Impact of gradual reopening strategies using POLYMOD contact data

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Highlights

- Reopening schools, work and allowing social visits are least likely to keep R below 1.
- Reopening libraries and parks are most likely to keep R below 1.
- We do not account for indirect effects. For example, restarting bars and restaurants, but not social visits is likely to move those visits from at home to the bar or restaurant. This could result in many more contacts at bars and restaurants than before the pandemic.
- For a significant number of contacts location and activity are unknown and it is unclear what would happen to these if other activities were started again.
- R_0 only represents the initial reproduction rate and its link to the final attack rate is complex. This is especially true when relying on Polymod data, because there the early reproduction rate (in a fully susceptible population) is dominated by reproduction in school age children.

Methods

- We assumed current reproduction number R_c to be between 0.6 and 1 and R_0 was between 2.4 and 3.0.
- We used Polymod data enhanced with time use data to calculate average number of contact per activity (manuscript in prep; Table 3).
- Google mobility data used to estimate current amount of time spent on each activity
- Each activity can be "switched on".
  - The **default** scenario assumed the activity would be as before the pandemic.
  - The **optimistic** scenario assumed people are more careful, resulting in a 0.5 reduction in transmission.
- Polymod matrices were bootstrapped using the `socialmixr` package.
- To calculate the probability that R was kept below 1 we rescaled the relative eigenvalues from the adjusted polymod matrices to match the findings for current and initial reproduction number. First, we sampled the current and initial reproduction numbers from a uniform distribution $R_c \sim U(0.6, 1); R_0 \sim U(2.4, 3.0)$. Next, we created bootstrapped samples of the polymod matrix. Using these samples, the time use data (see Table 3) and the Google mobility data we estimated the current contribution of each polymod location to the total number of contacts. We can then calculate the current and initial dominant eigenvalue ($\rho_{ci}; \rho_{0i}$). Finally, we calculated the changes in contact patterns when different activities are restarted again and used that to estimate the reproduction number for that scenario as follows:

$$R_{ai} = \frac{\rho_{ai} - \rho_{ci}}{\rho_{0i} - \rho_{ci}}(R_{0i} - R_{ci}) + R_{ci}.$$

The fraction of samples with a reproduction number below 1 was then used as the probability that the reproduction number stayed below 1.

Table 1: The probability R is kept below 1 when restarting different activities. Clearly, the impact of restarting school, work or social visits was the largest. There were a large number of contacts that cannot be linked to any of the other activities. These unspecified contacts did also have a large impact. Fully reopening libraries and parks had the lowest impact. Impact under the optimistic scenario was lower, but still significant.

Scenario	default	optimistic
library	0.985	0.995
parks	0.897	0.959
transport	0.596	0.808
cultural	0.289	0.649
indoor exercise	0.089	0.551
holiday	0.002	0.467
bars and restaurants	0.000	0.406
shopping	0.000	0.278
school	0.000	0.000
unspecified	0.000	0.000
visit	0.000	0.000
work	0.000	0.000

Table 2: Here we explored what happened when restarting activities cumulatively. Activities were restarted in order of least impact (see previous table).

Scenario	default	optimistic
library	0.985	0.995
parks	0.880	0.947
transport	0.451	0.741
cultural	0.000	0.382
indoor exercise	0.000	0.000
holiday	0.000	0.000
bars and restaurants	0.000	0.000
school	0.000	0.000
shopping	0.000	0.000
unspecified	0.000	0.000
visit	0.000	0.000
work	0.000	0.000

Table 3: Relative weight of each activity by POLYMOD location and age group. Home alone and bed were weighted as zero to reflect that no (new) contacts occur when alone or in bed (for sleeping, not asleep, or sick). The last column shows how much this activity is currently assumed to still happen. This value is based on Google Mobility data, except for schools where we have direct data available

Location	Activity	[0,16)	[16,25)	[25,45)	[45,65)	[65,+)	Current
home	alone	0.000	0.000	0.000	0.000	0.000	1.000
	bed	0.000	0.000	0.000	0.000	0.000	1.000
	home	0.988	0.977	0.981	0.978	0.966	1.000
	visit	0.012	0.023	0.019	0.022	0.034	0.262
leisure	bars and restaurants	0.042	0.136	0.209	0.231	0.196	0.000
	cultural	0.063	0.059	0.074	0.080	0.112	0.000
	indoor exercise	0.100	0.097	0.103	0.106	0.092	0.000
	library	0.001	0.002	0.004	0.003	0.006	0.000
	parks	0.122	0.045	0.089	0.086	0.057	0.846
	visit	0.671	0.661	0.522	0.493	0.537	0.262
otherplace	bed	0.000	0.000	0.000	0.000	0.000	1.000
	holiday	0.165	0.120	0.181	0.207	0.147	0.262
	shopping	0.166	0.219	0.221	0.244	0.283	0.262
	shopping essential	0.038	0.056	0.079	0.077	0.070	0.698
	unspecified	0.631	0.605	0.519	0.471	0.501	0.262
school	school	1.000	1.000	1.000	1.000	1.000	0.030
transport	cultural	0.083	0.052	0.074	0.053	0.060	0.000
	holiday	0.031	0.031	0.019	0.030	0.031	0.262
	indoor exercise	0.074	0.046	0.029	0.021	0.027	0.000
	parks	0.034	0.016	0.023	0.021	0.035	0.846
	school	0.220	0.131	0.053	0.019	0.008	0.030
	shopping	0.076	0.088	0.102	0.110	0.166	0.262
	transport	0.285	0.252	0.291	0.356	0.440	0.286
	visit	0.180	0.199	0.145	0.127	0.156	0.262
	work	0.017	0.184	0.265	0.263	0.077	0.282
work	work	1.000	1.000	1.000	1.000	1.000	0.282