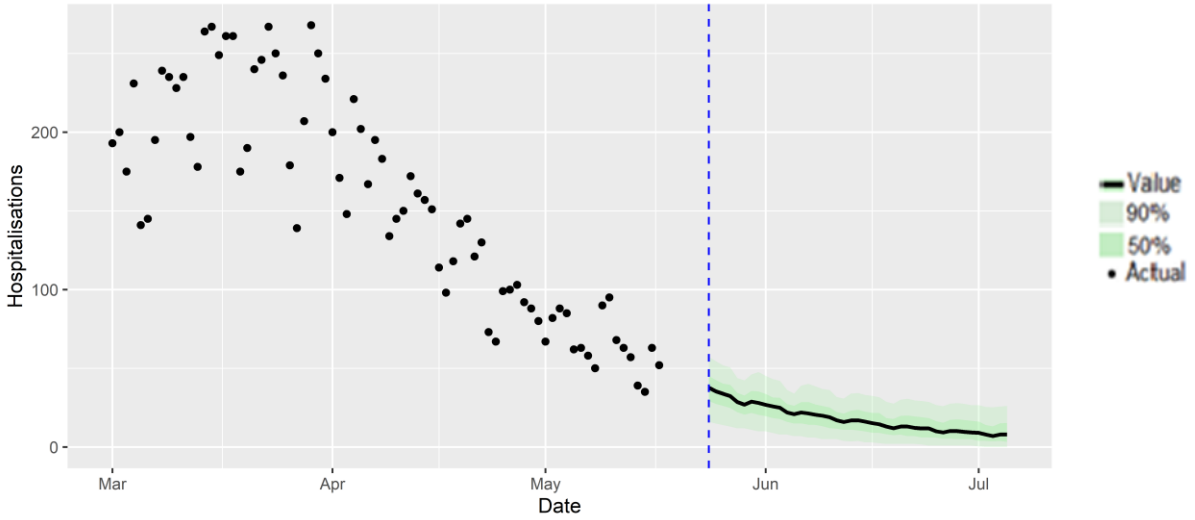
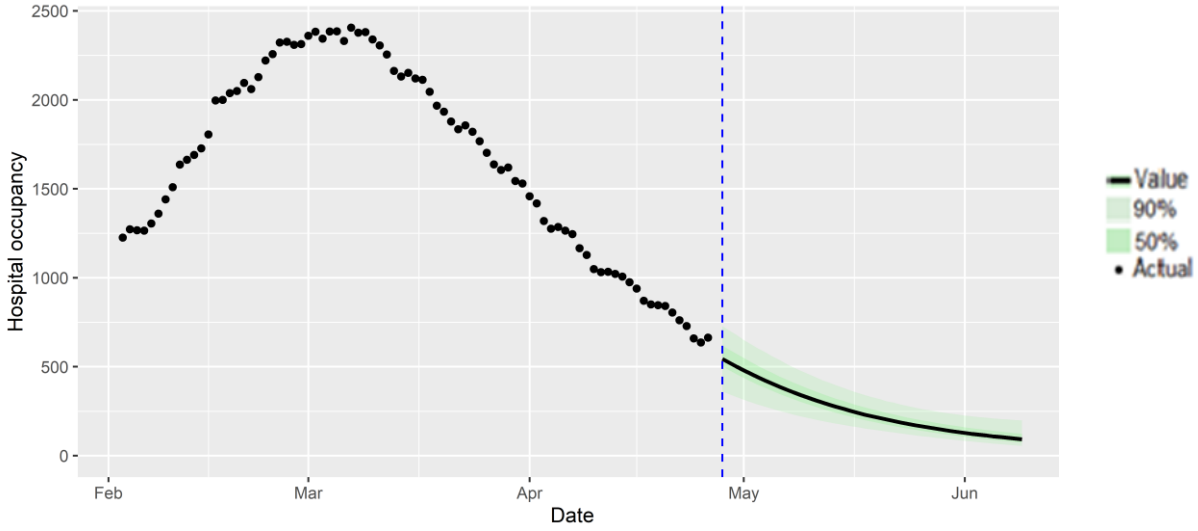


Figure 10 shows the SPI-M-O consensus on hospital occupancy. Hospital occupancy is determined by the combination of admissions and length of stay, the latter of which is difficult to model with confidence.

Figure 10. SPI-M-O medium-term projection of hospital occupancy in Scotland, at 50% and 90% credible intervals



Looking to the future

What may happen in the future around SARS-CoV-2 is uncertain and therefore there are a number of possible Covid-19 futures that may occur in the future. For example, the current Omicron wave may dissipate leaving low levels of Covid-19, or a new variant may emerge potentially having vaccine escape or increased severity, or people's behaviours may change. One approach to this uncertainty is to model alternative versions of the future through the development of different Covid-19 scenarios.

Given what we know about Covid-19 these possible futures range from a world where immunity reduces Covid-19 hospitalisations and deaths to low levels, through to variant world where a variant with immune escape enters Scotland and Covid-19 hospitalisations and deaths could increase. In between these two extremes there could be possible futures where people's behaviour becomes polarised between those who continue with Covid-19 precautions e.g. hand washing etc. and those who do not.

The scenarios we provide in the next section look at what could happen for planning purposes, not to forecast what will happen. These scenarios include all announced changes to restrictions. The assumptions are based on our most up to date knowledge, but do not include the effect of

future changes in treatment of Covid-19 e.g. widespread use of antivirals or changes in behaviour in response to high levels of infections e.g. in variant world. Therefore, in the most extreme scenarios the peak may be lower than suggested if behaviour or restrictions changed.

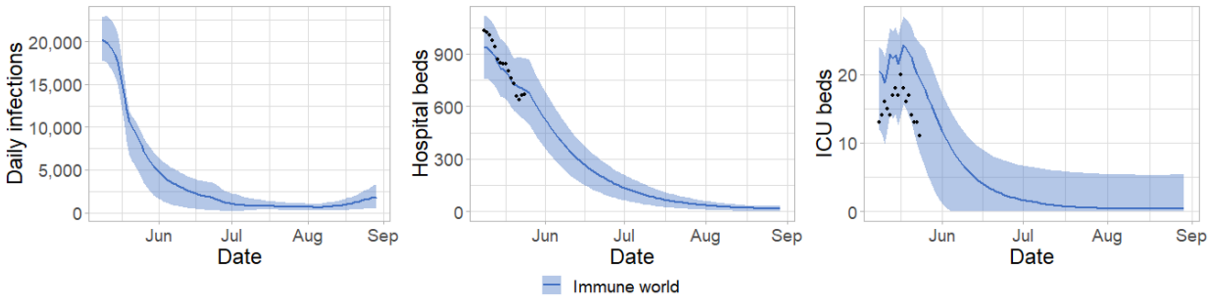
There is no linear progression between the worlds and all are plausible. Each world inherently contains a different threat level requiring a different approach to management.

Immune World

In this possible future vaccines and natural immunity are effective at keeping Covid-19 at low levels. New variants may emerge in Scotland but for the foreseeable future infections are based around Omicron.

Infections may decrease from current levels over the coming weeks and months to very low levels. Likewise hospital and ICU occupancy may follow this trend relieving the pressure on healthcare services. Issues with new variants are not considered in this world and therefore levels of infections remain low.

Figure 11. Potential infections, hospital occupancy and ICU occupancy trajectory in Immune World[5]



In Immune World Covid-19 in Scotland reduces below epidemic levels, becoming endemic. Cases of Covid-19 therefore spring up only as rare outbreaks which are controlled through public health measures. People's lives return to something close to normality e.g. physical distancing is not needed but people still choose to self-isolate and hygiene is good. As vaccines are effective, take-up of first/second/third doses are good and boosters become part of an annual cycle like flu. The numbers of people who need medical treatment or hospitalisation for Covid-19 remain low.

[5] Coronavirus (COVID-19): trends in daily data - gov.scot (www.gov.scot)

The focus moves away from Covid-19 response and into recovery. This includes addressing learning losses, treating Long Covid and working through the hospital backlog. Wellbeing measures improve with reduced anxiety and increased happiness. Those from the highest risk groups feel they can reintegrate without government interventions. The economy begins to recover from the effects of Covid-19. Travellers do not face significant issues with trips overseas.

Polarised World

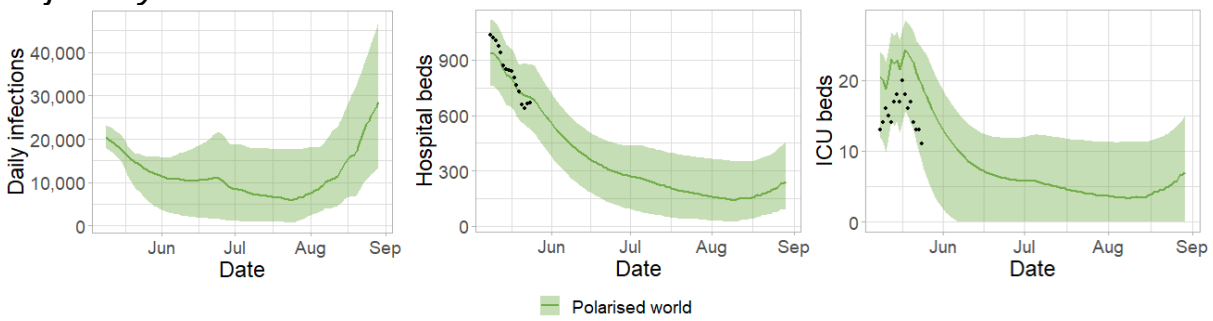
In this world, vaccines and natural immunity are effective at reducing infections. The approach followed relies on individual risk assessment and behaviours. However, society becomes polarised as some continue to take up vaccines and follow guidance while others are more reluctant. Covid-19 becomes a disease associated with those who do not or cannot get full vaccine benefit and do not or cannot adopt a risk based approach maintaining baseline measures.

Infections may remain at current levels initially before increasing with a decrease following thereafter as the natural immunity begins to offset the waning of vaccine acquired immunity.

This world assumes that behavioural changes beginning to occur in response to the lifting of restrictions and to the better weather.

Impacts on hospital/ICU occupancy are uncertain but levels may be higher than has been observed in summer 2020 and 2021 and higher than what may happen in Immune World (see Figure 12).

Figure 12. Potential infections, hospital occupancy and ICU occupancy trajectory in Polarised World[6]



[6] COVID-19 vaccine weekly surveillance reports (weeks 39 to 17, 2021 to 2022) - GOV.UK (www.gov.uk)

Cases of Covid-19 spring up and are hard to control in those who are not vaccinated or vulnerable. People's lives return to a "new normal" but, due to polarised groups in society with some following and some not following the guidance on baseline restrictions, infections remain.

Vaccines are effective so older and more vulnerable people come forward for future doses in high numbers.

The focus remains on Covid-19 and the shift onto recovery is slower. Existing learning losses are harder to rectify and continue to accrue due to infections within education settings. The hospital backlog is difficult to address as hospitals are still dealing with Covid-19 cases. The population becomes polarised in to those whose wellbeing improves e.g. lower risk people and those whose wellbeing deteriorates e.g. higher risk or poorer people whose levels of anxiety increase as Covid-19 circulates. They continue to experience greater illness, greater poverty or disruption to their income. The economy continues to be impacted from the effects of Covid-19.

Variant World – vaccine escape with same severity as Delta

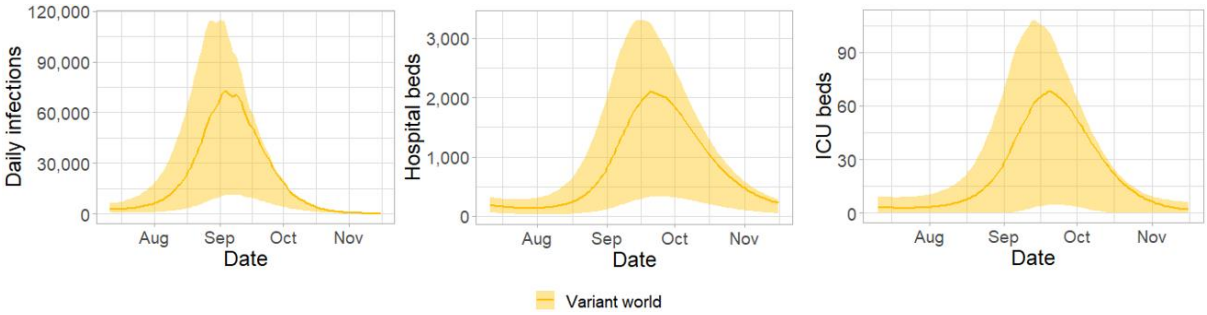
In this possible future a variant with vaccine escape emerges in Scotland presenting a challenge even for fully vaccinated people. This new variant leads to increased transmission, but not to increased severity compared to previous variants. In this scenario other non-pharmaceutical interventions may need to be put in place for a short time. This world is similar to what has happened in Scotland with the emergence of Omicron.

Omicron may be reduced to low levels within Scotland as a new variant takes over. This causes a new wave of Covid-19 infections as well as increases in hospital and ICU occupancy. People's lives are disrupted due to the increasingly high levels of infections leading to time off work ill or isolating.

To show the potential impact assume a new variant appears in Scotland as people return from their summer holidays and return to work and school. The timing is uncertain and a potential new variant may appear sooner than the summer or significantly later but has currently been lined up with the summer holidays to show illustratively what could happen. The new variant may cause Omicron infections to decrease significantly or disappear entirely (and is not shown). The new variant is modelled with similar transmissibility and vaccine escape as Omicron

with severity characteristics similar to Delta. It could lead to high levels of infections leading to hospital occupancy rising above capacity restrictions. With sustained high levels of infection we could again see increased staff absences in a number of sectors that were affected by this in the recent Omicron wave.

Figure 13. Potential infections, hospital occupancy and ICU occupancy trajectory in Variant World with the same severity as Delta[7]



The focus remains on Covid-19 and it is hard to shift on to recovery. Continued infections within education settings and staff shortages may impact schools. The Covid-19 strain on hospitals is high due to the very high numbers of infections and workforce pressures grow making it difficult to address the hospital backlog. Wellbeing measures deteriorate with people reporting low happiness and general 'tiredness with it all'. The economy continues to be impacted from the effects of Covid-19 with many people off work. Travellers may not want to come to the UK as the new variant sweeps through.

Variant World – vaccine escape with increased severity compared to Delta

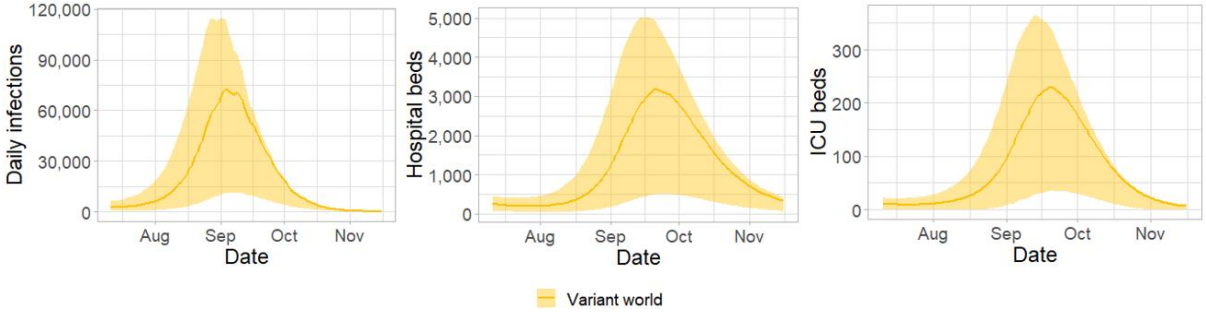
As with the other example of Variant World, a new variant appears in Scotland as people return from their summer holidays and return to work and school. The timing is uncertain but has currently been lined up with the summer holidays where reduced travel restrictions may make it more likely that a new variant is brought into Scotland.

The new variant may cause Omicron infections to decrease significantly or disappear entirely (and this is not shown on the graph). It is modelled with similar transmissibility and vaccine escape as Omicron with severity characteristics 50% higher than Delta, purely for illustrative purposes.

[7] Coronavirus (COVID-19): trends in daily data - gov.scot (www.gov.scot)

It could lead to high levels of infections leading to hospital occupancy rising well above capacity restrictions. With sustained high levels of infection we could again see increased staff absences in a number of sectors that were affected by this in the recent Omicron wave.

Figure 14. Potential infections, hospital occupancy and ICU occupancy trajectory in Variant World with the increased severity compared to Delta[8]



The focus remains on Covid-19 and it is hard to shift on to recovery. Continued infections within education settings and staff shortages may impact schools. The Covid-19 strain on hospitals is high due to the very high numbers of infections and workforce pressures grow making it difficult to address the hospital backlog. Wellbeing measures deteriorate with people reporting low happiness and general 'tiredness with it all'. The economy continues to be impacted from the effects of Covid-19 with many people off work. Travellers may not want to come to the UK as the new variant sweeps through.

Summary of spatial analysis of Covid-19 spread in Scotland

Researchers at the Edinburgh Roslin Institute have conducted spatial analysis of Covid-19 Spread in Scotland. A summary of findings from the week from 8th May to 22nd May 2022 is included here.

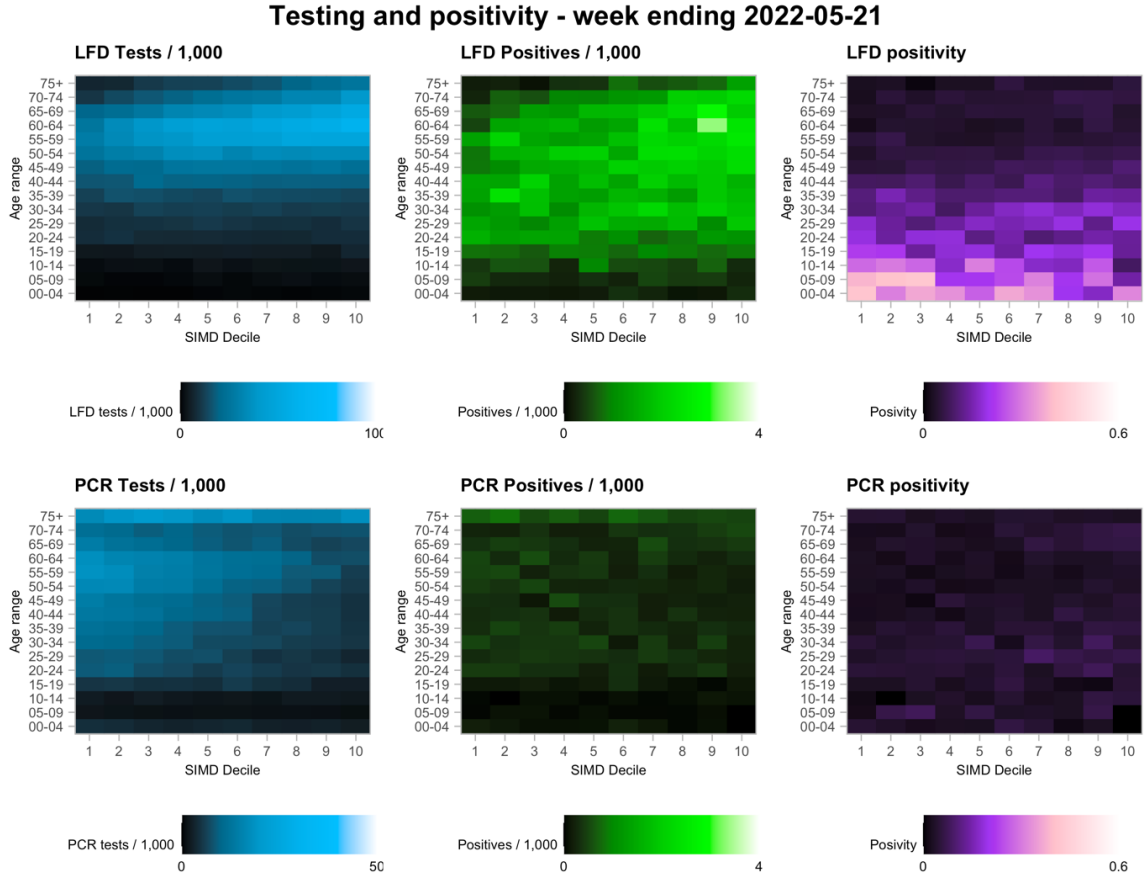
There remains a substantial variation in risk of infection by average census age in each datazone. Deprivation in this period is not a substantial factor when comparing across local authorities. Risk factors remain stable, when comparing to previous weeks.

The trend where numbers of PCR and LFD tests are both declining, continues across all deprivation scores.

[8] Coronavirus (COVID-19): trends in daily data - gov.scot (www.gov.scot)

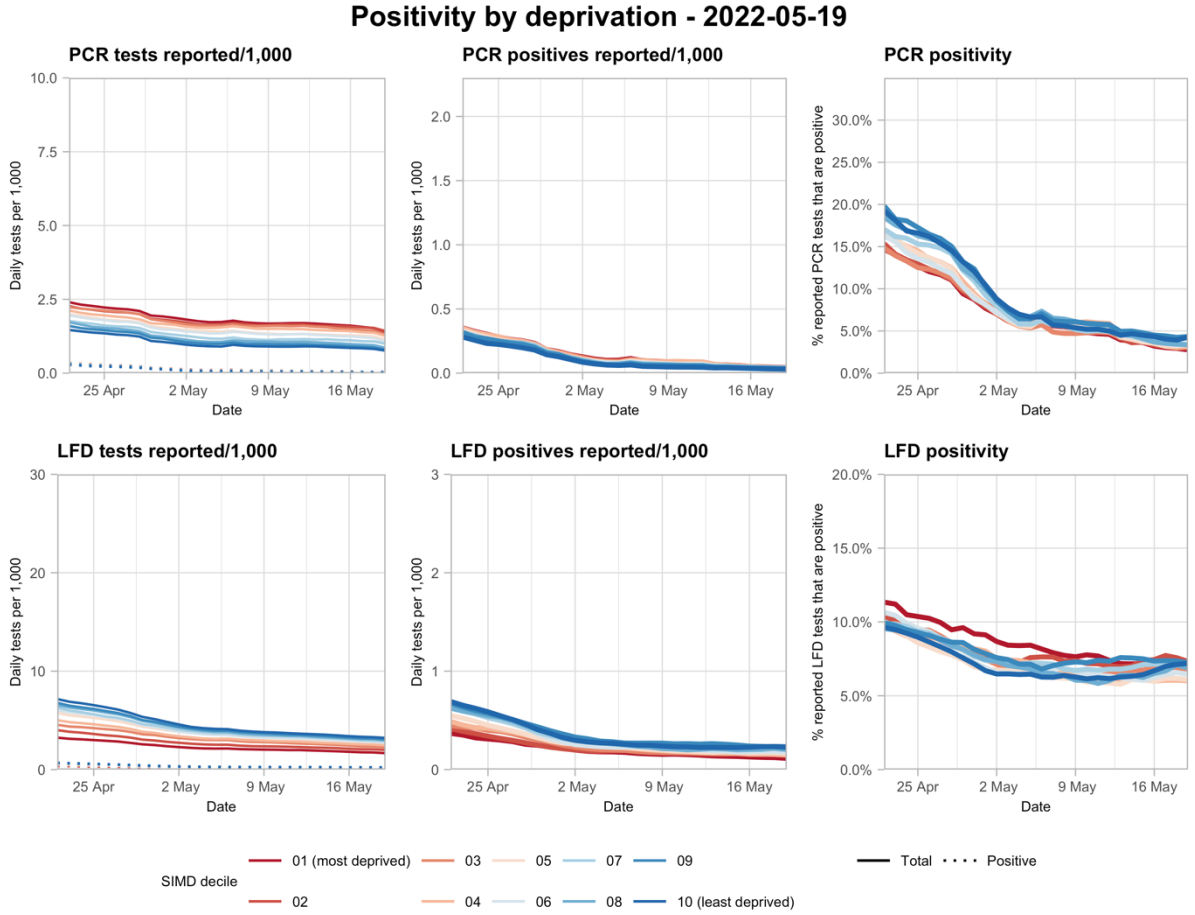
The distribution of lateral flow/LFD tests being reported varies substantially by both age and deprivation status, with many fewer tests reported in younger adults across all deciles of deprivation, and for children in more deprived deciles. The high level of LFD positivity in the latter category is marked, and when compared to the high number of positives amongst the least deprived, suggests that ascertainment may be lower in younger people in deprived areas.

Figure 15. Variation in testing outcomes comparing Lateral Flow and PCR testing considering age and deprivation status of the data zone of record based on data to 22nd May 2022[9].



[9] An adjustment to the colour axes has been made in light of declining testing. The previous axes limits were: LFD tests/1,000: 0-350, PCR tests/1,000: 0-100, PCR/LFD positives/1,000: 0-40.

Figure 16. Variation in testing outcomes comparing Lateral Flow and PCR testing, separated by deprivation (Based on data to 19th May).



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

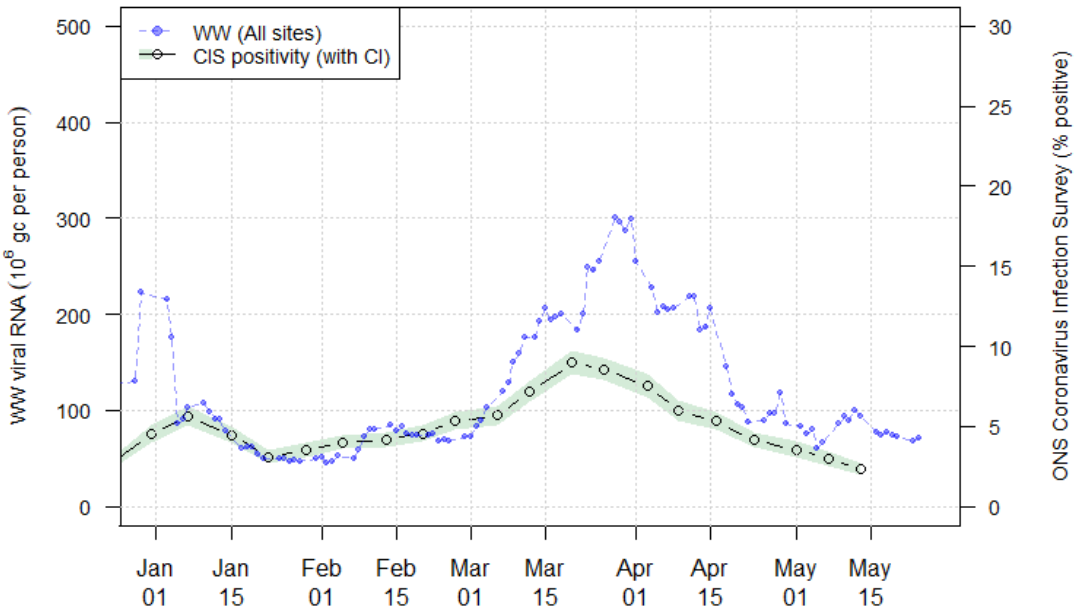
Levels of Covid-19 RNA in wastewater (WW) collected at a number of sites around Scotland are adjusted for population and local changes in intake flow rate (or ammonia levels where flow is not available). See Technical Annex in Issue 34 of Scottish Government Research Findings for the methodology. These reports are based on the most recent data available. Future updates to data may lead to small retrospective changes.

Nationwide, wastewater Covid-19 RNA in the past two weeks as been at a a similar level as in two weeks previously. In the two weeks from 11th to 24th May, the median level of Covid-19 in wastewater was 76 million gene copies per person per day (Mgc/p/d). This compares to 82 Mgc/p/d in the two weeks from 27th April to 10th May. There is no significant difference between the two weeks.

In Figure 17, we plot wastewater viral levels, covering the period since the start of 2022 with the 4/26 batch removed, as in the previous research findings report. The Omicron variant emerged in Scotland around mid-December 2021. After the end of 2021, S-gene dropout testing data suggest that nearly all cases are from the Omicron variant. During the period of change in the dominant variant, a change in the relationship between the WW RNA levels and case numbers was observed and postulated to be due to different levels of virus shed by individuals with the two variants. From February, the BA.2 sub-variant of Omicron emerged. It is not clear what further changes might have resulted from this variant.

Wastewater viral levels over the past two weeks do not appear to have been overall significantly different from those of the previous two weeks, if we account for the variation within each of the two week periods. If we also superimpose data from the newest ONS Coronavirus Infection Survey (CIS) up until the 13th May, we see a gradual decline in the CIS. The axis scaling in Figure 17 is chosen to match Jan-Feb 2022 levels of WW RNA and CIS prevalence. The current ratio of WW viral RNA levels to CIS estimated positivity levels closer to that seen earlier in the year that it was during most of March and April.

Figure 17. National running average trends in wastewater RNA as of 24th May[10].



[10] 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 is overlaid, with a scale chosen to approximately match Jan/Feb trends in WW RNA. A batch of samples analysed on the 26th of April is excluded.

What next?

UKHSA does not plan to provide a consensus statement in the week beginning 6th June due to the holiday weekend. We will continue to publish the Modelling the Epidemia report that week, showing other modelling outputs which are not reliant on consensus positions.

Archiving of models is currently being undertaken via the Data Science Scotland GitHub organisation. Details of the Scottish Contact Survey, Wastewater and Exceedance models are currently available. More models will be added over the coming weeks - see the Technical Annex of issue 96 for further details.

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.

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

Table 1 provides population weighted daily averages for normalised WW Covid-19 levels in the weeks ending 17th May and 24th May 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 period[11].

Table 1. Average Covid-19 wastewater levels (Mgc/p/d)[12].

Local Authority (LA)	w/e 17th May	w/e 24th May	Coverage
Aberdeen City	67	83	99%
Aberdeenshire	77	65	52%
Angus	50	66	68%
Argyll and Bute	65	85	12%
City of Edinburgh	79	79	96%
Clackmannanshire	51	98	92%
Dumfries and Galloway	49	51	39%
Dundee City	64	56	100%
East Ayrshire	94	72	72%
East Dunbartonshire	168	80	99%
East Lothian	70	79	56%
East Renfrewshire	56	62	95%
Falkirk	98	62	96%
Fife	45	72	84%
Glasgow City	97	71	75%
Highland	81	76	48%
Inverclyde	54	23	98%
Midlothian	77	85	88%
Moray	83	99	70%
Na h-Eileanan Siar	–	23	21%
North Ayrshire	69	50	92%
North Lanarkshire	64	79	95%
Orkney Islands	41	–	0%
Perth and Kinross	53	60	45%
Renfrewshire	70	45	97%
Scottish Borders	44	92	48%
Shetland Islands	38	27	29%
South Ayrshire	93	70	88%
South Lanarkshire	75	90	88%
Stirling	13	35	63%
West Dunbartonshire	86	45	98%
West Lothian	53	83	85%

[11] 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 SARS-CoV-2 RNA levels with the outliers removed. See Technical Annex in Issue 60 of these Research Findings for further details.

[12] Coverage as for week ending 24th May 2022.

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