

Scottish Government Central Analysis Division

Coronavirus (Covid-19): modelling the epidemic in Scotland (Issue No. 103)

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 23rd June 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.

Key Points

- The reproduction rate R in Scotland is currently estimated as being between 1.0 and 1.2, as at 21st June. Both the lower and upper limits are unchanged since the last publication.
- The daily growth rate for Scotland is currently estimated as between 0% and 4% as at 21st June. The lower limit has decreased since last publication.
- The number of new daily infections for Scotland is estimated as being between 407 and 858 per 100,000 people as at 21st June.
- Average contacts from the most recent wave of the Scottish Contact Survey (23rd June - 29th June) indicate an average of 6.0 contacts. This has increased by 27% compared to the previous wave of the survey (9th June - 15th June) where average contacts were 4.8. This compares to a UK average of 10.8 prior to the Covid-19 pandemic.
- Mean contacts within the work and other setting (contacts outside home, school and work) have increased by 32% over the last two weeks. Contacts within the home have decreased by 7% over the same period.
- Average contacts have increased for those in the 18-49 age groups, with those in the 18-29 reporting more than double the average

number of contacts compared to two weeks prior. Those aged 50 and over reported a decrease in average contacts.

- The highest number of interactions are observed between those within the 18-29 age group with each other.
- The biggest increase in the proportion of participants visiting different locations is seen in those visiting a healthcare facility, this increased from 22% to 24% 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 increased from 29% to 33%.
- In the survey pertaining to 23rd June - 29th June, 46% of people had taken at least one lateral flow test in the previous 7 days, increasing from 39%.
- 51% of participants believe they have had Covid-19 at least once since March 2020.
- The SPI-M-O consensus view is that by 2nd August, daily hospitalisations from Covid-19 in Scotland are estimated to be between 76 and 276, and hospital occupancy is estimated to be between 924 and 2,772.
- 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 stabilising in reported tests across all deprivation deciles, but a substantial increase in both positive tests and overall positivity, and continuing growth in reported positives. There is no clear trend in positivity with respect to deprivation, contrary to nearly all earlier periods of the epidemic where positivity was substantially higher in more deprived datazones. There is a similar rise in PCR positives and positivity, but the volume of testing remains very low.
- 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, during the period 18th June – 1st July Covid-19 wastewater levels have remained between 157 and 182 million gene copies per person per day (Mgc/p/d). Compared with the previous reporting period (3rd – 17th June 2022), there has been a confirmed rise in Covid-19 levels in wastewater. However, there is no indication this increase is continuing.

Overview of Scottish Government Modelling

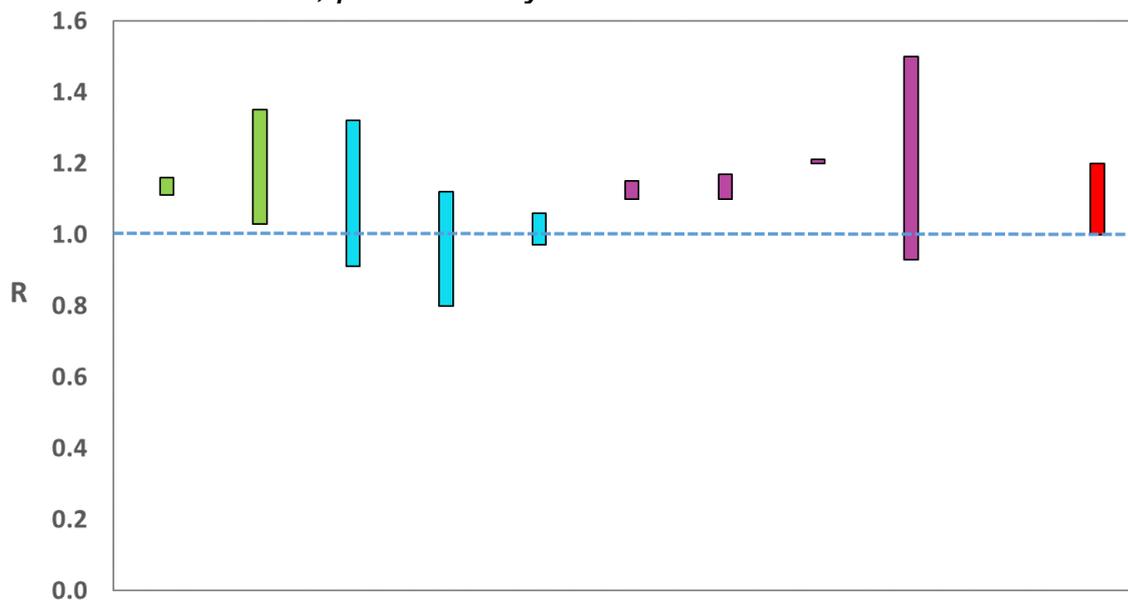
Modelling outputs are provided here on the current epidemic in Scotland as a whole, based on a range of methods. Because it takes a little over three weeks on average for a person who catches SARS-CoV-2 (the causative agent of Covid-19) to show symptoms, become sick and either die or recover, there is a time lag in what our model can tell us about any changes 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 the EMRG, which sits within UKHSA. These are based on data up to 4th July.

The consensus view of the UKHSA across these methods was that the value of R in Scotland is between 1.0 and 1.2 as of 21st June 2022 (Figure 1). These limits are unchanged since previous publication. R is an indicator that lags by two to three weeks.

Figure 1: Estimates of R_t for Scotland as of 21st June, including 90% confidence intervals, produced by EMRG.

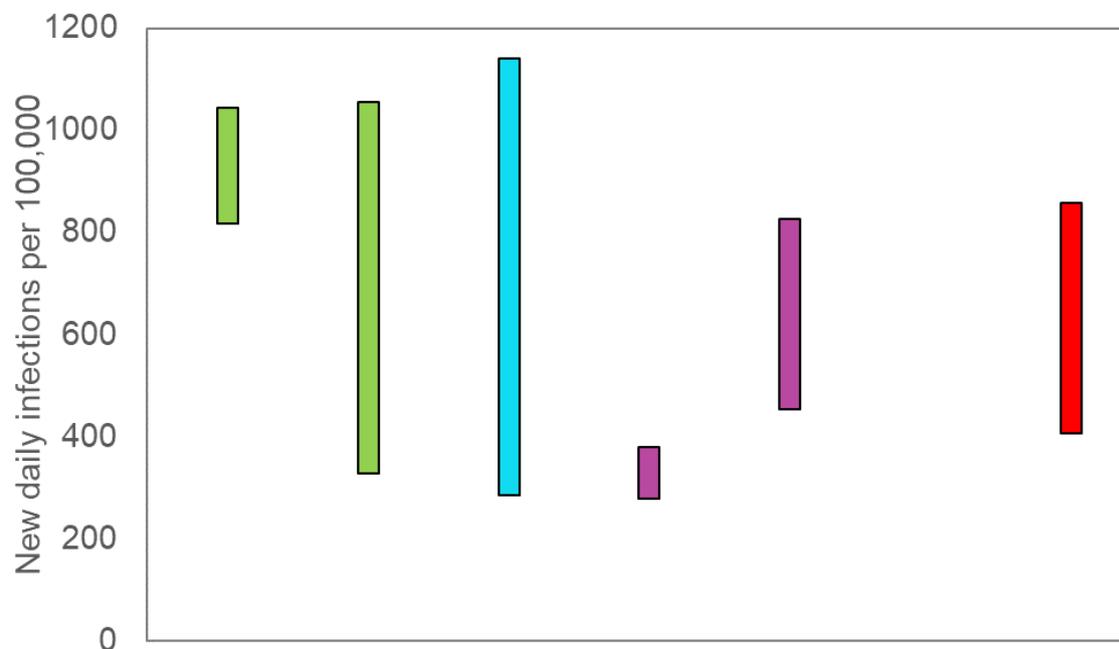


Source: EMRG

The consensus from UKHSA is that the growth rate in Scotland is between 0% and 4% per day as at 21st June. The lower limit has decreased since last publication.

The various groups which report to EMRG use different sources of data in their models to produce estimates of incidence (Figure 2). The consensus view of the UKHSA across these methods, as at 21st June, was that the incidence of new daily infections in Scotland was between 407 and 858 new infections per 100,000. This equates to between 22,200 and 46,900 people becoming infected each day in Scotland.

Figure 2 Estimates of incidence for Scotland, as at 21st June, including 90% confidence intervals, produced by EMRG



Source: EMRG

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 study¹.

Average contacts from the most recent wave of the Scottish Contact Survey (23rd June - 29th June) indicate an average of 6.0 contacts. This has increased by 27% compared to the previous wave of the survey (9th June - 15th June) where average contacts were 4.8, as seen in Figure 3.

¹ The UK POLYMOD figures from <https://bmcmmedicine.biomedcentral.com/track/pdf/10.1186/s12916-020-01597-8>

Mean contacts within the work and other setting (contacts outside home, school and work) have increased by 32% over the last two weeks. Contacts within the home have decreased by 7% over the same period.

Figure 3: Mean contacts per day for adults in Scotland (truncated to 100 contacts per participant).

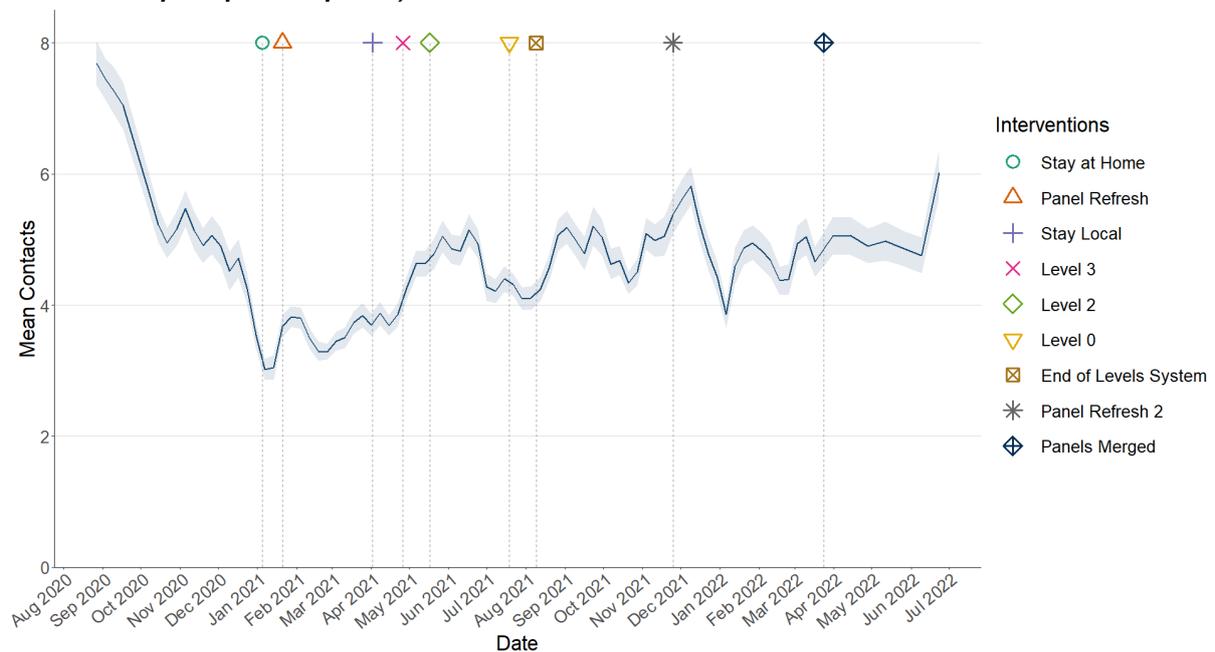
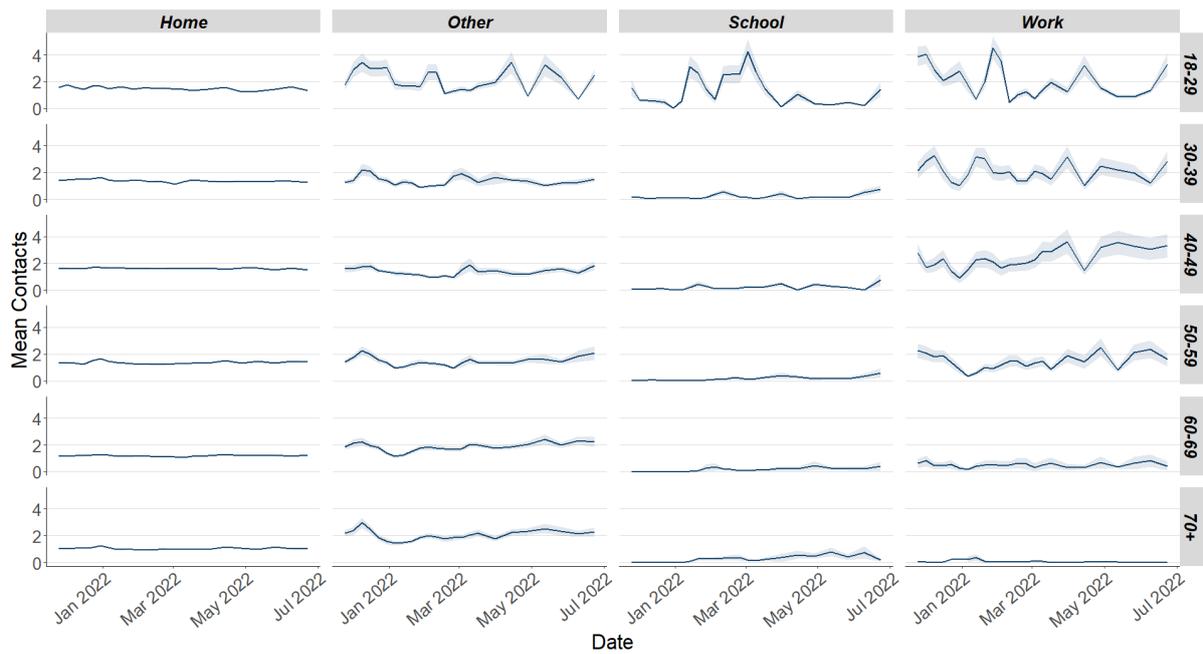


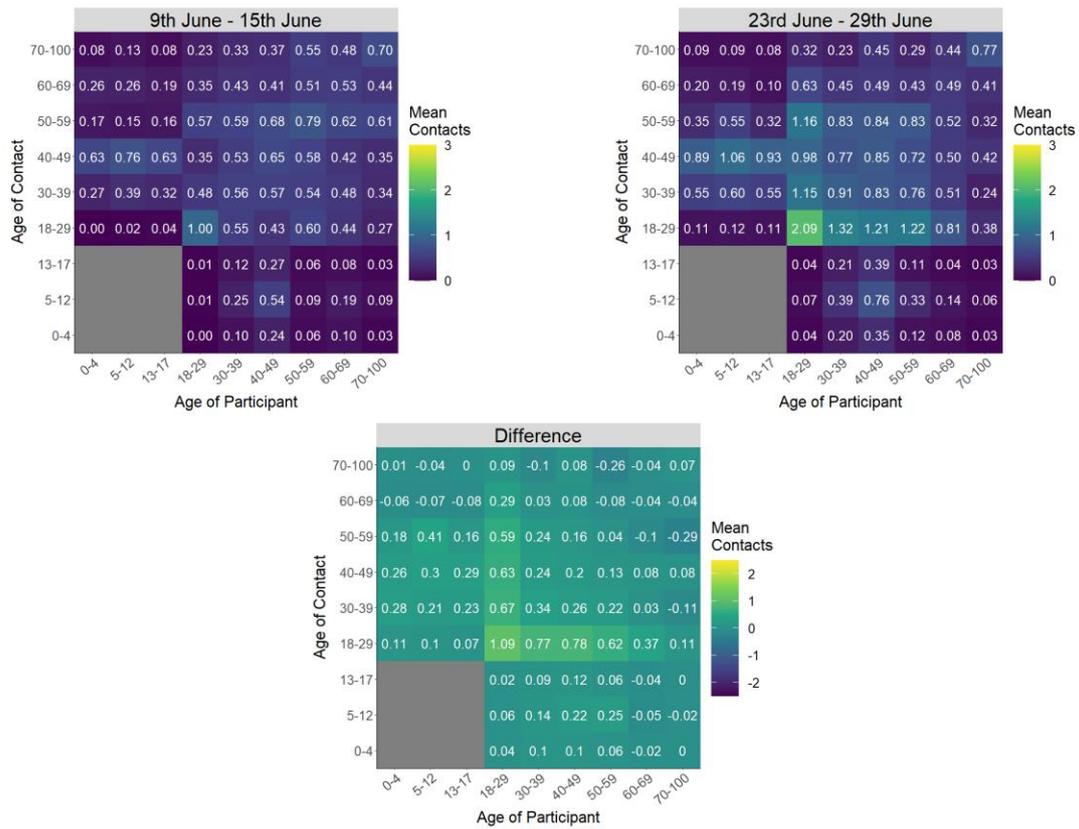
Figure 4 shows how contacts change across age group and setting. Average contacts have increased for those in the 18-49 age groups, with those in the 18-29 reporting more than double the average number of contacts compared to two weeks prior. Those aged 50 and over reported a decrease in average contacts.

Figure 4: Mean contacts per day for adults in Scotland (truncated to 100 contacts per participant) by age group and setting.



The heatmaps in Figure 5 show the mean overall contacts between age groups for the surveys relating to 9th June - 15th June and 23rd June - 29th June and the difference between these periods. The highest number of interactions are observed between the those within the 18-29 age group with each other.

Figure 5: Mean contacts per day between age groups (truncated to 100 contacts per participant).



The biggest increase in the proportion of participants visiting different locations is seen in those visiting a healthcare facility. This increased from 22% to 24% in the last two weeks as shown in Figure 6.

Figure 6: Locations visited by participants at least once.

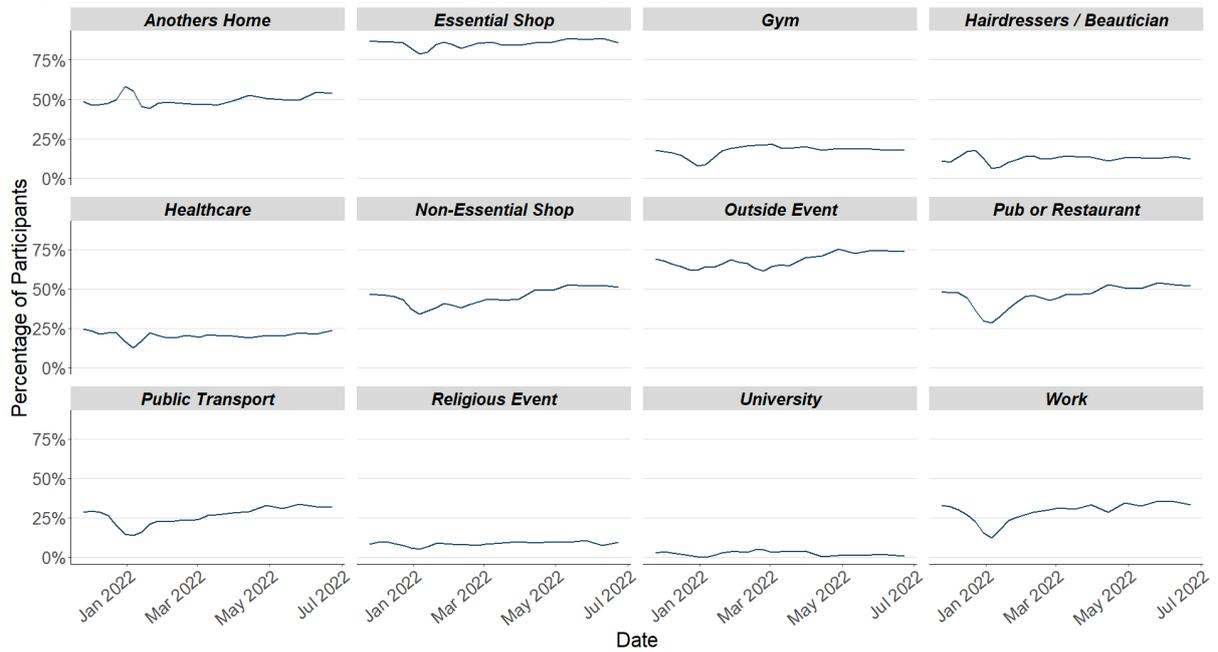
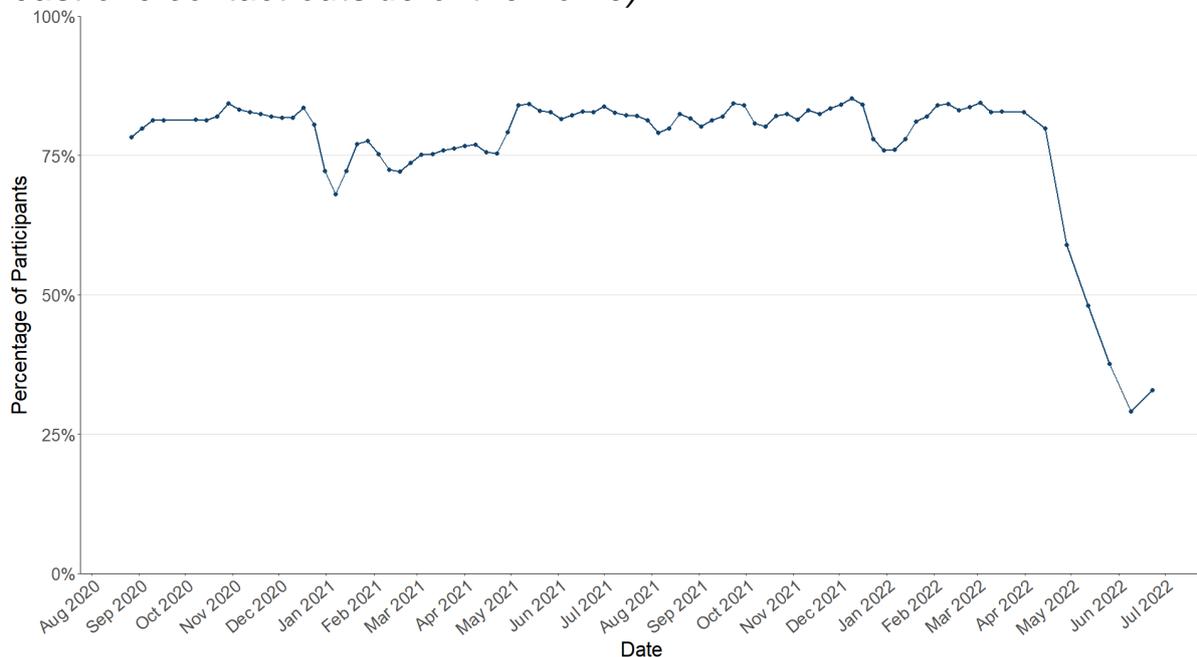


Figure 7 shows the percentage of people wearing a face covering where they have at least one contact outside of the home. This has increased from 29% to 33% since the last wave of the survey.

Figure 7: Percentage of participants wearing a face covering (with at least one contact outside of the home).



In the survey pertaining to 23rd June - 29th June, 46% of people had taken at least one lateral flow test in the previous 7 days, increasing from 39% in the previous wave of the survey pertaining to the 9th June - 15th June.

Figure 8: Percentage of participants who had taken at least one lateral flow test in the last 7 days.

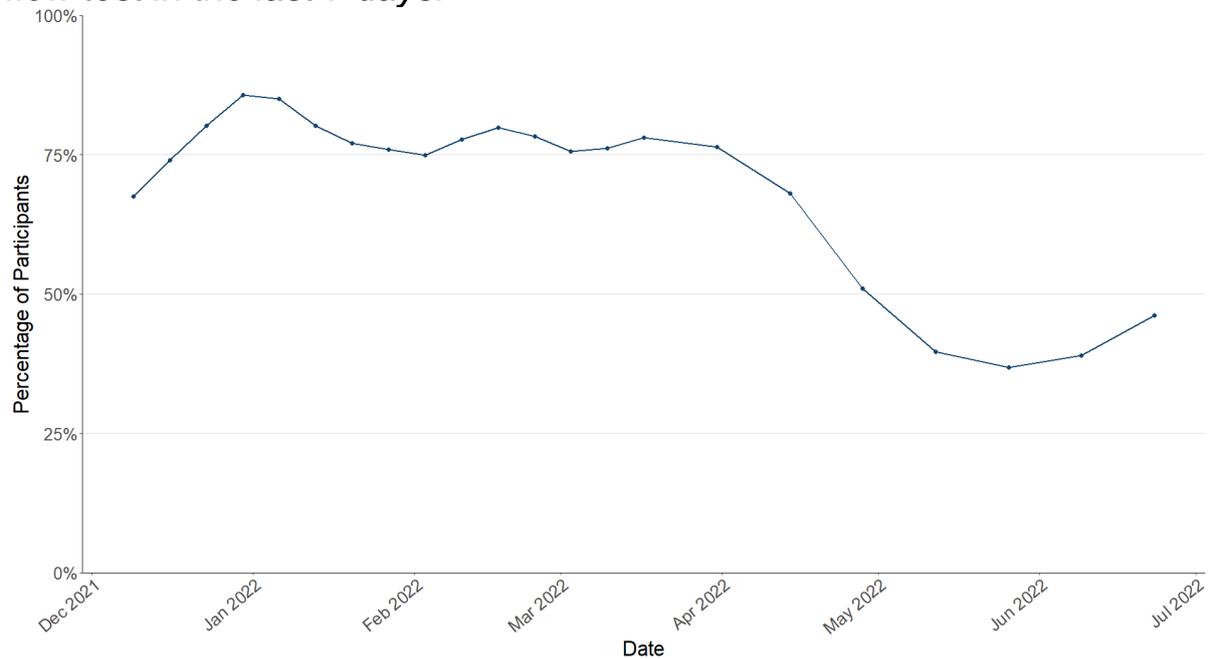
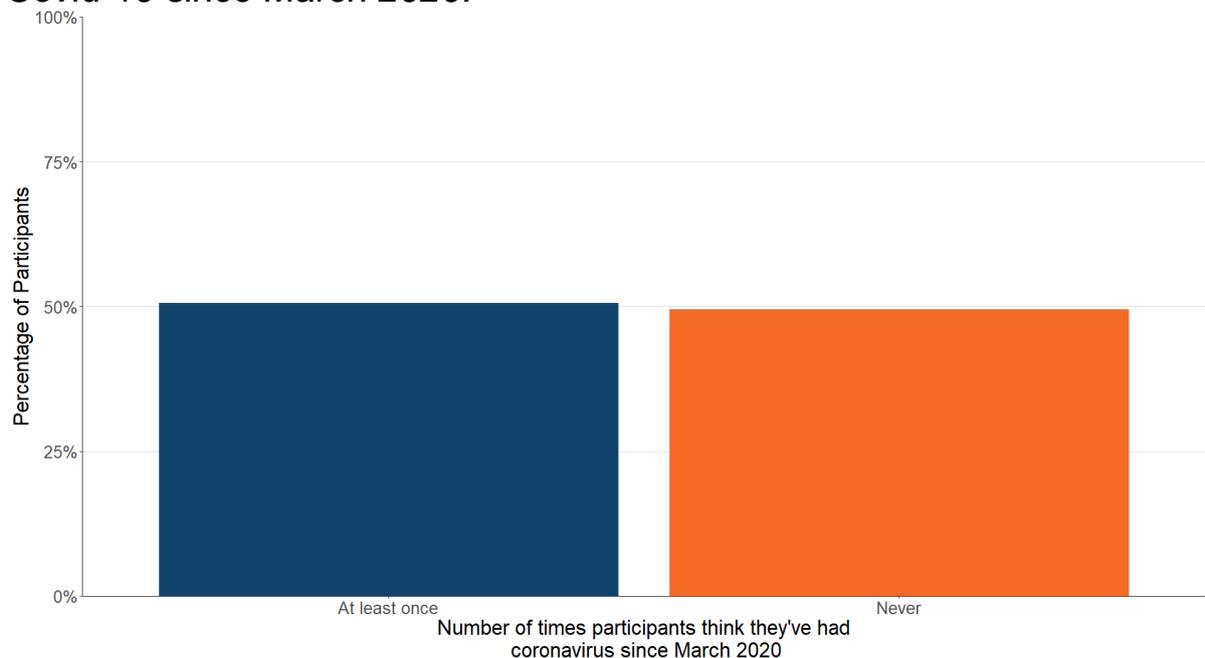


Figure 9 shows that 51% of participants believe they have had Covid-19 at least once since March 2020. Of those who think they have had Covid-19, 96% have had this confirmed through a test.

Figure 9: Percentage of participants who believe they have had Covid-19 since March 2020.



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

SPI-M-O produces projections of the epidemic (Figures 10 - 11), 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 4th July and do not include the effects of any future policy or behavioural changes. The delay between infection, developing symptoms and the need for hospital care means they cannot fully reflect the impact of behaviour changes in the two to three weeks prior to 4th July. 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 10. SPI-M-O medium-term projection of daily hospitalisations in Scotland, at 50% and 90% credible intervals.

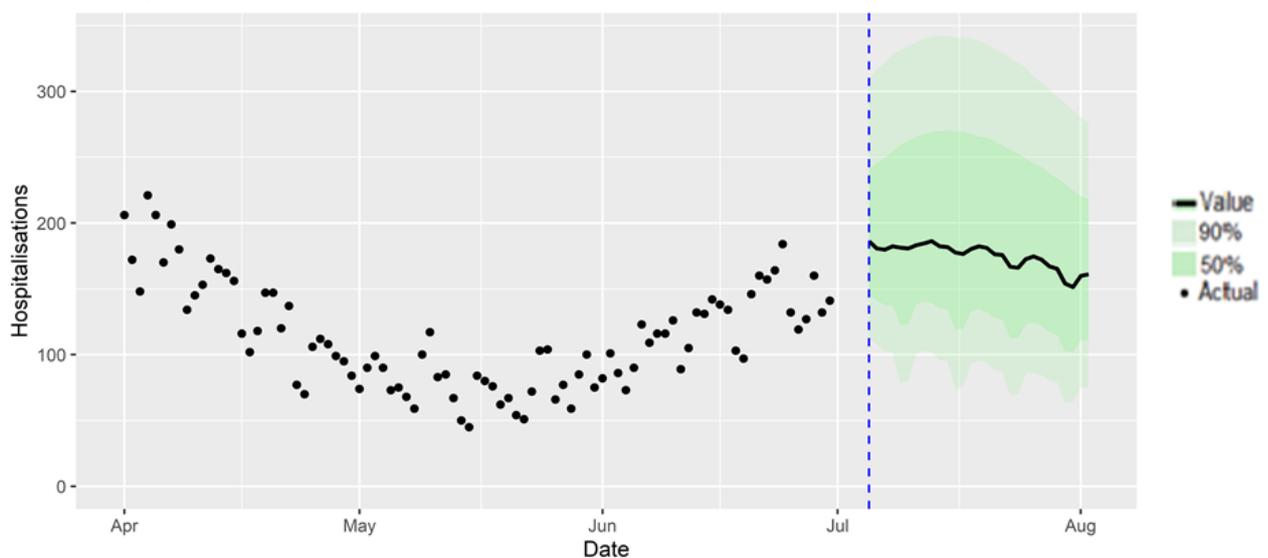
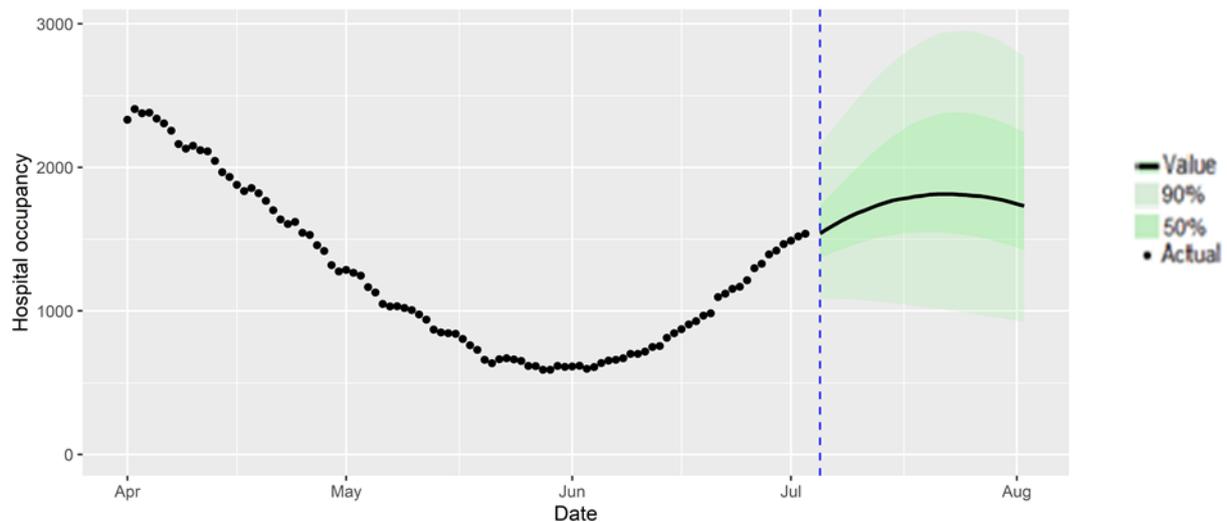


Figure 11 shows the SPI-M-O consensus on hospital occupancy. Hospital occupancy is determined by the combination of admissions and length of stay, the latter of which is difficult to model with confidence.

Figure 11. SPI-M-O medium-term projection of hospital occupancy in Scotland, at 50% and 90% credible intervals



The SPI-M-O consensus view is that by 2nd August, daily hospitalisations from Covid-19 in Scotland are estimated to be between 76 and 276, and hospital occupancy is estimated to be between 924 and 2,772.

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 15th June to 29th June 2022 is included here.

Rates of LFD and PCR testing have since stabilised, albeit at substantially lower rates than those seen earlier in the epidemic.

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 12. Variation in testing outcomes comparing Lateral Flow and PCR testing considering age and deprivation status of the data zone of record based on data in week ending 25th June 2022.

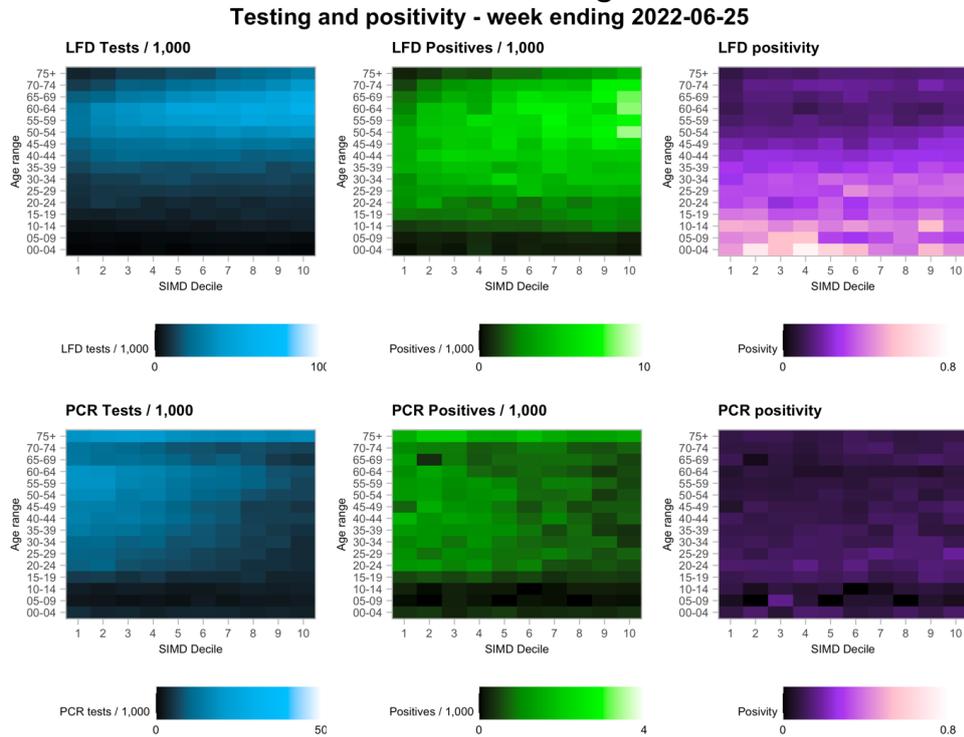
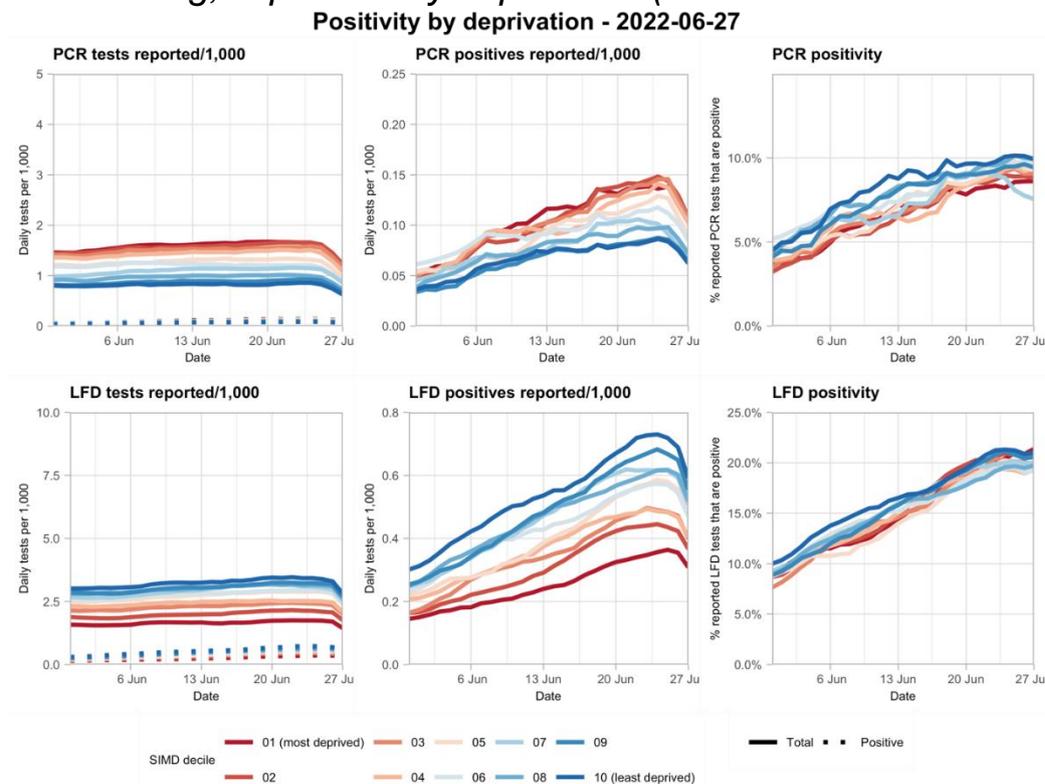


Figure 13. Variation in testing outcomes comparing Lateral Flow and PCR testing, separated by deprivation (Based on data to 27th June).



Please note, Public Health Scotland became aware that the recent testing data were likely to be under reported. This was due to a data

processing issue since 9am on 25th June 2022² which has been subsequently resolved³.

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.

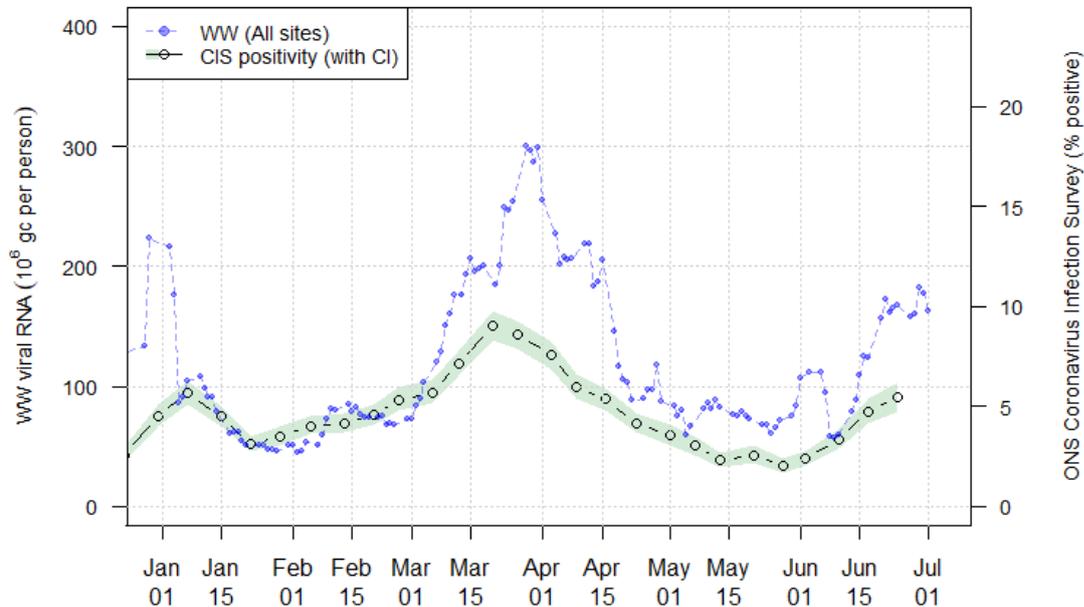
Nationwide, during the period 18th June – 1st July Covid-19 wastewater levels have remained between 157 and 182 million gene copies per person per day (Mgc/p/d). Compared with the previous reporting period (3rd – 17th June 2022), there has been a confirmed rise in Covid-19 levels in wastewater. However, there is no indication this increase is continuing.

In Figure 14, we show national running average trends in Covid-19 in wastewater as of 1st July 2022. In recent reports, we have been cautious in interpreting short term changes in viral RNA in wastewater because their pattern of variability may not have been driven by changes in population viral loads. However, using lab quality control data we can confirm the overall impression that there has been no systematic further rise in Covid-19 levels in wastewater in recent days. We also note that the recent trend in wastewater (an increase followed by a plateau) agrees with the recent ONS Coronavirus Infection Survey (CIS) to 24th June.

² [Public Health Scotland COVID-19 Statistical Report](#)

³ [COVID-19 Statistical Report \(publichealthscotland.scot\)](#)

Figure 14. National running average trends in wastewater Covid-19 as of 1st July⁴.



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.

⁴ 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 Jan/Feb trends in WW RNA.

The scenarios we provide in this section look at what could happen for planning purposes, not to forecast what will happen. 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.

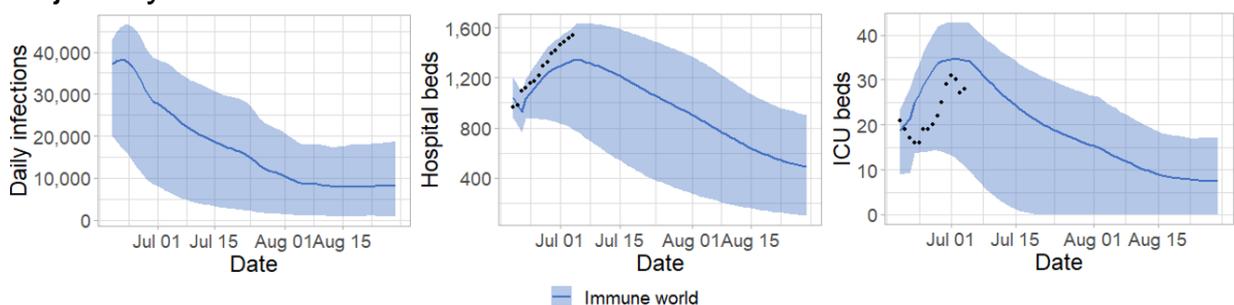
There is no linear progression between the worlds and all are plausible. Each world inherently contains a different threat level requiring a different approach to management.

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 15. Potential infections, hospital occupancy and ICU occupancy trajectory in Immune World⁵



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

⁵ [Coronavirus \(Covid-19\): trends in daily data - gov.scot \(www.gov.scot\)](https://www.gov.scot/coronavirus-trends-daily-data)

people who need medical treatment or hospitalisation for Covid-19 remain low.

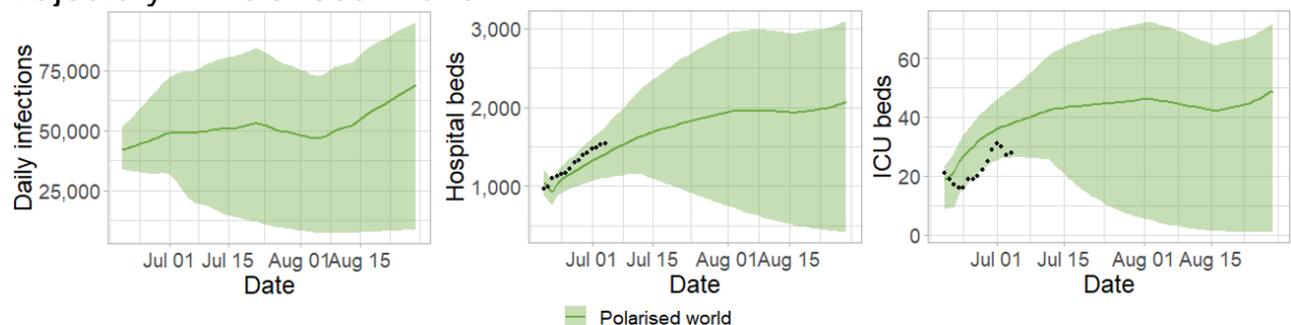
The focus moves away from Covid-19 response and into recovery. This includes addressing learning losses, treating Long Covid and working through the hospital backlog. Wellbeing measures improve with reduced anxiety and increased happiness. Those from the highest risk groups feel they can reintegrate 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.

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 21).

Figure 16. Potential infections, hospital occupancy and ICU occupancy trajectory in Polarised World⁶



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 guidance, infections remain.

⁶ [Covid-19 vaccine weekly surveillance reports \(weeks 39 to 7, 2021 to 2022\) - GOV.UK](https://www.gov.uk/government/collections/covid-19-vaccine-weekly-surveillance-reports) (www.gov.uk)

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.

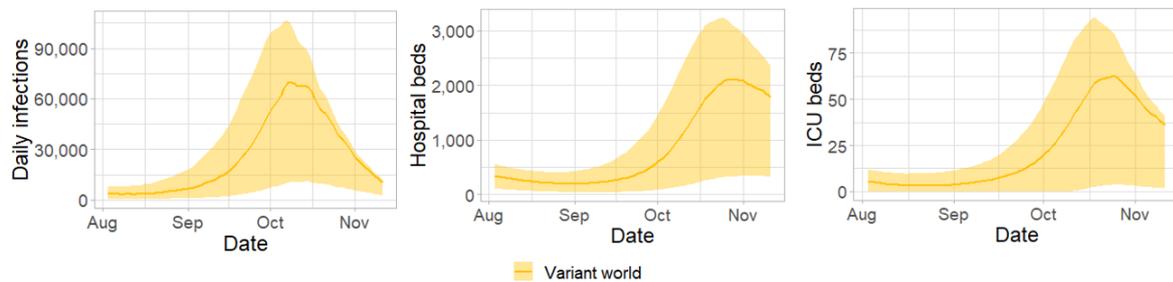
Variant world – vaccine escape with same severity as Delta

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 NPIs 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 17. Potential infections, hospital occupancy and ICU occupancy trajectory in Variant World with the same severity as Delta⁷



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

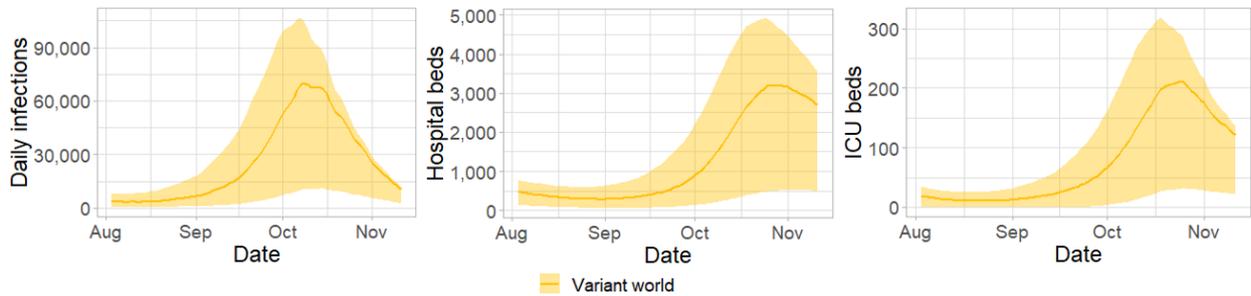
As with the other example of Variant world, a new variant appears in Scotland as people return from their summer holidays and return to work and school. The timing is uncertain but has currently been lined up with the summer holidays where reduced travel restrictions may make it more likely that a new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

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.

⁷ [Coronavirus \(Covid-19\): trends in daily data - gov.scot \(www.gov.scot\)](https://www.gov.scot/coronavirus-trends-in-daily-data)

Figure 18. Potential infections, hospital occupancy and ICU occupancy trajectory in Variant World with the increased severity compared to Delta⁸



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.

What next?

Archiving of models is currently being undertaken via the [Data Science Scotland](#) GitHub organisation. More models will be added over the coming weeks - see the Technical Annex of issue 96 for further details.

⁸ [Coronavirus \(Covid-19\): trends in daily data - gov.scot \(www.gov.scot\)](https://www.gov.scot/coronavirus-trends-daily-data)

Technical Annex

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

Table 1 provides population weighted daily averages for normalised wastewater Covid-19 levels in the weeks ending 24th June and 1st July 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.

Table 1. Average Covid-19 wastewater levels (Mgc/p/d)⁹.

| Local Authority (LA) | w/e 24 th June | w/e 1 st July | Coverage |
|-----------------------|---------------------------|--------------------------|----------|
| Aberdeen City | 181 | 154 | 99% |
| Aberdeenshire | 112 | 107 | 52% |
| Angus | 133 | 132 | 68% |
| Argyll and Bute | 48 | 111 | 23% |
| City of Edinburgh | 229 | 167 | 98% |
| Clackmannanshire | 93 | 229 | 92% |
| Dumfries and Galloway | 111 | 210 | 39% |
| Dundee City | 163 | 162 | 100% |
| East Ayrshire | 214 | 181 | 72% |
| East Dunbartonshire | 264 | 124 | 99% |
| East Lothian | 201 | 142 | 74% |
| East Renfrewshire | 191 | 186 | 95% |
| Falkirk | 156 | 230 | 88% |
| Fife | 119 | 124 | 84% |
| Glasgow City | 183 | 156 | 98% |
| Highland | 88 | 178 | 44% |
| Inverclyde | 133 | 87 | 98% |
| Midlothian | 215 | 212 | 88% |
| Moray | 151 | 168 | 28% |
| Na h-Eileanan Siar | 130 | 131 | 21% |
| North Ayrshire | 168 | 160 | 92% |
| North Lanarkshire | 182 | 154 | 94% |
| Orkney Islands | – | 207 | 34% |
| Perth and Kinross | 119 | 61 | 45% |
| Renfrewshire | 147 | 143 | 97% |
| Scottish Borders | 160 | 336 | 58% |
| Shetland Islands | – | – | 0% |
| South Ayrshire | 206 | 214 | 84% |
| South Lanarkshire | 155 | 222 | 90% |
| Stirling | 54 | 146 | 63% |
| West Dunbartonshire | 134 | 74 | 98% |
| West Lothian | 118 | 175 | 95% |

⁹ Coverage as for week ending 1st July 2022.

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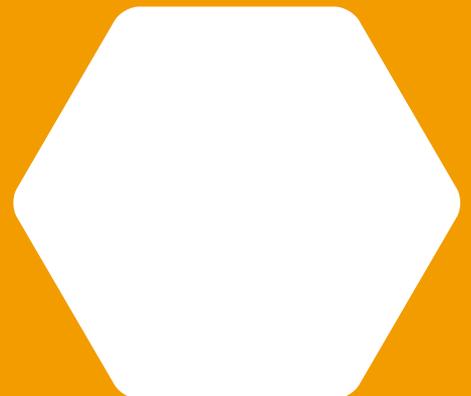
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This document is also available from our website at www.gov.scot.
ISBN: 978-1-80435-717-0

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

Produced for
the Scottish Government
by APS Group Scotland
PPDAS1120562 (07/22)
Published by
the Scottish Government,
July 2022



ISBN 978-1-80435-717-0

Web Publication

PPDAS1120562 (07/22)