Critical weaknesses in shielding strategies for COVID-19

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Pre-print PDF on arXiv

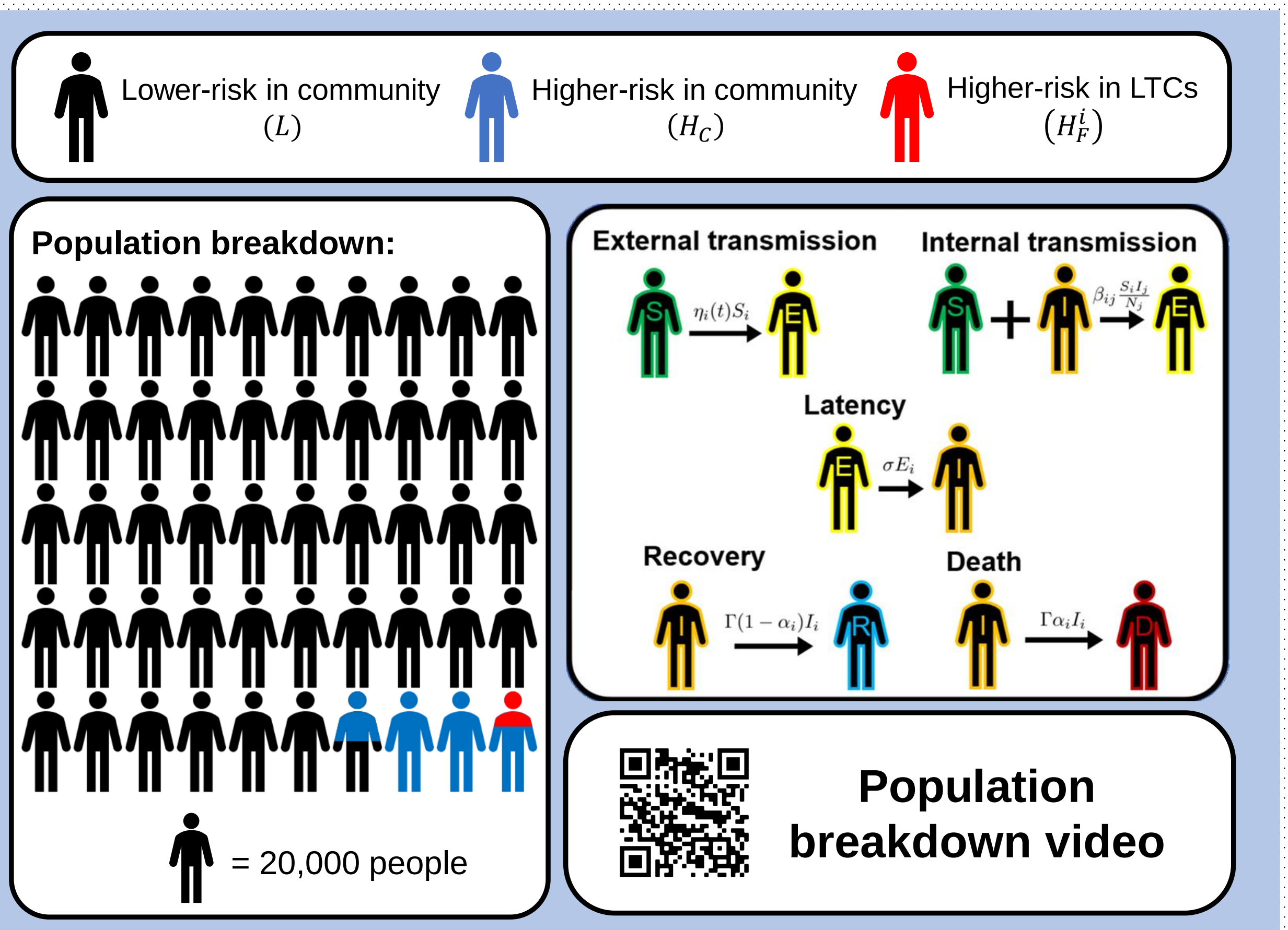
Motivation

Shielding strategies[1-3] – protecting the elderly and infirm to leverage the uneven risk profile for COVID-19 – have been suggested as alternatives to damaging lockdowns and other non-pharmaceutical interventions (NPIs) throughout the pandemic.

We aim to establish the viability of such strategies, whether there are **consequences** to ending shielding, and to understand the effects of behaviours such as **voluntary reductions in contacts** or **external infections** entering the population.

We use a **stochastic SEIR** model on a location- and risk-stratified population

Population and interactions



Population breakdown video

Shielding matrix

q_{ij} - Effectiveness of shielding between type i and j contacts. 0 is no contact, 1 is all usual contacts.

Characterised by six values:

q_1 - $(L \leftrightarrow L)$; q_2 - $(H_C \leftrightarrow H_C)$; q_3 - $(H_F \leftrightarrow H_F)$;

q_4 - $(L \leftrightarrow H_C)$; q_5 - $(L \leftrightarrow H_F)$; q_6 - $(H_C \leftrightarrow H_F)$;

No shielding:

$$q_k = 1, \text{ for every } k.$$

Perfect shielding:

$$q_1 = 1, q_k = 0 \text{ for } k \neq 1$$

Imperfect shielding:

$$q_1 = 1, q_6 = 0, q_k = 0.2 \text{ for } k \neq 1{,}6.$$

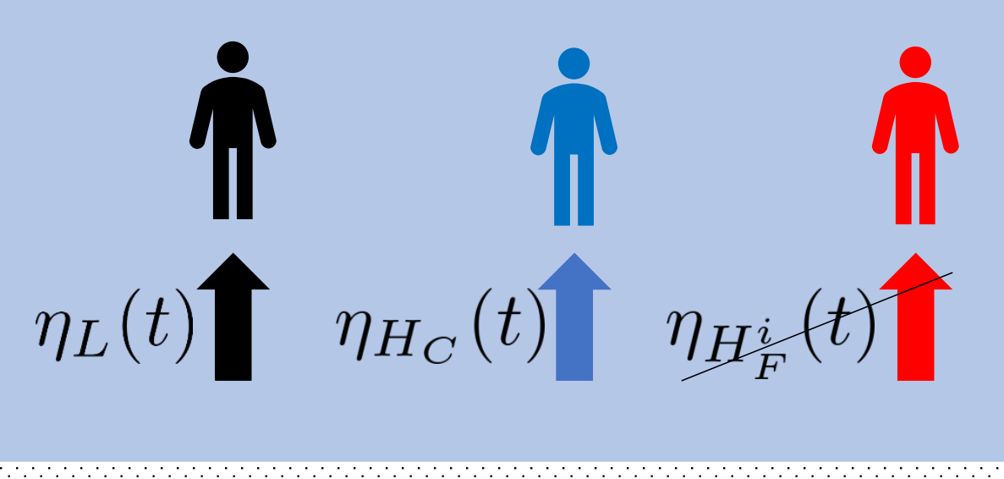
External infections

$\eta_i(t)$ - External infection rate:

Can only affect the **community**.

No external infection while shielding.

Constant rate while shielding interventions are not in force



Transmission

β_{ij} - The transmission rate for a person of type j to type i:

$$\beta_{ij} = \beta_0\, r\, p_{ij}\, q_{ij}$$

Transmission rate per contact

Average number of contacts

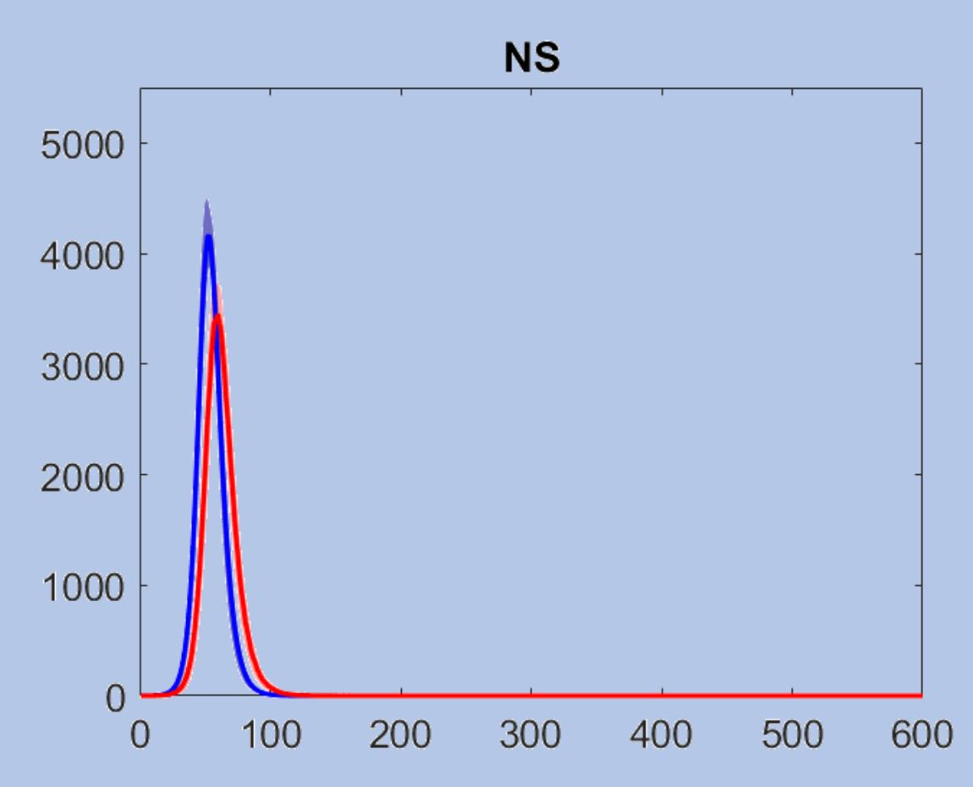
Proportion of a type i's contacts which are with a type j individual.

Within LTC: $p_{ij} = \lambda \approx 1$.
No inter-LTC mixing.
Other values proportional to proportion of remaining population.

Shielding matrix

Results

Baseline case

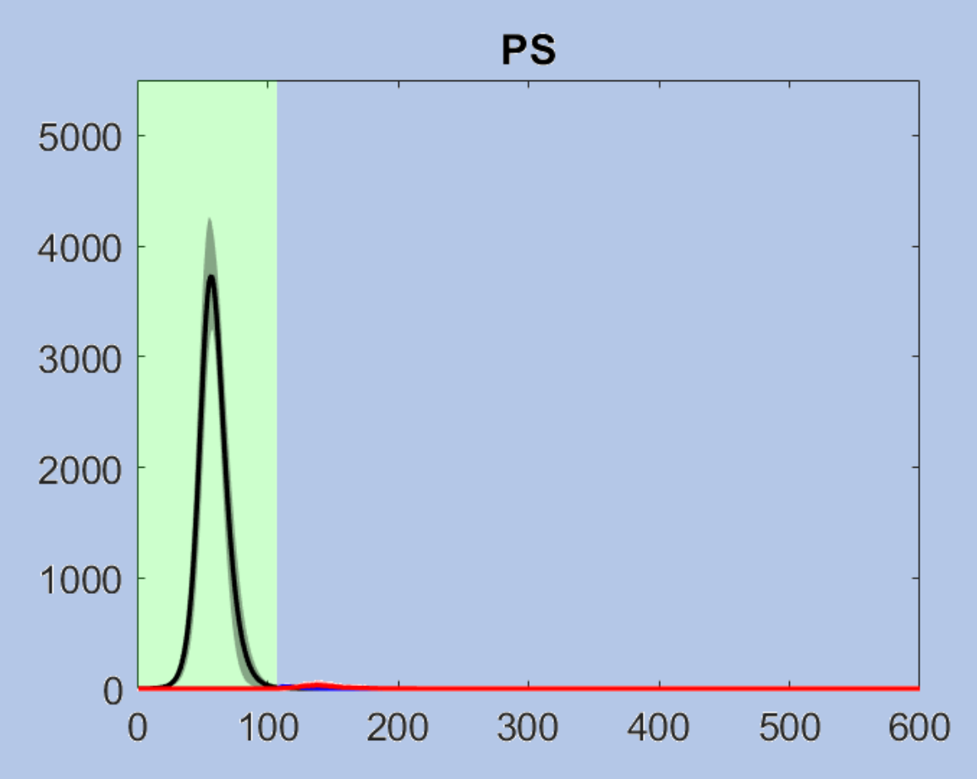


Deaths per 100,000			
L	H_C	H_F	All
93.7	4702.1	4532.6	415.1

Perfect shielding

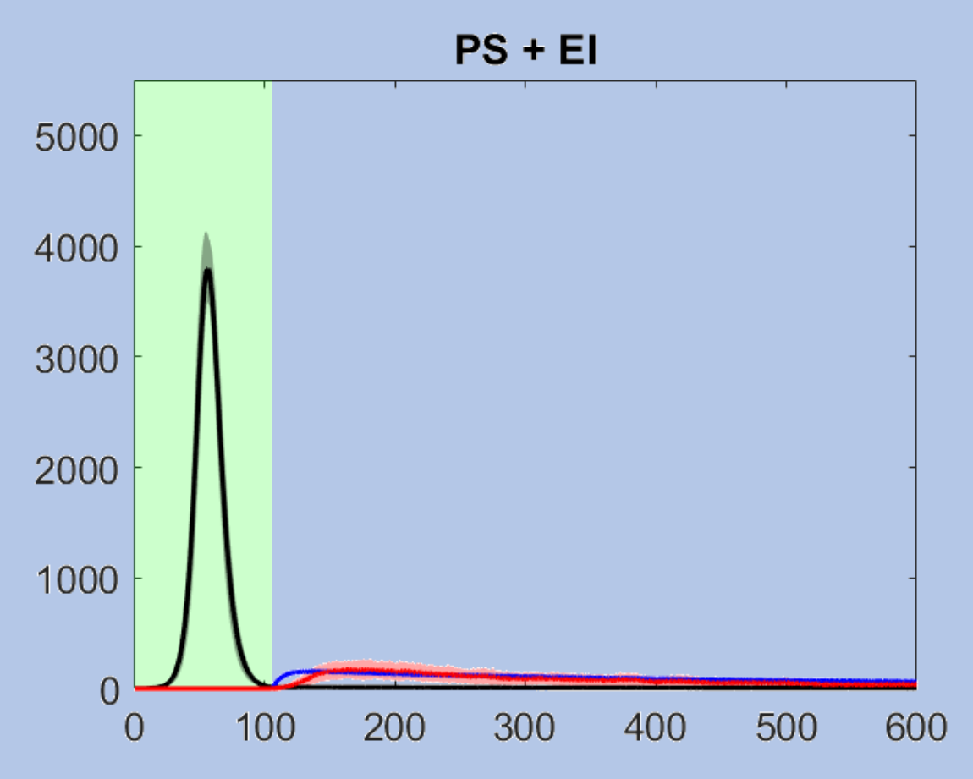
Imperfect shielding

Add reduced contact: q_1=0.5

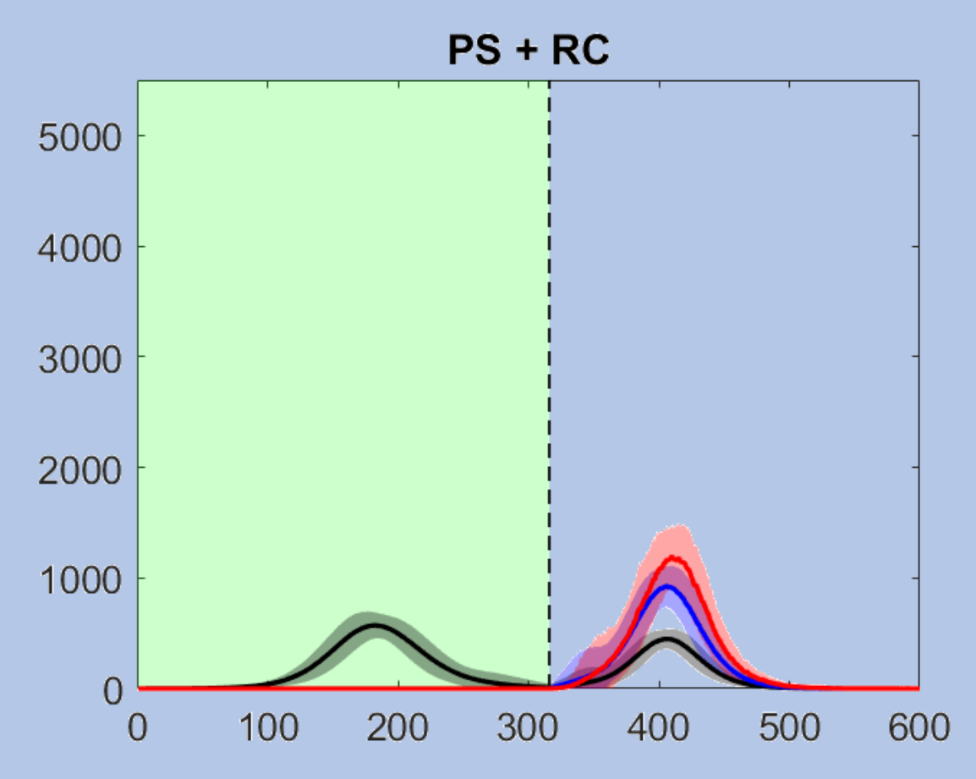


Deaths per 100,000			
L	H_C	H_F	All
92.5	18.6	54.3	87.6
92.4	2090.9	613.6	221.7

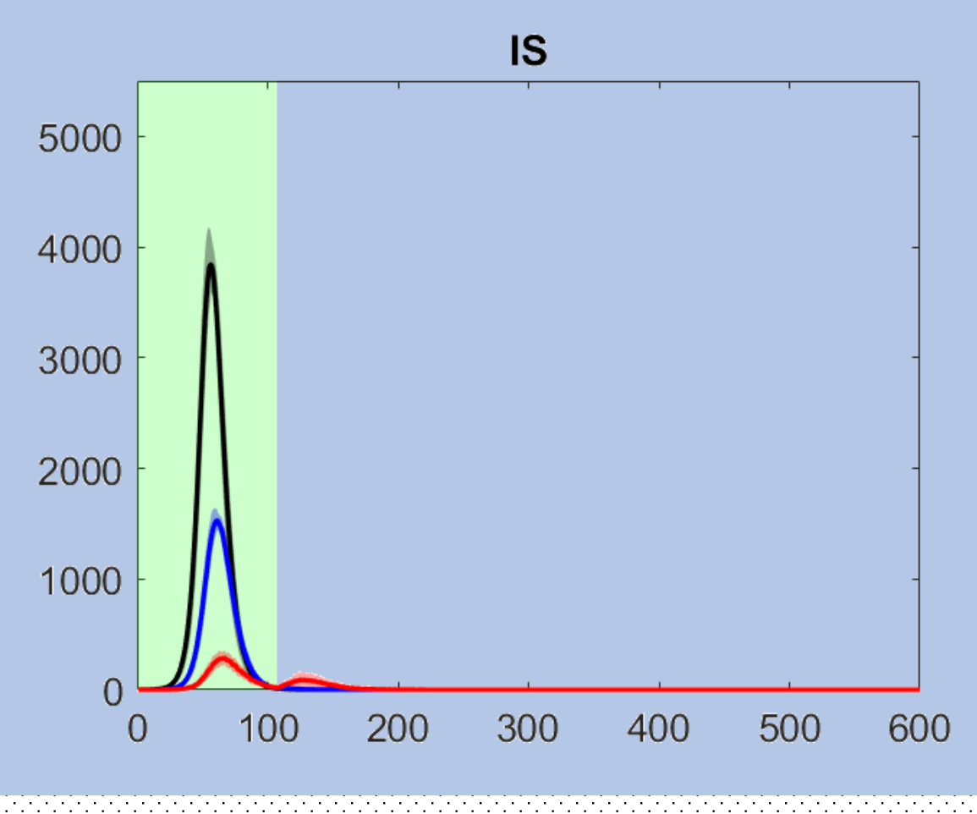
Add external infection

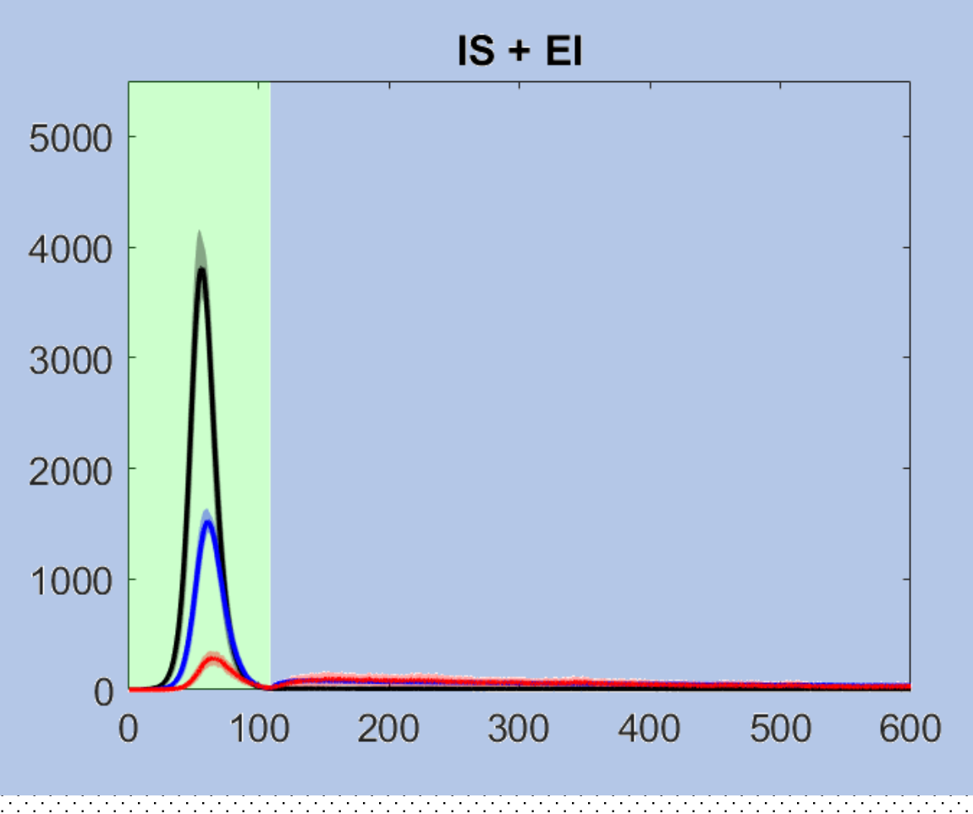


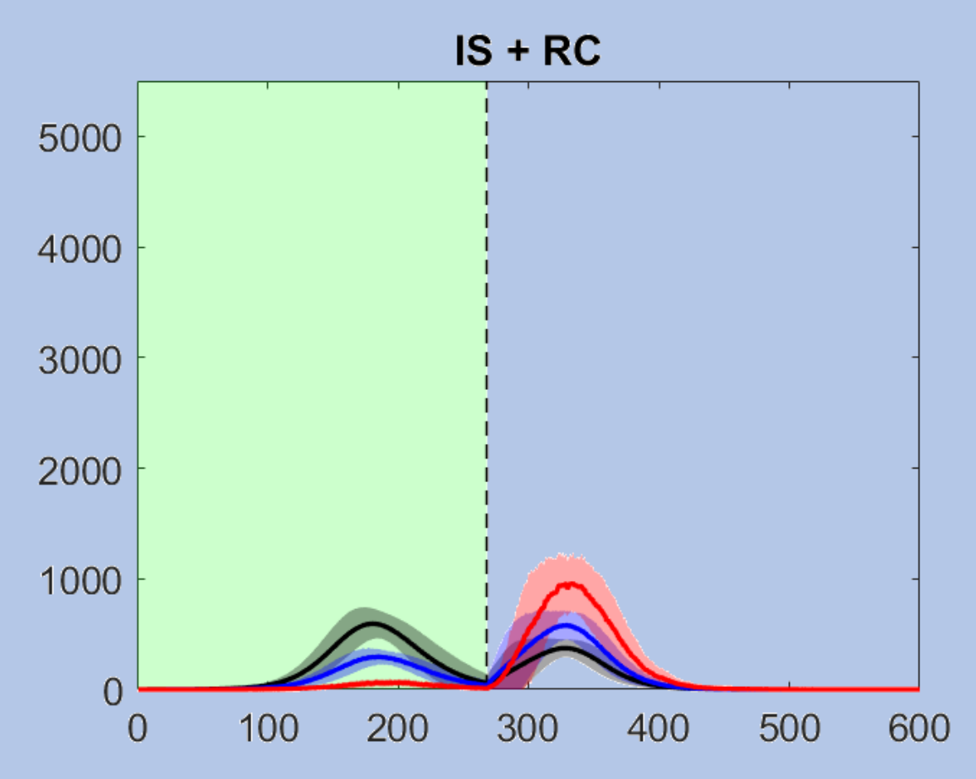
Deaths per 100,000			
L	H_C	H_F	All
96.3	2487.2	2023.9	260.3
96.3	3450.5	1868.5	319.7



Deaths per 100,000			
L	H_C	H_F	All
81.2	3114.4	3944.2	299.5
80.3	3491.5	3783.7	321.2







References

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Conclusions

Perfect shielding is effective at protecting those at higher-risk, **but is unrealistic** – requires those at risk to have no contact with any others.

Making the shielding 80% effective (**imperfect shielding**) causes **large increases in deaths** in the higher-risk subpopulations.

External infections again cause **higher death numbers**, this caused by **uneven protection of herd immunity**.

The lower-risk population **reducing their contact** also causes **significant outbreaks** as the **herd immunity threshold is not reached**.

Parameters

Name	Value	Ref.
Population size, N	10^6	
Prop. high-risk, h	0.07	
Prop high-risk in community, c	0.897	
Transmission rate, $\beta_0 r$	1.5* (day^{-1})	
Latency period, $1/\sigma$	5 (day)	[4]
Recovery period, $1/\Gamma$	2 (day)	[4]
Prob. death, low-risk, α_L	0.001	[5,6]
Prob. Death, high-risk, $\alpha_{H.}$	0.05	[5,6]
External infection, $\eta_.(t)$	10^{-3}	
Prop. Within-LTC contacts, λ	0.9	

*Chosen so that $R_0 = 3$[7].

Natural Environment Research Council

This work was supported by NERC grants NE/V003909/1 (CAS, BA) and NE/N014979/1 (BA)

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