The effect of social distancing on the reproduction number and number of contacts in the UK from a social contact survey
Report for survey week 33

Christopher Jarvis, James Munday, Amy Gimma, Kerry Wong, Kevin Van Zandvoort, Sebastian Funk, John Edmunds on behalf of CMMID COVID-19 Working Group, London School of Hygiene and Tropical Medicine.

Report for SPI-M-O and SAGE, 17th November 2020

Summary

- We estimate R_0 for England to be 1.00 (95% interval 0.59 1.42) for the period of the 4th of November to the 10th of November.
- We estimate that in England R_0 has decreased from 1.68 to 1.00 since mid-September.
- Changes in R_0 have been more variable in Scotland and Wales, but most recent estimates of R_0 from both Northern Ireland and Wales are below 1. Current estimates of R0 for Scotland are 1.29, with wide uncertainty (0.77 - 1.84)
- Lockdown in England on November 5th seems to have resulted in reductions in mean contacts made by individuals who were previously under Tier 1 or Tier 2 restrictions, but appears to have made no significant difference to mean contacts reported by individuals in Tier 3 (though the sample size is small).
- Estimates of R_0 can be influenced by a few participants reporting very large numbers of contacts. We have assessed the sensitivity of our estimates to different methods for dealing with these large numbers of reported contacts. Our base case method (where the number of contacts per age group is truncated at 200) appears to be consistent with estimates of R_t from the REACT1 survey [1].

Results

Estimating R_0 in England

The estimates of the R_0 using POLYMOD[2] and CoMix[3] appear consistent with the R_t estimates from the REACT1 survey (Figure 1). Truncating the contacts reduces the variation around the estimates. Truncating at 50 appears to smooth the data to be more similar to the two round (green) estimates from REACT1 whereas truncating at 200 appears to follow the single round (blue) estimates more closely. Note that R_0 should be higher than R_t as it does not take immunity in the population into account.

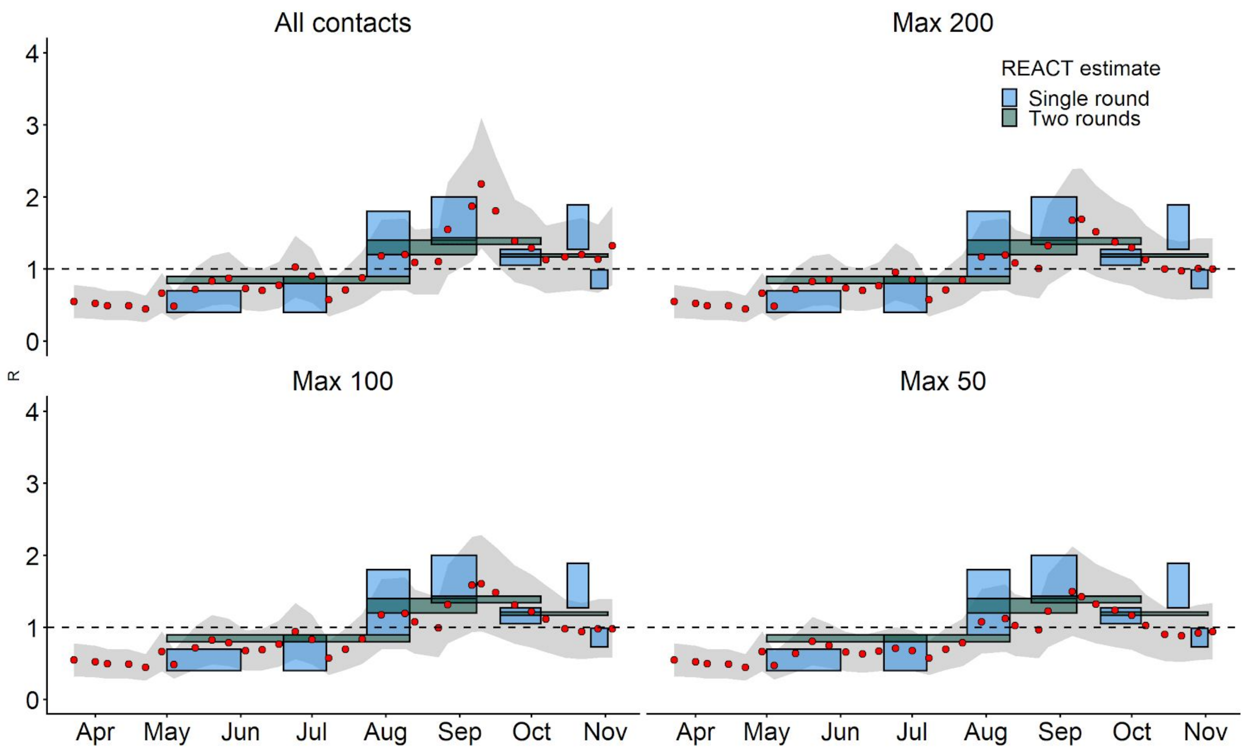

Figure 1: Estimates of R_0 from CoMix compared to R_t from REACT study for England over time. Estimates of R_0 were calculated by applying the ratio of the dominant eigenvalues of CoMix and POLYMOD to an assumed R_0 of 2.6. A truncated negative binomial model was applied to the number of contacts for each participant. The graph displays the impact of no truncations, truncating at 200, 100, and 50, per age-group contact. Excluding the most recent estimate, observations were combined across two weeks to smooth panel variation. For the first 6 weeks, children's data was not collected, as previously shown children's contacts were consistent from the early weeks (schools were closed at the time) and therefore we used children's data from survey week 6 and 7 for weeks that did not collect information on children.

Estimates of R_0 in England

Table 1 shows the estimate of R_0 over time in England using a negative binomial model that truncated participant's contacts at 200 per age-group pair. Estimates of the reproduction number were highest in early to mid-September and have gradually reduced over time. They are currently at around 1.

Table 1: Estimate of R_0 for England, comparing CoMix with POLYMOD over time. Values of R_0 for two week periods, excluding the most recent estimate with 95% intervals.

Start date	End Date	R_0	Lower	Upper
06/09/2020	16/09/2020	1.68	0.99	2.39
10/09/2020	21/09/2020	1.69	1.00	2.40
16/09/2020	30/09/2020	1.52	0.90	2.16
24/09/2020	06/10/2020	1.37	0.81	1.96
01/10/2020	14/10/2020	1.29	0.77	1.84
07/10/2020	20/10/2020	1.13	0.67	1.61
15/10/2020	28/10/2020	1.00	0.59	1.43
22/10/2020	04/11/2020	0.97	0.58	1.38
29/10/2020	10/11/2020	1.01	0.60	1.44
04/11/2020	10/11/2020	1.00	0.59	1.42

Estimating R_0 in UK countries

We present two weekly rolling averages from October 1st until November 12th (Table 2). Our approach estimates markedly different trajectories and estimates of R_0 between countries (Figure 2). Wales, Northern Ireland, and England have seen decreases in R_0 since September (Figure 2), with all estimates for these countries being around or below one for the most recent two time periods. Scotland has been consistently estimated above one for the last three time periods (after the half term break).

Table 2: Estimate of R_0 by country, comparing CoMix with POLYMOD over time. Values of R_0 for two week periods, excluding the most recent estimate with 95% intervals.

Country	1/10/2020 to 14/10/2020	7/10/2020 to 20/10/2020	15/10/2020 to 28/10/2020	22/10/2020 to 04/10/2020	29/10/2020 to 10/11/2020	4/11/2020 to 10/11/2020
England	1.29 (0.77, 1.84)	1.13 (0.67 1.61)	1.00 (0.59 1.43)	0.97 (0.58 1.38)	1.01 (0.60 1.44)	1 (0.59 1.42)
Northern Ireland	1.05 (0.62, 1.50)	0.79 (0.47 1.13)	0.75 (0.44 1.07)	0.85 (0.50 1.21)	0.89 (0.53 1.27)	0.68 (0.40 0.97)
Scotland	1.69 (1.00 2.40)	0.79 (0.47 1.12)	1.00 (0.59 1.43)	1.31 (0.78 1.87)	1.31 (0.77 1.86)	1.29 (0.77 1.84)
Wales	2.47 (1.46 3.52)	1.38 (0.82 1.96)	0.99 (0.59 1.41)	0.76 (0.45 1.08)	0.84 (0.50 1.20)	0.54 (0.32 0.77)

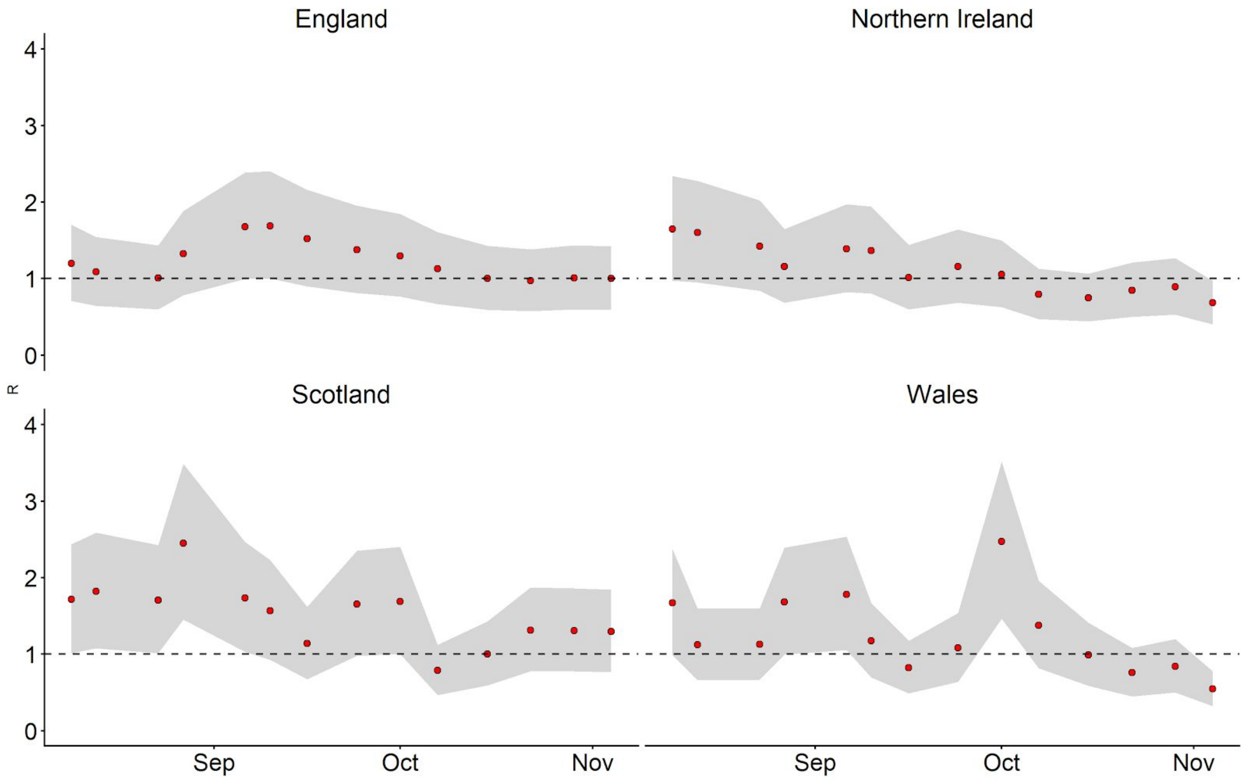

Figure 2: Estimates of R_0 from CoMix by country. Estimates of R_0 by country of the UK, using the base-case method (truncation at 200). Estimates of R_0 were calculated by applying the ratio of the dominant eigenvalues of CoMix and POLYMOD to an assumed R_0 of 2.6. Excluding the most recent estimate, observations were combined across two weeks to smooth panel variation. Children's data was collected for all weeks presented so no substitution was required.

Impact of change from "Tiers" to Lockdown in England

We investigated the impact of the change to lockdown in England by comparing the number of contacts reported by individuals in the two weeks prior to the 5th of November with their contacts after the 5th of November. We stratified the analysis by each of the three Tiers. The data were consistent with more people in Tier 1 and 2 decreasing their contacts than would be expected due to chance (Table 3). However the change in mean differences was variable for Tier 2 and 3 due to small numbers and differences in work attendance between weeks. Data on participants was available up to the 10th of November and therefore we have limited observations on which to base this analysis.

Table 3: Change and paired mean difference in all contacts comparing before and after each Tier moved into the national lockdown.

Restriction	N	Decreased	Same	Increased	p-value
Tier 1	459	140	223	96	<0.01
Tier 2	336	92	177	67	0.03
Tier 3	60	14	35	11	0.35

Restriction	Before	After	Difference	Lower	Upper	p-value
Tier 1	3.36	2.72	-0.64	-1.25	-0.05	0.03
Tier 2	3.22	2.54	-0.68	-1.53	0.07	0.10
Tier 3	2.92	3.77	0.85	-1.18	3.4	0.51

Methods

CoMix is a behavioural survey, launched on 24th of March 2020, with a study sample recruited to be broadly representative of the UK adult population. Participant's respond to the survey once every two weeks. We collect weekly data by running two alternating panels, with the same participants responding to the survey once every two weeks. Parent's complete the survey on behalf of children (17 years old or younger). Participants recorded 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 contact was physical (skin-to-skin contact), and where contact occurred (e.g. at home, work, while undertaking leisure activities, etc). Further details have been published elsewhere[3]. The contact survey is based on the POLYMOD contact survey[2].

We constructed age-stratified contact matrices for nine age-groups (0-4, 5-11, 12-17, 18-29, 30-39, 40-49, 50-59, 60-69, and 70+). For children participants and contacts, we did not have exact ages and therefore sampled from the reported age-group uniformly. We fitted a truncated negative binomial model to calculate the mean contacts between each participant and contact age-groups. To find the population normalised symmetrical contact matrix we multiplied the columns of the matrix by the mean-normalised proportion of the UK population in each age-group. For rounds one to six and 17 to 19, where no child participants were surveyed, we used contacts reported by children in rounds seven and eight to construct a full contact matrix.

Using the same approach, we constructed an age-stratified contact matrix for POLYMOD with the same age bands. Since contacts in polymod are right censored at 29, we corrected for this by fitting a truncated negative binomial distribution. For all participants with 29 recorded contacts, we increased the number of contacts according to the fitted distribution with a left censor at 28, and assigned age-groups proportionally to the contacts the participant reported.

We estimated R_0 by applying a scaling factor of the ratio of the dominant eigenvalues of the CoMix contact matrix over the POLYMOD contact matrix. This scaling factor was applied to an estimate of R_0 sampled from a normal distribution with mean of 2.6 and standard deviation of 0.56. We repeated this approach and applied a truncation of 200, 100, and 50 contacts per age-group combination and then compared this visually to estimates of R from the REACT1 study.

To investigate the impact of the lockdown, we compare individuals' reported contacts just before and just after the English lockdown on 5th November using permutation tests. Analysis was stratified by Tiers. The closest pairs of observations were identified within two weeks before and after the lockdown. We performed two tests, first on the proportion of people who reduced contacts after the lockdown, second on the paired mean difference (where the number of contacts recorded by individuals was capped at 50).

References

1. Real-time Assessment of Community Transmission findings. https://www.imperial.ac.uk/medicine/research-and-impact/groups/react-study/real-time-assessment-of-community-transmission-findings/.
2. Mossong, J. *et al.* Social contacts and mixing patterns relevant to the spread of infectious diseases. *PLoS Med.* **5**, e74 (2008).
3. Jarvis, C. I. *et al.* Quantifying the impact of physical distance measures on the transmission of COVID-19 in the UK. *BMC Med.* **18**, 124 (2020).