MRC Centre for Global Infectious Disease Analysis

Modelling proposed GB exit strategies

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Policy scenarios

Scenario 1:

PHASE 0 (Lockdown)

- 20% of workplaces open as usual. Closed workplaces have 5% of usual attendance
- Schools and universities closed
- 80% reduction in non-work contacts outside the home
- R=0.7 currently

PHASE 1: Starting on 11 May

- An increase in workplace contacts representing a return of an additional 20% compared to now
- 11% of children attending school (representing key workers' children so assume mix of ages)

PHASE 2: Starting on 1 June

- An additional increase in workplace contacts of 10% on top of the phase 1
- 25% of children attending school (representing key workers' and vulnerable children plus transition years [as per scenario 2+3 in children's subgroup paper - attached]).
- 10% increase in leisure contacts from current levels

PHASE 3: Starting on 1 July

- An additional increase in workplace contacts of 10% on top of phase 1+2
- 60% of children attending school (representing key workers children plus transition years plus primary school [as per scenario 2+3+5 in children's subgroup paper])
- 30% increase in leisure contacts from current levels

PHASE 4: Starting 15 August

- An additional increase in workplace contacts of 10% on top of phase 1+2+3, giving 70% of pre-lockdown contacts overall.
- 100% of children attending school from the start of the school year
- 75% increase in leisure contacts from current level

Scenario 2:

- As scenario 1, except for phase 2 where 50% of children are attending school (representing key workers' and vulnerable children and all primary schools [as per scenario 2+5 in children's subgroup paper])

Contact tracing

Assumed to be in place from phase 1. Average of 30 contacts per case assumed in the absence of social distancing and school/workplace closure. These numbers are substantially reduced in the presence of social distancing or school/workplace closure. Two alternatives are explored:

- 80% of contacts within 48h
- 40% of contacts within 48h

We were not able to implement absolute daily case limits on contact tracing in time for this report, so the results shown optimistically assume tracing can continue even over 25,000 cases per day.

Reactive school and/or workplace closure

In light of the results for Scenarios 1 and 2 alone, we also examined additional case-triggered measures. Results are shown for:

- No reactive closure
- Reactive closure of individual schools for 2 weeks after the detection of a symptomatic case in that school (pupil or staff member)
- Reactive closure of individual schools and workplaces for 2 weeks after the detection of a symptomatic case in that school or workplace (pupil or staff member). 40% of workplaces are assumed to not be able to close.

Transmission/infectiousness scenarios

This work uses a spatially explicit individual based simulation of respiratory virus transmission in the entire GB population. The model was first previously developed for pandemic influenza planning [Ferguson et al., Nature, Nature, 2005. 437(7056): p. 209-14], including non-pharmaceutical interventions (NPIs) [Halloran et al, PNAS, 2008. 105:4639-4644]. The model has been parameterised to reproduce current knowledge of COVID-19 epidemiology, including age-dependence in severity and healthcare utilisation.

We assume a gamma distributed latent period with mean 4.59 days, SD 3.94 days, a fixed 0.5 day delay from the end of latency to symptom onset (giving a 5.09 day mean incubation period). After latency, infectiousness varies over time according to the density function of a gamma distribution with mean 2.2 days and SD 1.64 days. This gives a generation time distribution with mean 6.48 days, SD 3.83 days, of gamma form, matching current estimates from contact tracing studies. We assume individuals vary in infectiousness according to a gamma distribution with mean 1, SD 1/sqrt(k) where k=1 This gives a negative binomial offspring distribution with k=1. We assume 2/3 of all infections assumed to be symptomatic (at least mildly). Symptomatic infections are assumed 1.5-fold more infectious than asymptomatic, but 50% less likely to make social contacts outside the school, workplace or household.

We examine four transmission scenarios spanning current uncertainty in COVID-19 transmission:

- *Default* – as used in previous modelling. Approximately 1/6th of transmission occurs before symptom onset. 1/3 of transmission occurs in households, 1/3 in schools and workplaces, and 1/3 in other contexts.
- *PreSymp* – higher level of presymptomatic transmission (1.5 days, 1/3 of all transmission).
- *MoreSocial* – lower level of household (~1/4) and school/workplace transmission (~1/4), more in other social contexts (~1/2). This scenario also assumes the PreSymp scenario assumptions.
- *LoKids* – higher asymptomatic fraction overall (50%+); and children less susceptible (0-5 – 70%; 5-10 – 80%; 10-15 – 90%, >15 – 100%) and less symptomatic (0-5 – 20%; 5-10 – 30%; 10-15 – 40%, >15 – 50%). This scenario also has an Infection Fatality Ratio (IFR) reduced by ¼.

Other assumptions

- R_0 values of 2.8, 3 and 3.2 examined
- Contact tracing model tuned to give a mean of ~30 contacts per index case (excl. household) in the absence of social distancing or school/workplace closure. We assume a 2 day delay between symptom onset in the index case and the start of (14 days of) contact isolation.
- Contacts distributed between general social mixing and schools/workplaces.
- Case isolation (7 days) and household quarantine (14 days) continued throughout (all household members assumed to be contacts). 90% adherence to case isolation assumed, 75% with household quarantine. Case isolation assumed to reduce contacts outside the home by 90%, household quarantine by 75%.
- We also (optimistically) assume effective shielding of the elderly from Phase IV, with adherence rising from 50% at age 65 to 70% at age 80+, and resulting in a 75% reduction in contacts outside the home for adherent individuals.

Results

Figures 1-4 show illustrative dynamics for the policy options explored. All results are for GB.

Conclusions

- **Take-home: With good contact tracing, Scenario 1 is unlikely to lead to rapid growth of case numbers until Phase IV. Scenario 2 poses higher risks of letting case numbers accelerate. All scenarios are predicted to lead to large autumn waves of transmission, healthcare demand and deaths in the absence of additional control measures or higher long-term levels of social distancing.**
- Phase I leads to no increase in R – indeed we predict a minor reduction associated with the introduction of contact tracing. Case numbers continue to decline.
- In Phase II, Scenario 1 sees R stay below 1, but in Scenario 2, R rises to around 1.1 for the default and MoreSocial transmission scenarios, but to 1.3 for the PreSymp and LoKids scenarios. The higher rise for the latter two model variants is due to the larger amount of asymptomatic or presymptomatic transmission assumed. Case incidence starts to rise, but remains at levels of under ~5,000 cases per day for Scenario 1 for all transmission scenarios (and much lower for some).
- In Phase III, R initially rises above 1 in all scenarios, rising to between 1.2 and 1.7 depending on the transmission scenario assumed and on whether 15 or 30 contacts per case can be traced. Case numbers rise, but are predicted to stay under ~10,000 per day in Scenario 1 (but not Scenario 2) for all transmission scenarios. With the advent of the school holidays, R then (briefly) dips below 1 once more.
- In Phase IV, R rises above one again, even in the last two weeks of the school holidays, before rising to 1.3-1.7, depending on the transmission scenario and the numbers of contacts traced per case.
- 25,000 cases per day are exceeded from sometime between August and late October, depending on the transmission scenario and the numbers of contacts traced per case. For

the worst-case transmission assumptions, there is a risk of this capacity being exceeded in July for Scenario 2.

- Under all transmission scenarios, we predict a second wave of transmission larger (in terms of both deaths and ICU beds occupied) than the epidemic seen between February and now, for both Scenarios 1 and 2. This is despite moderately effective shielding and assumed ongoing contact tracing.
- Thus, for anything approaching Phase IV to be achieved without a major autumn wave, additional measures must be substituted in order to maintain control of transmission.
- Reactive closure (closing an individual school or workplace for 2 weeks in response to a case in a pupil or staff member) is predicted to have a substantial effect on the magnitude of the predicted autumn wave, with closing workplaces as well as schools having a larger impact than just closing schools.
- However even reactive school and workplace closure is not predicted to be sufficient to keep R below 1 for most transmission scenarios.
- Fundamentally, to keep R<1, we need to maintain substantially more than the 25% reduction in social contacts compared with pre-lockdown levels that phase 4 envisages.
- A 50% reduction in potentially infectious social contacts outside schools and workplaces is needed to maintain R<1, even with contact tracing and reactive school and workplace closure.
- However, a 50% reduction in potentially infectious contacts need not necessarily translate into a 50% reduction in all social activities outside the home. Research is urgently needed to identify the key behaviours and types of contacts which pose greatest risk of transmission, and to use the results to inform more nuanced policymaking.

Figure 1: Daily deaths through time for policies examined, default scenario. Notation: 1= scenario 1, 2=scenario 2, a=no reactive school or workplace closure, b=reactive school closure, c=reactive school or workplace closure, n15=contact tracing limited to 15 contacts per case, n30=contact tracing limited to 30 contacts per case.

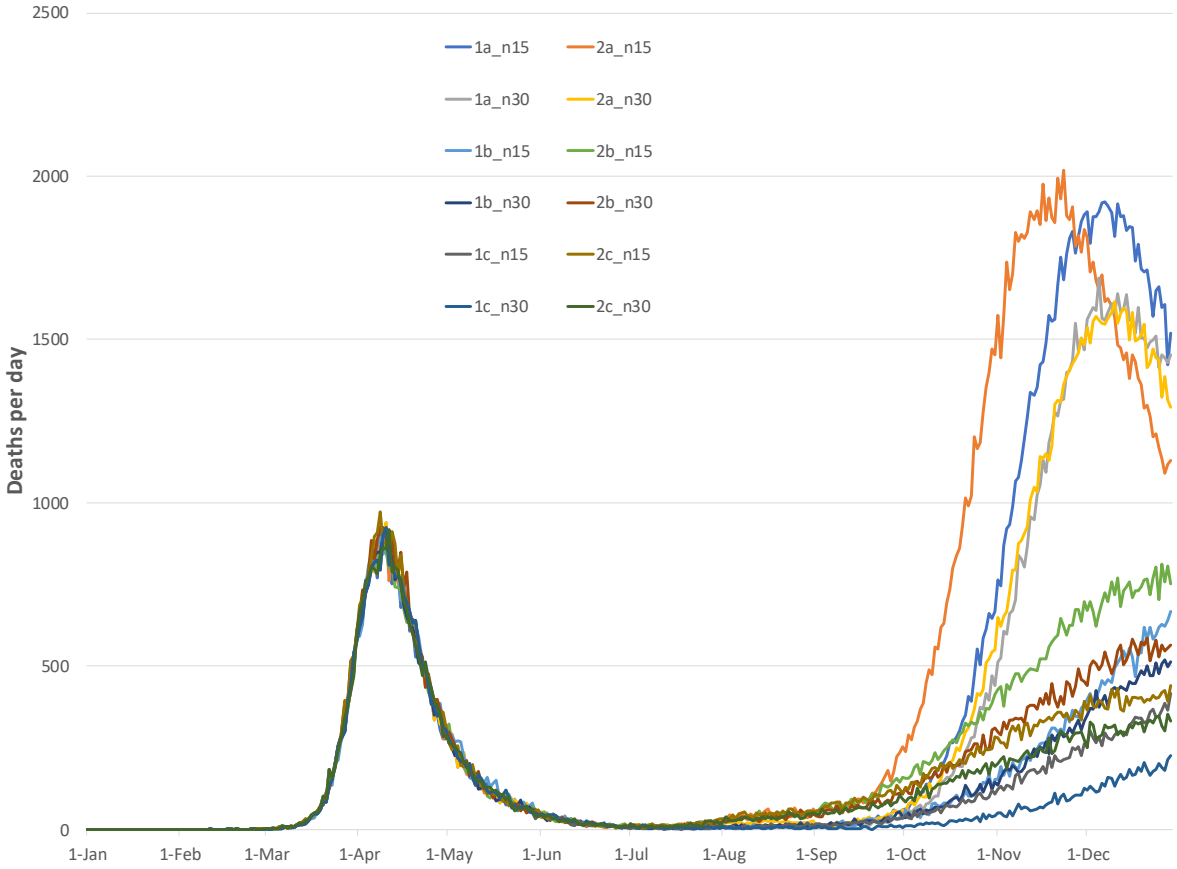

Figure 2: Reproduction number, R, through time for policies examined, default scenario. Notation: 1= scenario 1, 2=scenario 2, a=no reactive school or workplace closure, b=reactive school closure, c=reactive school or workplace closure, n15=contact tracing limited to 15 contacts per case, n30=contact tracing limited to 30 contacts per case.

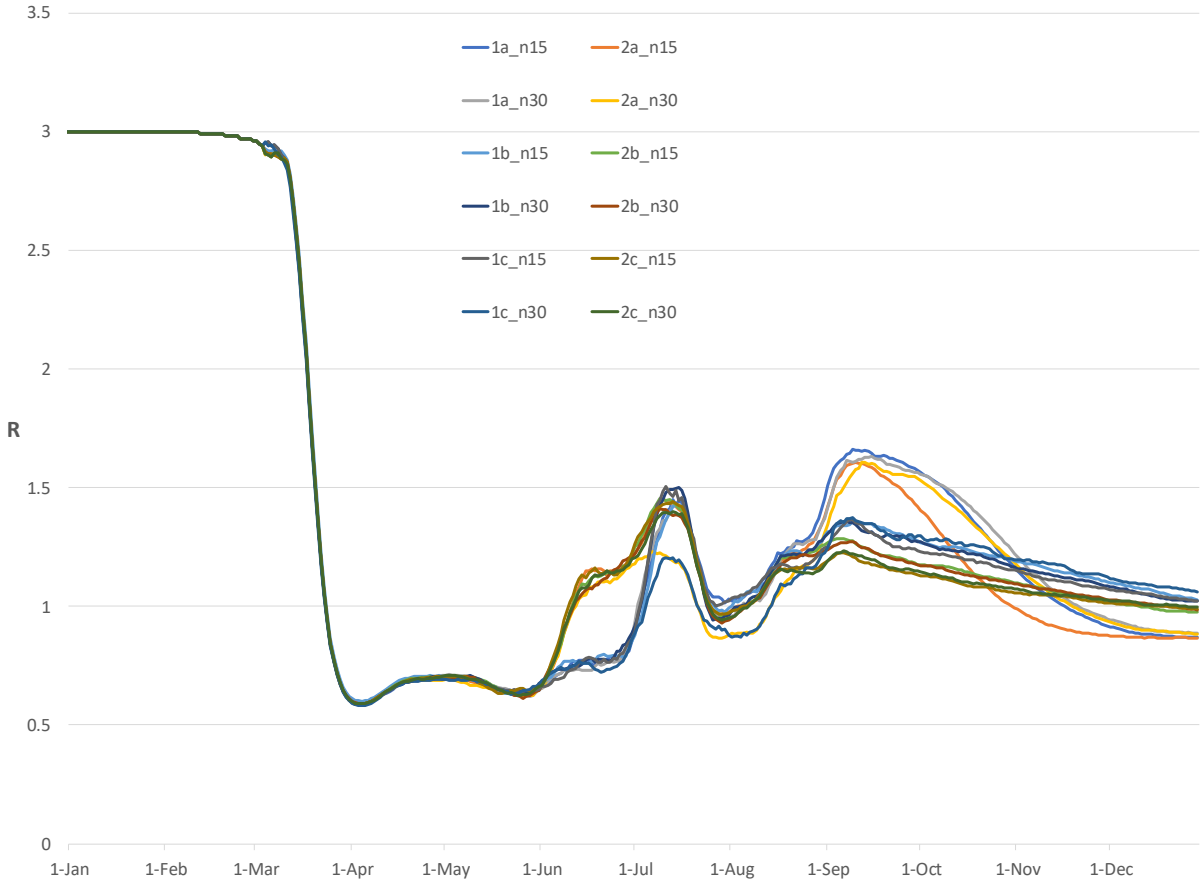

Figure 3: ICU beds occupied, through time for policies examined, default scenario. Notation: 1= scenario 1, 2=scenario 2, a=no reactive school or workplace closure, b=reactive school closure, c=reactive school or workplace closure, n15=contact tracing limited to 15 contacts per case, n30=contact tracing limited to 30 contacts per case.

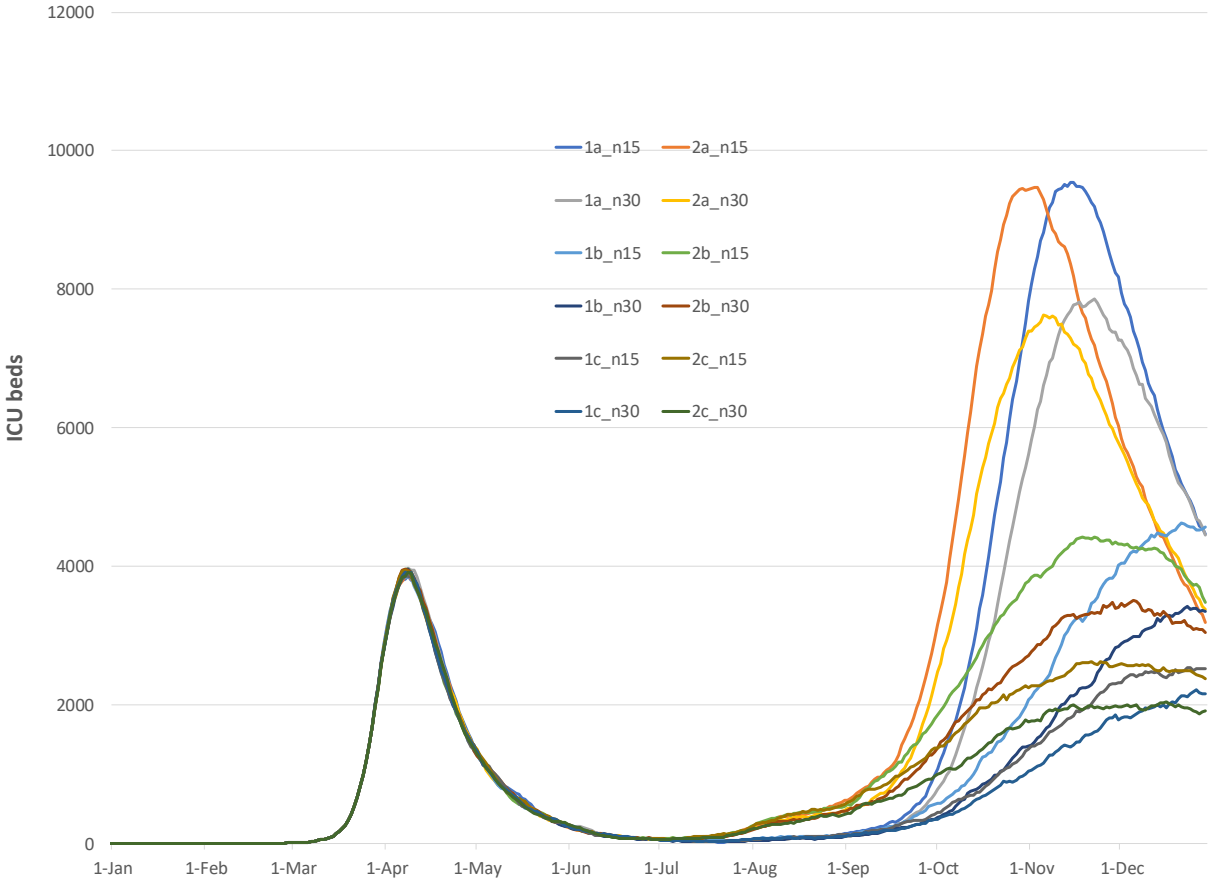

Figure 4: Daily symptomatic cases through time for policies examined, default scenario. Notation: 1= scenario 1, 2=scenario 2, a=no reactive school or workplace closure, b=reactive school closure, c=reactive school or workplace closure, n15=contact tracing limited to 15 contacts per case, n30=contact tracing limited to 30 contacts per case.