Enhanced shielding as an exit strategy from COVID-19 lockdown

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Recommendation

'Enhanced shielding' should be added to the policy options for exiting COVID-19 lockdown.

Rationale

We already identify vulnerable persons and issue specific advice for them to 'shield' from possible COVID-19 infection. This covers both households and institutions containing vulnerable populations, hospitals and care homes in particular.

Policy is to i) save lives; ii) protect NHS physical capacity (especially ICUs) and iii) protect NHs staff (to maintain health services). Enhanced shielding could help meet all these goals.

Proposition: If COVID-19 was circulating *only* in the non-vulnerable population then the NHS could cope with the levels of mild disease, some hospitalisations and occasional critical care. Numbers of deaths would be low.

Therefore, if we could reduce the incidence of infection in the vulnerable group the epidemic could be manageable. The shielding already advised is intended to reduce the incidence; to do more we need 'enhanced shielding'.

Beyond existing shielding, the key additional element of enhanced shielding is very intensive screening of all individuals in contact with vulnerable persons. I.e. members of the same household, carers, community health workers, care home staff, hospital staff etc. We label in these 'vulnerable population contacts' (VPCs).

The protocol for intensive screening of would need to be worked out in detail. A starting suggestion would be daily checks for symptoms, daily PCR tests (would have to be very rapid, i.e. <24 hours), regular serological testing and (perhaps) monitoring of frequent contacts (e.g. household members) of VPCs. [NB. Daily PCR tests are specifically to detect pre-symptomatic infection].

Other protective measures (hygiene, self-isolation of cases, quarantine of households with cases etc.) would still be required.

Illustration

We use a very simple model (Appendix 1) to explore the possible impact of enhanced shielding.

The model generates two epidemic curves: 1) the vulnerable population; 2) the (larger) non-vulnerable population. We ignore (2); the great majority of hospitalisations, ICU admissions and deaths will occur in (1).

The outputs show that enhanced shielding can (in principle) both lower the first peak and avoid a significantly larger second peak, so keeps the epidemic at manageable levels.

We conclude that enhanced shielding should be added to the policy options under consideration.

Caveats

This is a very simple model. The analysis should be repeated with more detailed models.

The actual impact of enhanced shielding will depend crucially on contact patterns (with and without the intervention) between vulnerable and non-vulnerable populations and within the vulnerable population (same household, same care home, same geriatric ward etc). This will need to be explored carefully.

The actual impact of enhanced shielding will depend crucially on the level of reductions in transmission rates achieved, especially from non-vulnerable to vulnerable populations and within the vulnerable population. What is practically achievable will need to be assessed carefully.

The long-term impact of enhanced shielding depends on the extent to which herd immunity builds up in the non-vulnerable population. Here we use an optimistic SIR framework. Under SIRS or SIS assumptions there is no or limited build-up of herd immunity; the benefits to the non-vulnerable population remain, but the shielding of the vulnerable population must be maintained for (much) longer. In other words, the greater the extent to which herd immunity builds up in the non-vulnerable population the greater likelihood that shielding can be reduced, and reduced sooner.

Here, we have not considered enhanced shielding in isolation. Our baseline scenario assumes substantial reductions in R_0 (to 1.5) achieved through measures in place before the current lockdown. In this model that reduction is sustained.

APPENDIX: Model outputs and model details.

Figure 1. Epidemic curves for the vulnerable population only. Enhanced shielding for 24 weeks. Note that for 80% or 100% efficacy the first peak is the highest. The strategy does not work for 40%, 20% or 0% efficacy. Cumulative I_s ranges from 0.58 (0% efficacy) to 0.11 (100%).

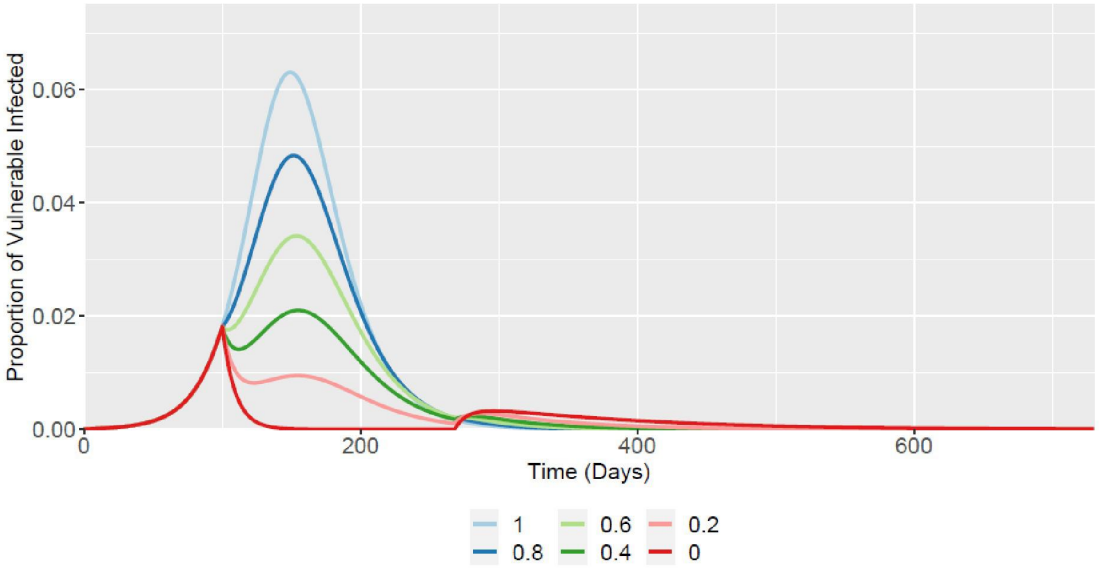


Figure 2. Epidemic curves for the non-vulnerable population only.

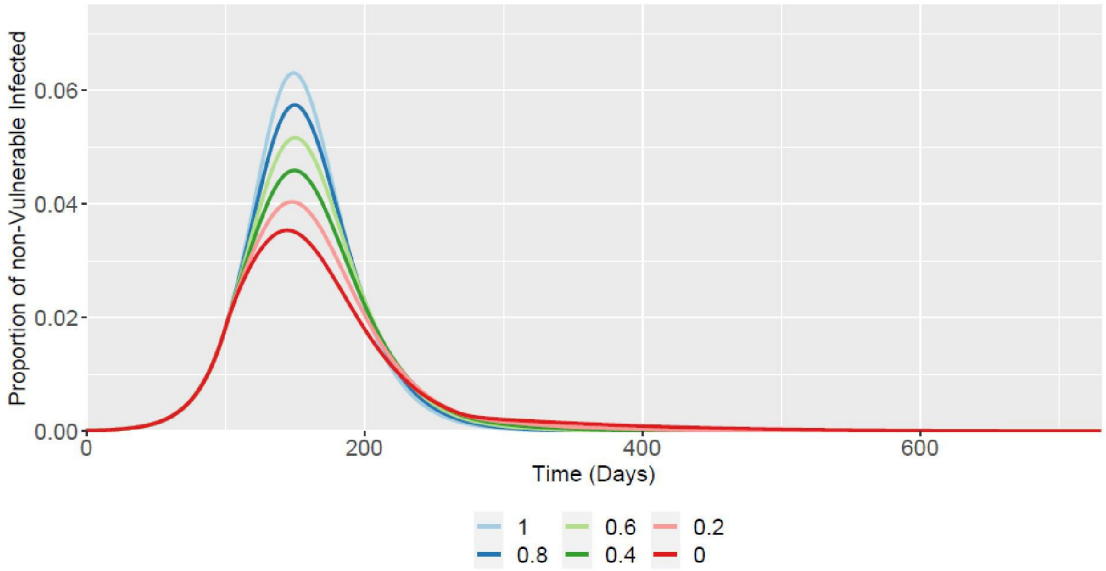


Figure 3. Epidemic curves for the recovered population (assuming SIR). For high efficacy herd immunity is achieved largely through exposure of the non-vulnerable population.

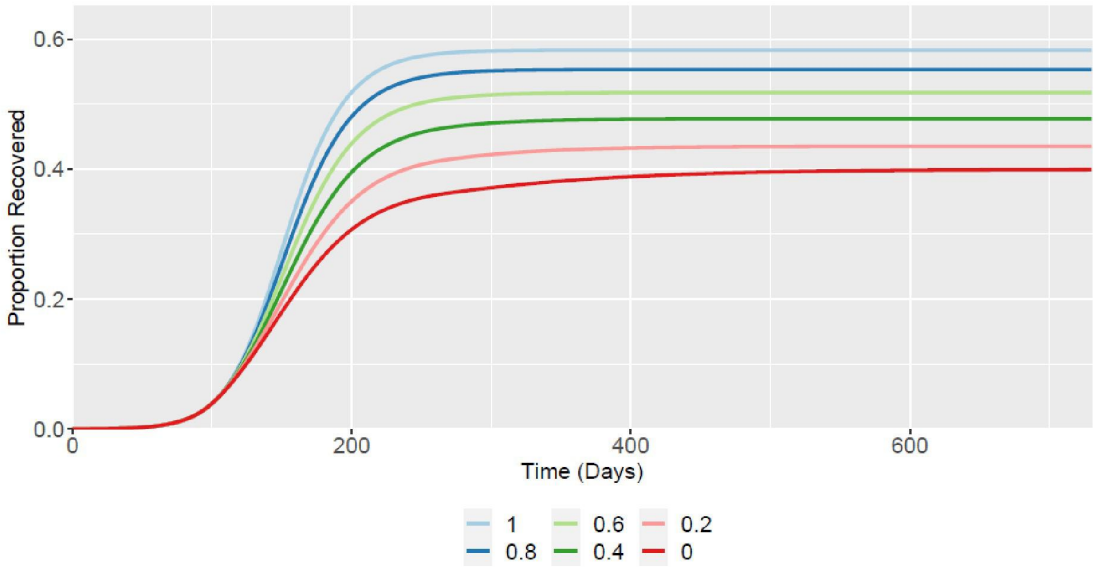
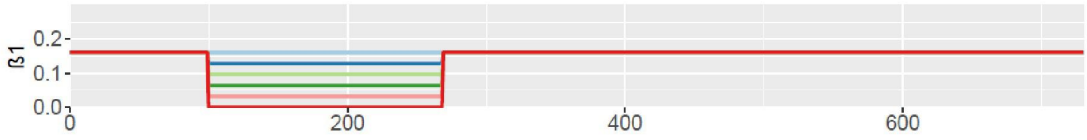
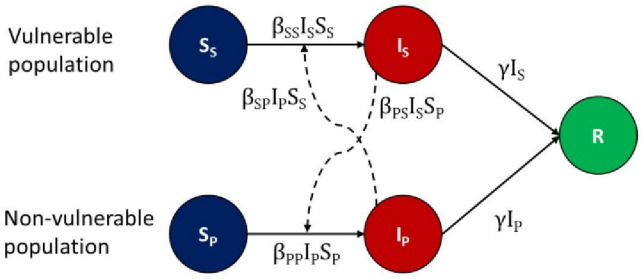


Figure 4. Assumed changes in transmission rates from non-vulnerable to vulnerable and within vulnerable population.



Model structure

SSIIR model with two I compartments: vulnerable (s); non-vulnerable (p).



Baseline R_0 = 1.5; Doubling time = 4.6; γ = 0.108
β_{ss}= β_{sp}=β_1 (baseline) = 0.161; β_1c (intervention)= 0.8*β_1, 0.6*β_1, 0.4*β_1, 0.2*β_1, 0
β_{pp}= β_{ps}=β_2 (throughout) = 0.161
Intervention point: $I(t)$ = 0.0182
Fraction vulnerable = 0.15
Intervention length = 24 weeks

Implementation

$$\frac{dS_S}{dt} = -\beta_{SS} I_S S_S - \beta_{SP} I_P S_S$$

$$\frac{dS_P}{dt} = -\beta_{PP} I_P S_P - \beta_{PS} I_S S_P$$

$$\frac{dI_S}{dt} = \beta_{SS} I_S S_S + \beta_{SP} I_P S_S - \gamma I_S$$

$$\frac{dI_P}{dt} = \beta_{PP} I_P S_P + \beta_{PS} I_S S_P - \gamma I_P$$

$$\frac{dR}{dt} = \gamma I_S + \gamma I_P$$

Model implemented in R and C++ independently.
Code available at https://github.com/bvbunnik/COVID-19

Sensitivity analyses

i) Higher baseline R_0 = 2.4
Requires higher shielding efficacy (close to 100%) to achieve similar outcome (as peak I_s value).

ii) Shorter intervention = 12 weeks
Generates a second wave, but this is similar to the first wave for 60% shielding efficacy or more.

iii) No impact on β_{ss} so $\beta_{ss} = \beta_1$ (throughout)
This generates a slightly worse outcome (higher peak I_s value) for intermediate reductions in β_{sp}.

iv) Different intervention points (equivalent to ±25 days start time)
Timing is important. For very effective interventions (>=80%) if the intervention point is 25 days earlier or later then the cumulative I_s is higher. However, peak I_s is lower for an earlier intervention point. [In practice, the position of the intervention point on the epidemic curve is uncertain].

v) SIS or SIRS not SIR
This makes a very substantial difference. In the SIS case there is no build-up of herd immunity and, in the simplest scenario, enhanced shielding must be maintained indefinitely.