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Coronavirus (COVID-19): Analysis

Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 18)

Background

This is a report on the Scottish Government modelling of the spread and level of Covid-19. This updates the previous publication on modelling of Covid-19 in Scotland published on 10 September 2020. The estimates in this document help the Scottish Government, the health service and the wider public sector plan and put in 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, and then goes on to introduce improved modelling based on how many contacts people have with one another.

Key Points

- The reproduction rate R in Scotland is currently estimated as being between 1.1 and 1.4.
- The growth rate for Scotland is estimated as being between +1% and +8%.
- The number of new daily infections for Scotland is estimated as being between 1 and 22 per 100,000 people.
- People have started to have more contact with each other, particularly in younger age groups, and therefore the risk of transmission has increased.

Overview of Scottish Government Modelling

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.

Firstly, modelling outputs are provided here on the current epidemic in Scotland as a whole, based on a range of methods. Because it takes a little over three weeks on average for a person who catches Covid-19 to show symptoms, become sick, and either die or recover, there is a time lag in what this model can tell us about any re-emergence of the epidemic and where in Scotland this might occur. However modelling of Covid deaths is an important measure of where Scotland lies in its epidemic as a whole. In addition the modelling groups which feed into the SAGE consensus use a range of other data along with deaths in their estimates of R and growth rate. These outputs are provided in the first part of this research findings. This week the type of data used in each model to estimate R is highlighted in Figure 2.

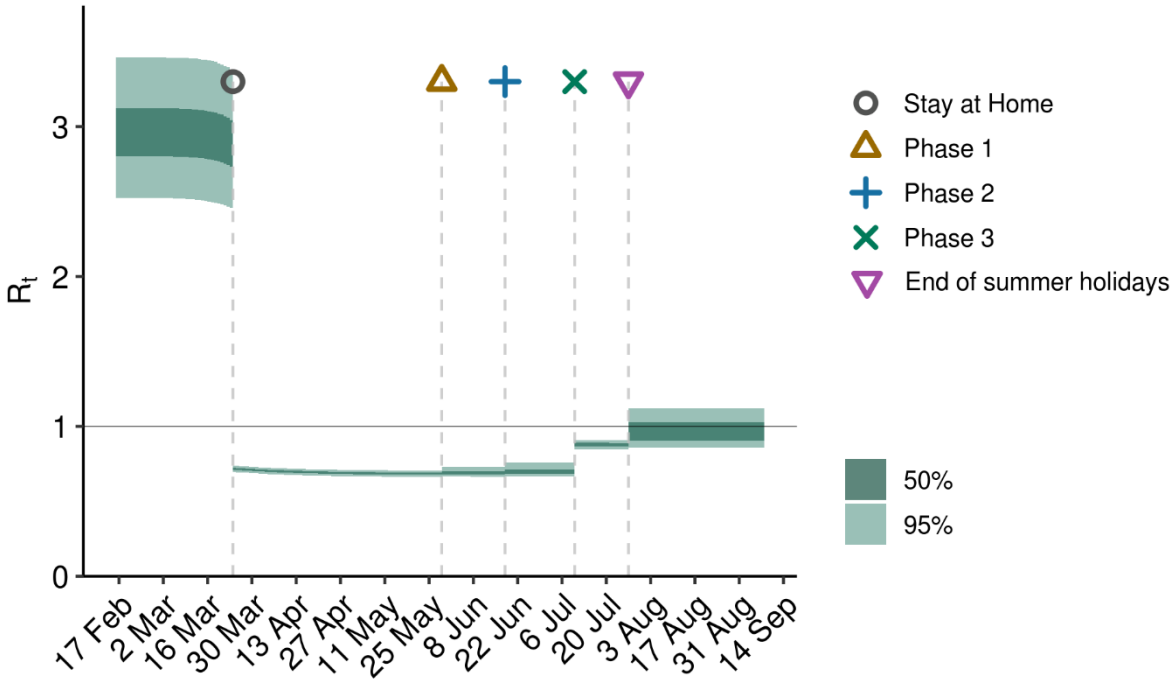
Secondly, a short term forecast of the number of cases in the next two weeks is provided, as the focus at this stage of the epidemic is the re-emergence of the virus in Scotland rather than whether there is sufficient hospital capacity to treat large numbers of Covid cases.

Finally, results showing the level of social contacts against baseline pre-pandemic levels are reported to illustrate where transmission may be occurring.

What the modelling tells us about the epidemic as a whole

Figure 1 shows how R_t has changed since February. Before the "stay at home" restrictions were put in place R_t was above 1, and most likely to have been between 2 and 4 before any interventions were put in place.

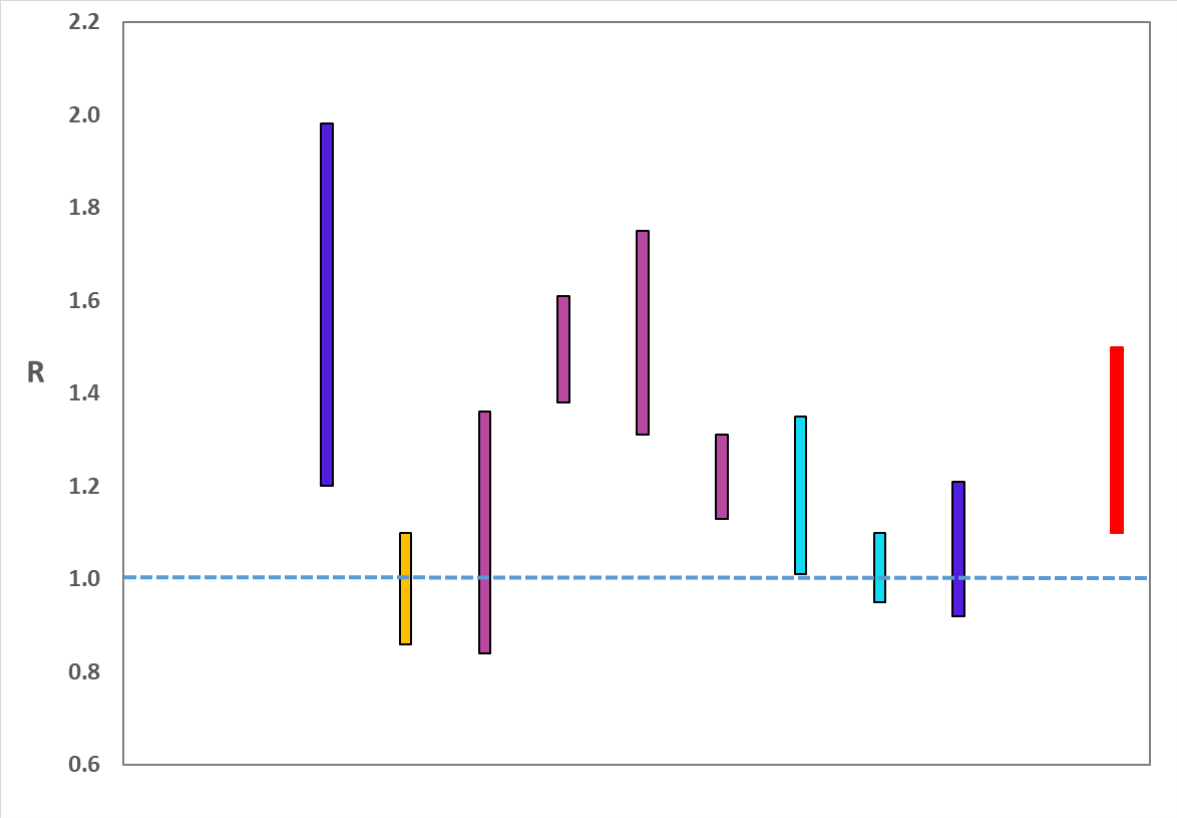
Figure 1: Trends in R_t for Scotland, 2020



Source: Scottish Government modelled estimates using Imperial College model code; actual data from https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/deaths-involving-coronavirus-covid-19-in-scotland

The various groups which report to the Scientific Pandemic Influenza Group on Modelling (SPI-M) use different sources of data in their models (i.e. deaths, hospital admissions, cases) so their estimates of R are also based on these different methods. SAGE's consensus view across these methods, as of 16 September, was that the value of R_t in Scotland was above 1, between 1.1 and 1.4, meaning that the epidemic is growing exponentially. The R value estimated by the Scottish Government falls within this range, and is similar to the estimates of other modelling groups (Figure 2).

Figure 2. Estimates of R_t for Scotland, as of 16 September, including 90% confidence intervals, produced by SAGE. The blue bars are death-based models, purple use multiple sources of data and cyan use Covid-19 test results. The estimate produced by the Scottish Government (a semi-mechanistic model) is the 2nd from left (yellow), while the SAGE consensus range is the right-most (red).



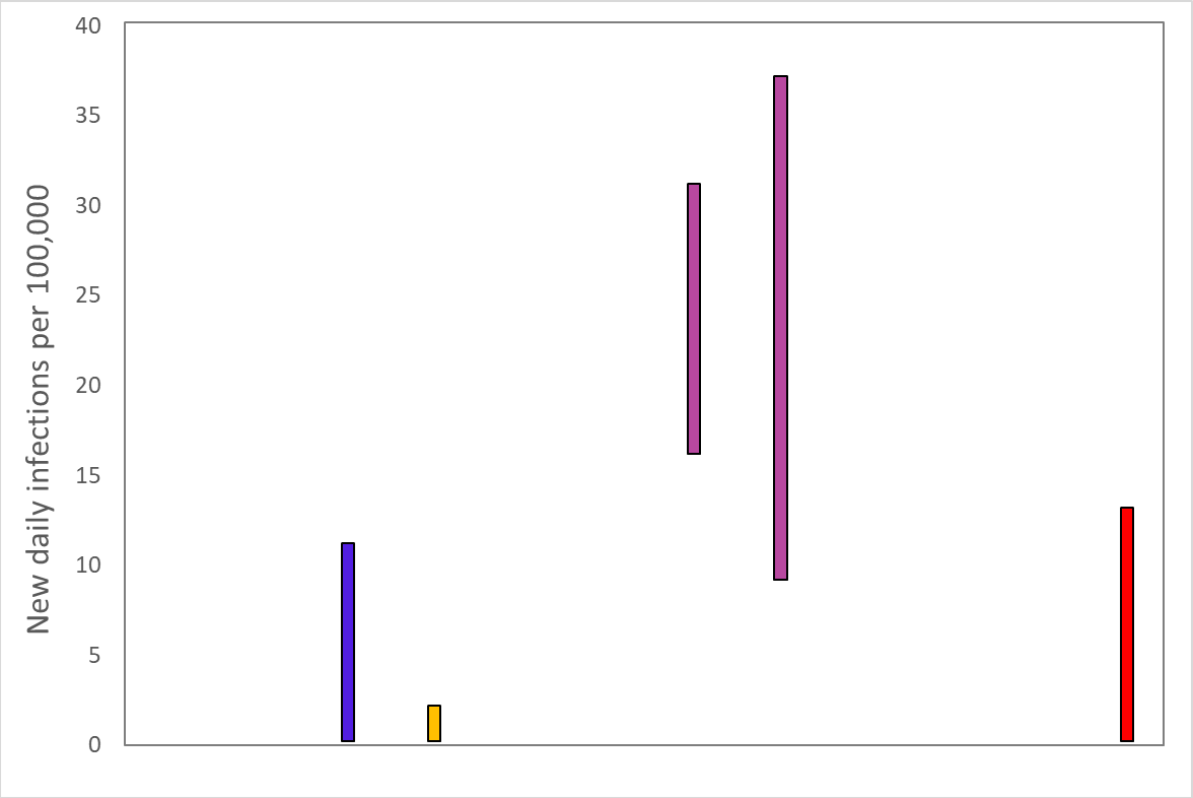
Source: Scientific Advisory Group for Emergencies (SAGE).

On 15 September, Public Health Scotland recorded 267[1] positive new cases, with 933 positive new cases over the week of 8 – 14 September.

The various groups which report to the Scientific Pandemic Influenza Group on Modelling (SPI-M) use different sources of data in their models to produce estimates of incidence. SPI-M's consensus view across these methods, as of 16 September, was that the incidence of new daily infections in Scotland was between 1 and 22 new infections per 100,000. The incidence value estimated by the Scottish Government falls within this range. This equates to between 60 – 1175 people becoming infected each day in Scotland. Given the level of asymptomatic infected people, 267 positive confirmed tests remains within this range.

[1] https://public.tableau.com/profile/phs.covid.19#!/vizhome/COVID-19DailyDashboard_15960160643010/Overview

Figure 3. Estimates of incidence for Scotland, as of 16 September, including 90% confidence intervals, produced by SPI-M. The blue bars are death-based models, purple use multiple sources of data and cyan use Covid-19 test results. The estimate produced by the Scottish Government (a semi-mechanistic model) is the 2nd from left (yellow), while the SAGE consensus range is the right-most (red).

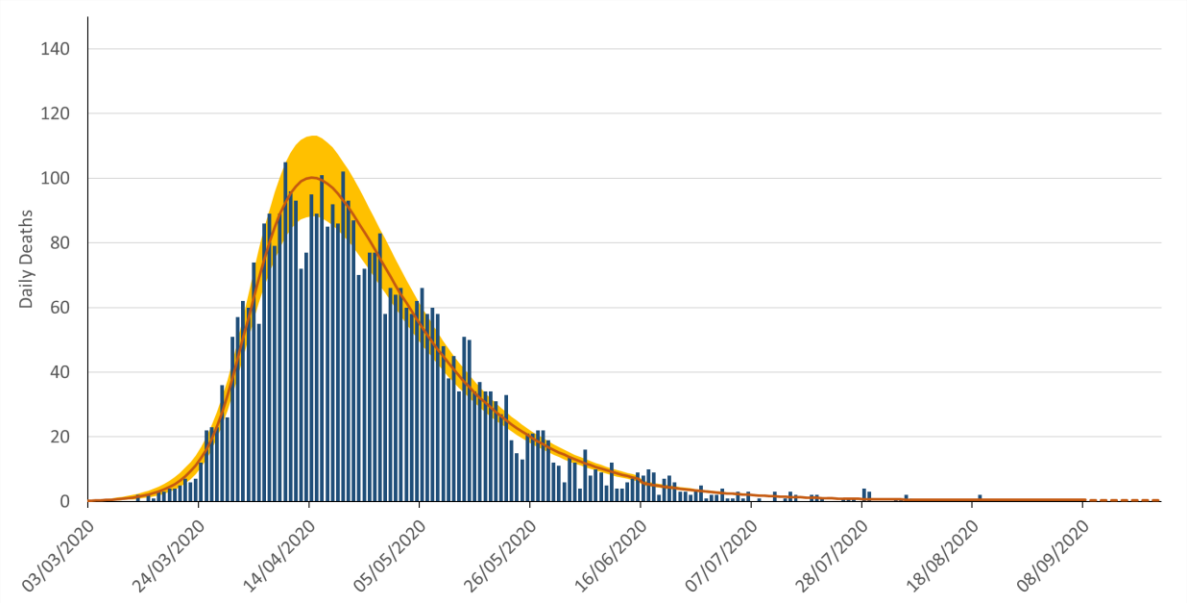


Source: Scientific Pandemic Influenza Group on Modelling (SPI-M).

The consensus from SAGE for this week is that the growth rate in Scotland is between +1% and +8% per day. This is slightly lower than last week, when the growth rate was in the range +3% to +9%.

Figure 4 shows the epidemiological model forecasts of daily deaths produced by the Scottish Government, given the present set of interventions. This measure of the epidemic is forecast to remain near zero in the weeks ahead.

Figure 4. Scottish Government short-term forecast of the number of deaths from Covid-19 in Scotland, based on actual data (10 September).



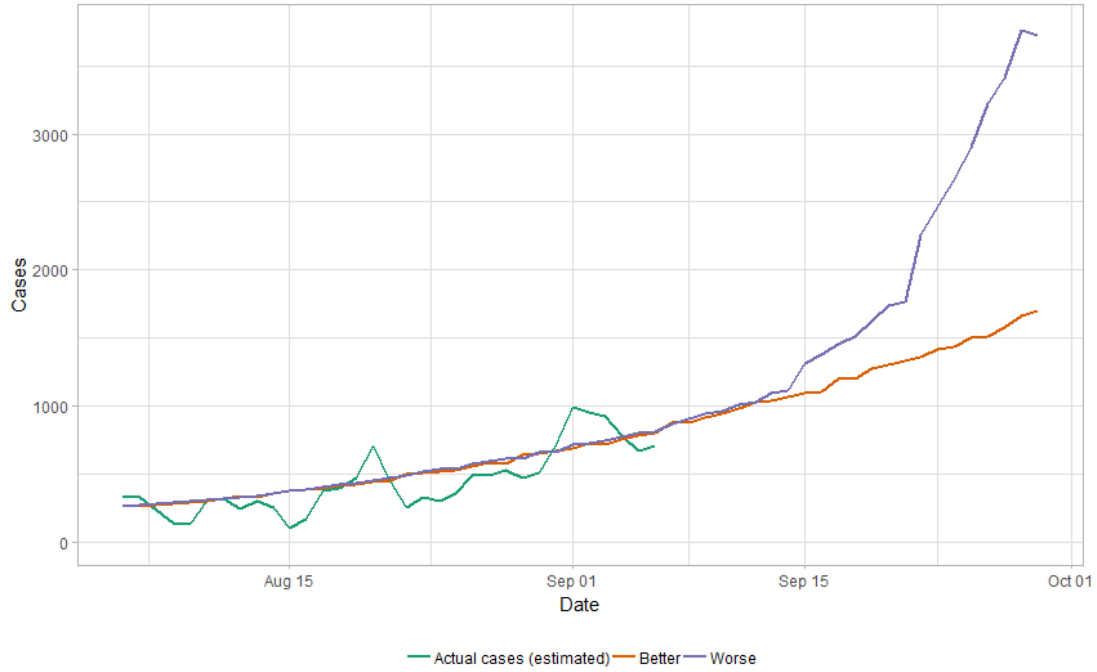
Source: Scottish Government modelled estimates using Imperial College model code; actual data from https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/deaths-involving-coronavirus-covid-19-in-scotland

The logistical model developed by Scottish Government analysts to assess implications for health care demand (see previous Research Findings) has been adapted to produce a short-term forecast of cases.

The following two week ahead predictions use this model to extend the estimated number of infections from the Imperial College model, in a manner that fits with the estimated number of actual cases, adjusting positive tests to account for asymptomatic and undetected infections. The extension begins in mid-July, and assumes an R_0 value of around 1.3. Future R_0 values are based on judgement.

Figure 5 shows two predictions from this model - a “better scenario”, which assumes the current R_0 value remains constant over the next two weeks, and a “worse scenario”, which assumes that transmission increases in mid-September.

Figure 5. Short term forecast of new cases, with 90% prediction intervals, from Scottish Government modelling (actual data up to 6 September).



Exceedance is a tool which helps us to spot hotspots of Covid where the number of new cases exceeds what was expected. As cases rise across the country, it becomes less informative as the background level of expected cases increases. As a result, this will not be reported this week.

What we know about how peoples contact patterns have changed

It is now possible for us to estimate how much contact people in Scotland have with each other, with a good degree of accuracy. This shows that, when compared to the lockdown period, people have started to have more contact with each other, particularly in younger age groups. This increased from the low number of contacts recorded during lockdown, before the schools went back, but increased even more afterwards, but to pre-pandemic levels (Figures 6 and 7). We know that contact is needed to transmit the virus, and therefore we likely to see a greater increase in Covid infection in younger age groups than in older people.

Figure 6. Mean contacts outside the home with non-household members by age group, during lockdown and before the pandemic (UK) (taken from LSHTM/Polymod[2])

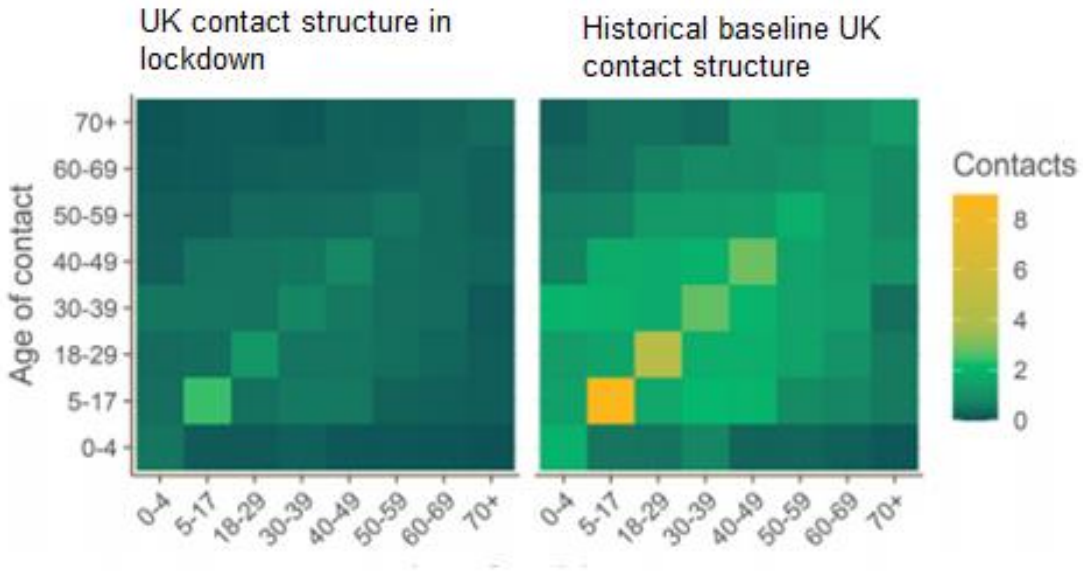
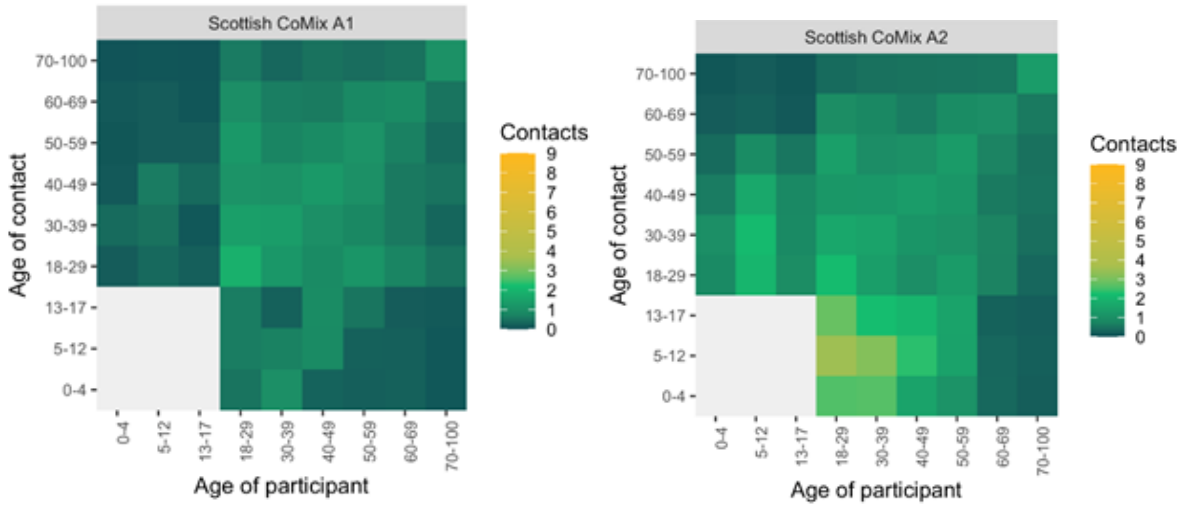


Figure 7. Mean contacts outside the home with non-household members by age group, before (A1) and after (A2) the schools returned in Scotland, August 2020, from SCS.



Survey results show the main change resulting from this has been that respondents are meeting others in someone else's homes more often (see Figure 8). There are also higher levels of non-essential shopping and visits to pubs, restaurants and cinemas. On 11 August this was followed by schools reopening and parents being able to return to more normal activities, leading to an increase in mean contacts outside the home in all age groups under-60, and therefore the risk of transmission has increased (Figure 8, 9, 10).

[2] https://cmmid.github.io/topics/covid19/reports/LSHTM-CMMID-20200401-CoMix-social-contacts.pdf

Figure 8. Locations visited by participants before and after the schools returned (from SCS).

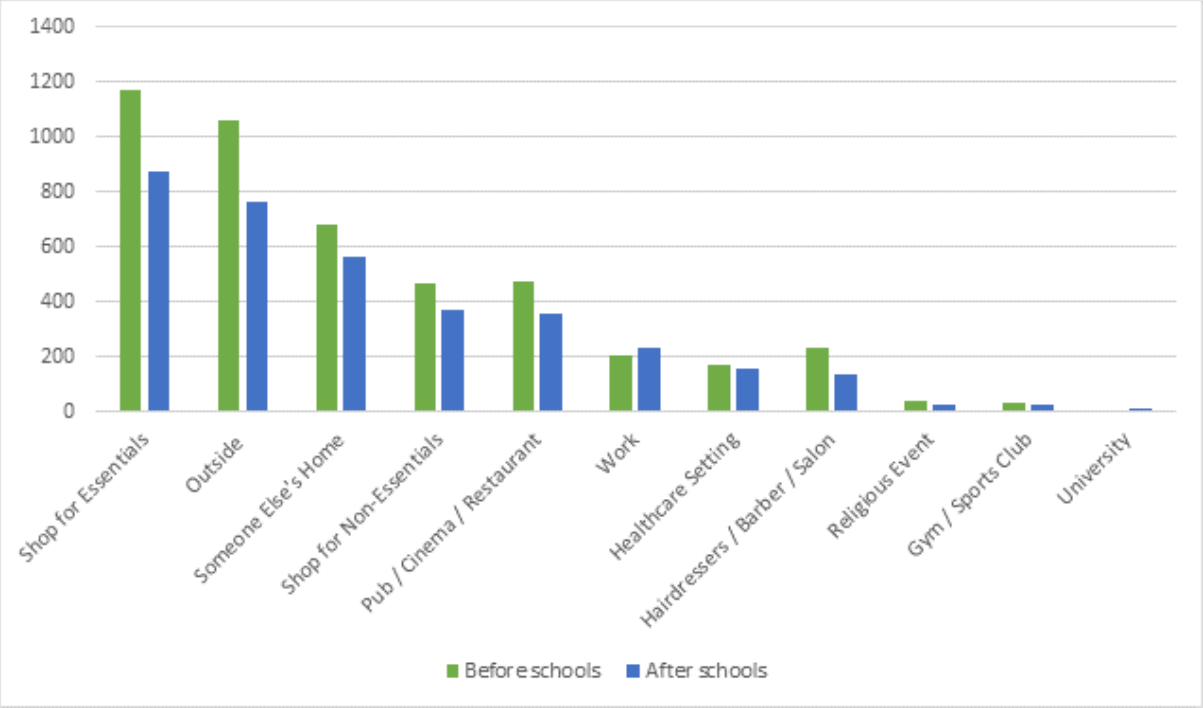


Figure 9. Adult mean contacts outside the home with non-household members by age group and time period (truncated to 100 contacts)

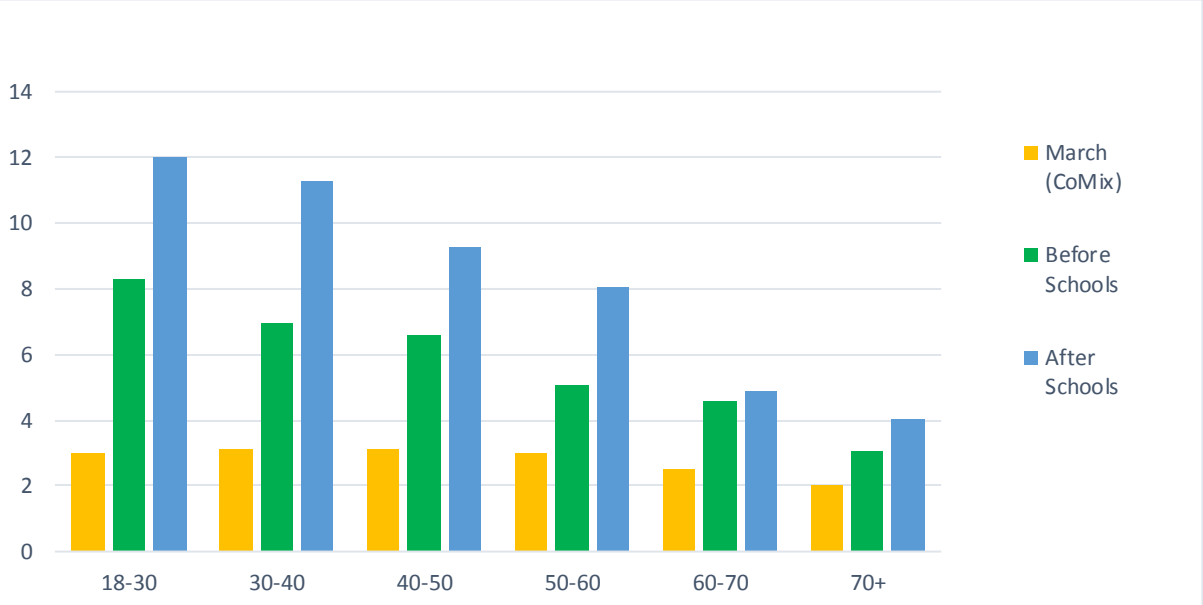
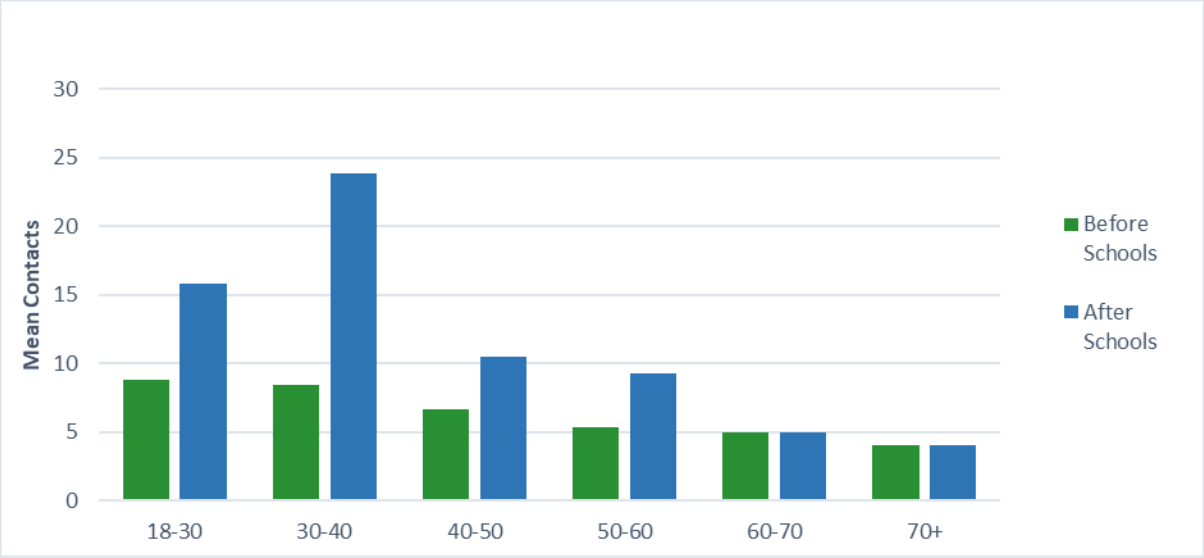


Figure 10. Mean number of adult contacts outside the home, with non-household members, by age group, before and after school reopening.



What next?

The Scottish Government continues to work with a number of academic modelling groups to develop other estimates of the epidemic in Scotland.

The modelled estimates of the numbers of new cases and infectious people will continue to be provided as measures of the epidemic as a whole, along with measures of the current point in the epidemic such as exceedance. R_t and growth rate will also be provided. Further information can be found at https://www.gov.scot/coronavirus-covid-19.

Technical Annex

The London School of Hygiene and Tropical Medicine have developed a modelling technique called “CoMix” which is based on how many contact people have each week. The contacts people have are collected via an online survey. Until now Scotland has been included in this modelling but represented by around 10% of respondents (under 150 people) leading to a high level of uncertainty in the results. Scottish Government are now running a Scottish Contact Survey (SCS) to boost these numbers to over 3,000 people. The outputs of the model provide alternative measures of the epidemic at the time (e.g. R number). Having a range of different types of models for Scotland is the best chance of spotting an upturn in cases and help us plan what to do if this happens.

SCS is a behavioural survey, asking questions to panels of people who have been recruited to be broadly representative of the Scottish population. It was launched in August 2020. Data is collected weekly, using two different groups (Panels A and B) in alternating weeks. Adults record their direct, face-to-face contacts made on the previous day, specifying certain characteristics for each contact including the age and sex of the contact, whether a meeting involved physical contact with another person, and where contact occurred (e.g. at home, at work, while undertaking other activities, etc.).

The average number of contacts each person has is calculated for a range of settings (home, work, school, and other). Exact ages of contacts is not recorded, so a uniform sample between the minimum and maximum age reported for the contact is used.

Tracking behavioural change can give a more rapid assessment of the impact of physical distancing measures than routine epidemiological surveillance. The next steps will be to use this information to calculate R and growth rates of the epidemic. We will continue to track behaviour during the Covid-19 pandemic, using SCS, and regularly update with new results.

This publication will be available in accessible HTML on the gov.scot website

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The views expressed in this report are those of the researcher and do not necessarily represent those of the Scottish Government or Scottish Ministers.

This document is also available from our website at www.gov.scot.
ISBN: 978-1-80004-086-1

The Scottish Government
St Andrew's House
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Produced for
the Scottish Government
by APS Group Scotland
PPDAS766586 (09/20)
Published by
the Scottish Government,
September 2020

ISBN 978-1-80004-086-1

Web Publication

PPDAS766586 (09/20)