Effect of reducing isolation/quarantine period and potential trade-offs with the probability of case self-report and isolation/quarantine uptake

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Key Points

We use two branching process models of infection and contact tracing and isolation/quarantine* to investigate the effects of shortening isolation/quarantine periods on Test Trace Isolate (TTI) effectiveness.

We found that **reducing the period of quarantine from 14 to 7 days reduced the effectiveness of TTI** in reducing growth rates (household branching process model) and the probability of a large epidemic (individual branching process model).

This **reduction in effectiveness would be compensated for if adherence to self-report and/or adherence to taking up isolation was improved**.

Individual Model (effects on probability of a large outbreak):

- If changing from 14 days to 7 days increases both self report probability (symptomatic cases recognise symptoms and attempt to book a test) and self isolation probability from 20% to 30%, the risk of a large outbreak decreases. (Fig 1)
- The trade-off remains beneficial even if reducing to 7 days prompts people to isolate for between 4 and 7 days instead of between 7 and 14 days. (Fig 2)

Household structured model (effects on epidemic growth rates):
A change from 14 to 7 day quarantine would be offset by an increase of the probability of:

- The case's household taking up isolation/quarantine of 12-14% or more, keeping self-reported probability constant. (Tab 1 and Fig 3)
- An increase in untraced cases self-reporting symptoms and booking a test by 5% or more, keeping the probability of self-reporting constant. (Tab 1 and Fig 3)

**Note: here we use 'isolation' to refer to cases and 'quarantine' to refer contacts (within and outside households). Isolation in the UK is currently 10 days and quarantine is 14 days. The household model differentiates between these periods and varies only quarantine; the individual model does not distinguish.*

Caveats

There is no evidence we are aware of as to whether or by what proportion shortening the duration of isolation would improve uptake of either self-report of symptoms for testing or uptake of isolation or both. This has simply been hypothesised as a reason to reduce the period.

Here, adherence to isolation is modelled as binary uptake/no uptake rather than as waning or as a % effectiveness (reduction in contacts). In the household model, the probability of isolation/quarantine take-up is applied at the household level.

Results

Individual branching process model

We can consider 20% self report probability, 20% self isolation probability and 14 day isolation period as a baseline (red line, dashed line, Fig 1). Switching to 7 days isolation (red, solid line) increases the risk of a large outbreak. However, if switching to 7 days isolation increases of 10% to self report probability (blue line) or self isolation probability (green line) the risk of a large outbreak is unchanged. If switching to 7 days isolation increases both report probability and self isolation probability (purple line) the risk of a large outbreak is reduced.

Figure 1: Risk of a large outbreak (>1500 cases) by 7 versus 14 day self-isolation/quarantine

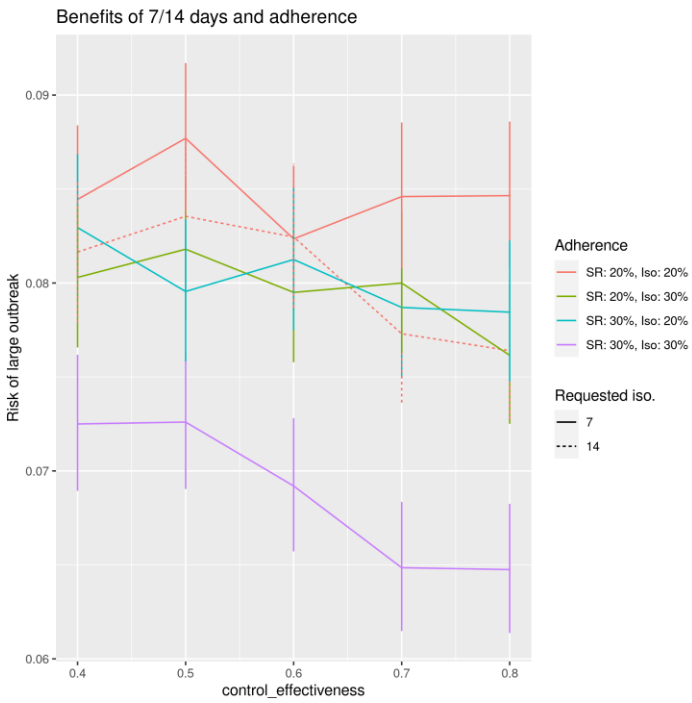
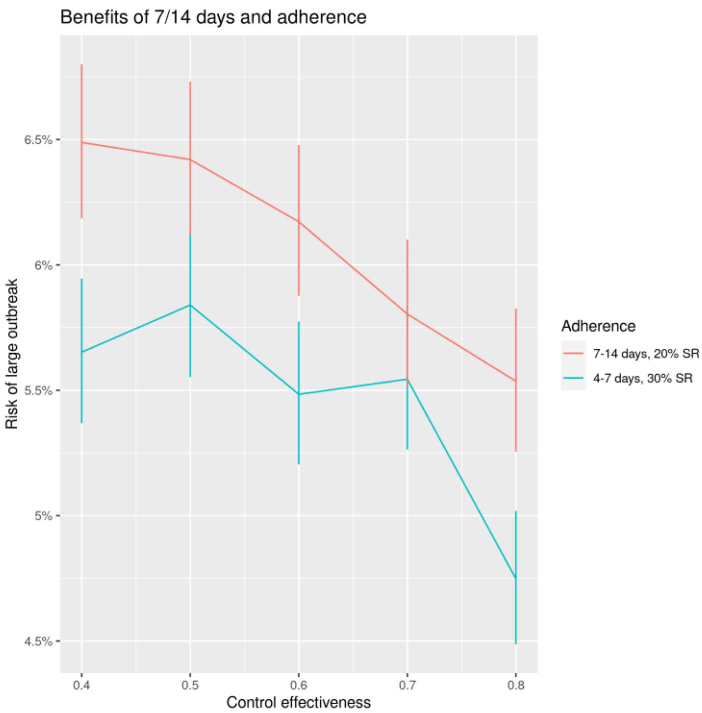


Figure 2: Risk of a large outbreak by control effectiveness for 7-14 versus 4-7 days range of isolation/quarantine.



Results from the individual branching process model. SR – self-report of cases, Iso. = isolation of cases/quarantine of contacts. Control effectiveness is the proportion of infected contacts who are successfully traced.

One risk of reducing the required isolation length to 7 days is that people then isolate for even less than 7 days. We compared a) 20% self report probability, 30% of people do not isolate at all and everyone else is uniform between 7 days and 14 days. (i.e. the rules say 14 but people do not manage the full 14) to b) 30% self report probability, 30% do not isolate at all and everyone else is uniform between 4 days and 7 days (i.e. the rules say 7 days so now some people only do 4, but the shorter period raises self report rates by 10%). Figure 2 shows that the increased self-report rate offsets the reduced self-isolation duration.

Household branching process model

The household model comes to broadly similar conclusions as the individual branching process model.

There is a reduction in the effectiveness of TTI on growth rates when the duration of quarantine reduces from 14 to 10 to 7 days, though when self-report of infection and probability of isolation uptake is very low the effects are less distinguished (Fig 3, overleaf).

Results from a linear regression analysis of parameter effects on growth rates (Table 1) indicate that a drop in effectiveness from a 14 versus 7 days quarantine could be compensated for if a greater than 5% improvement in infection reporting probability was achieved, or 12-14% improvement in the probability that households take up and fully adhere to the isolation/quarantine.

Table 1: Effects of quarantine duration*, self-reporting of infection among symptomatic cases and the proportion of households taking up isolation/quarantine on growth rates

Parameter	Coefficient	95% CI
Intercept	0.0274	0.0270, 0.0278
Ref. 7 days quarantine		
10 days	-0.0011	-0.0014, -0.0007
14 days	-0.0019	-0.0021, -0.0016
Infection reporting probability	-0.0376	-0.0384, -0.0368
Probability that household will take up infection/quarantine	-0.0149	-0.0157, -0.0142

Results from linear regression. Quarantine only was varied here, self-isolation fixed at 10 days. The proportion of outside household contacts reduced by 70% compared to POLYMOD. Household secondary attack rate of 25%. 9000 simulations with isolation uptake of 0.1, 0.2, 0.3, 0.4, 0.5, infection reporting probability of 0.1, 0.2, 0.3, 0.4, 0.5.

Methods

We use two branching process models of infection and contact tracing and isolation. One is population based (no household structure) and gives as outcomes a probability of preventing large outbreak. Details are reported in Lucas et al. (2020) along with parameter values [1]. The other includes household structure and gives results as growth rates (described in more detail [2]).

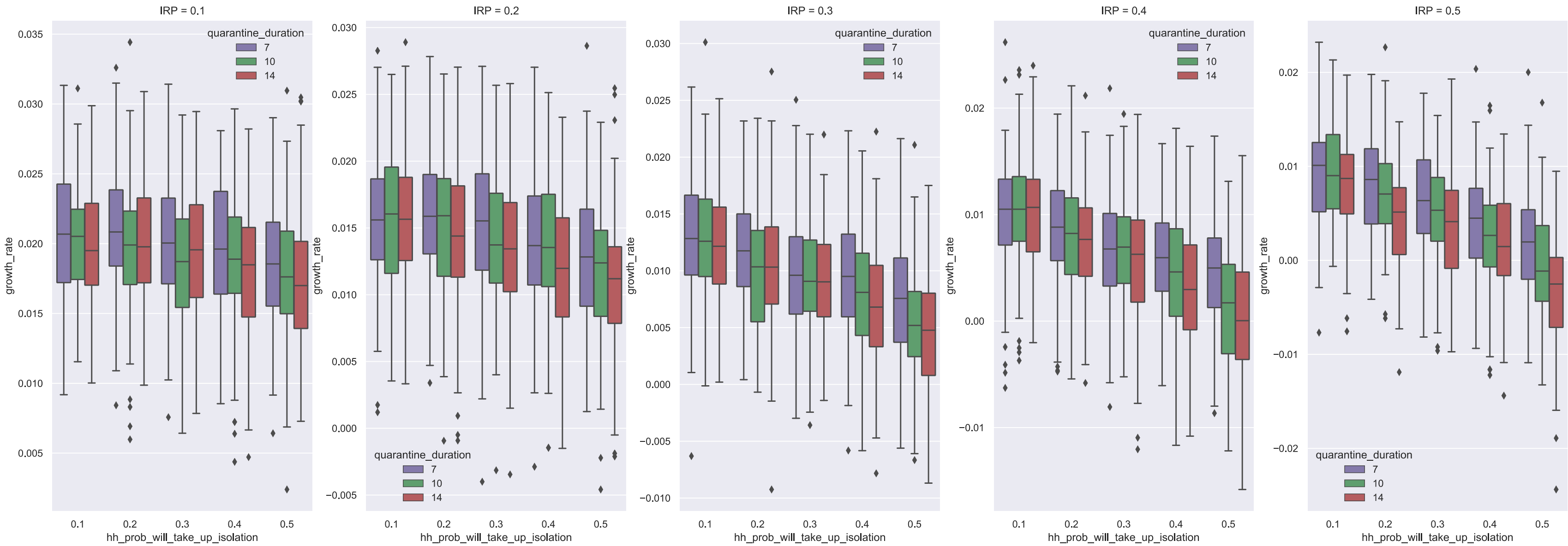
The individual model was parameterised as in Davis et al. (2020)[1] and the household model as Table 2.

The household model included a 70% reduction compared to Polymod outside-of-household contacts (we have previously found in this model no evidence that TTI effectiveness varies by % outside-household-contact reduction [2]).

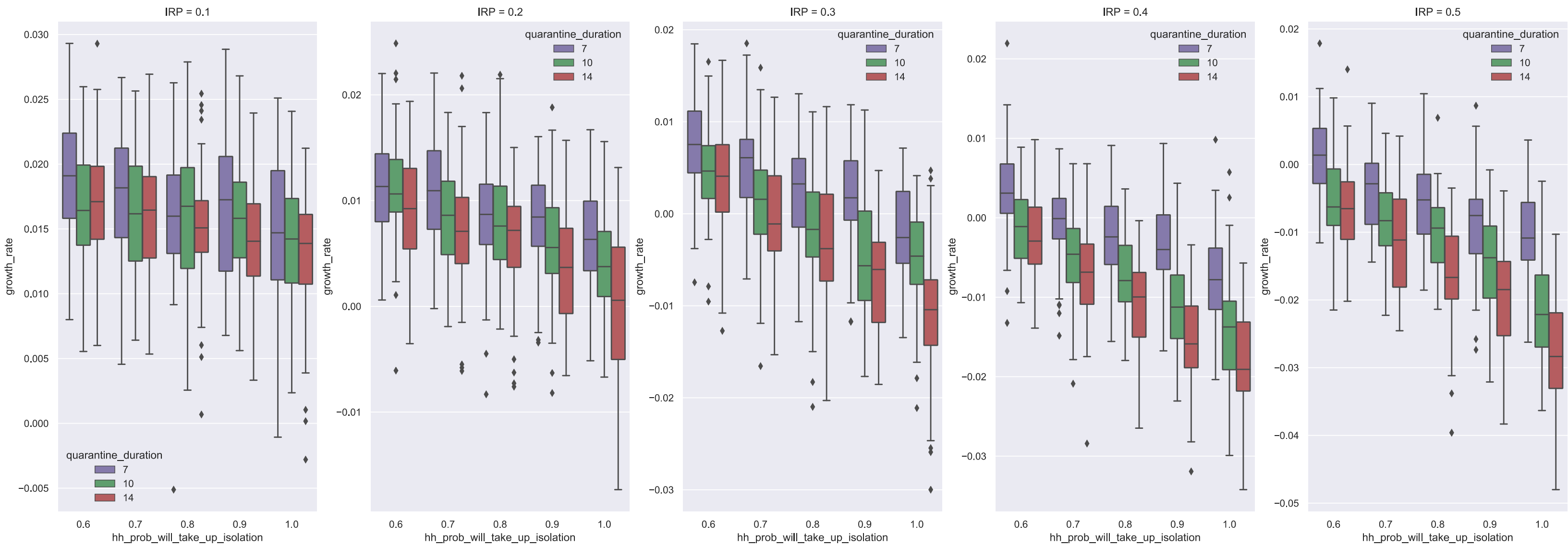
Estimates of self-reporting probability amongst symptomatic cases (reporting to book a test) and the proportion of individuals self-isolating are informed by the CORSAIR study [3] which found a test request of 11.9% (95% CI 10.1 – 13.8%) amongst those reporting symptoms and isolation adherence of 18.2% (16.4-19.9%). However, these estimates reflect the proportion of individuals leaving the house under isolation/quarantine for a variety of reasons; they likely do not reflect complete non-adherence over the whole period, so we examined a range of isolation uptake proportions.

Figure 3: Growth rates of an epidemic for 7, 10 and 14 days quarantine by infection reporting probability and the probability that households take up isolation/quarantine

a. For probabilities that households will take up isolation quarantine of 0.1, 0.2, 0.3, 0.4, 0.5



b. For probabilities that households will take up isolation quarantine of 0.6, 0.7, 0.8, 0.9, 1



Boxplots show Parameters as described for Table 2 and shown in Table 3. IRP = probability that an untraced case will report syptoms and book a test.

Table 2: Household model parameter values, where unspecified:

Parameter	**Values**
Growth Rate (pre-interventions or contact reductions)	0.22 per day (doubling time around 3 days)
Incubation period	Gamma (shape=3.019, scale=1.6 days)
Generation time	Weibull (mean=5, var=1.9^2 days)
Household Size Distribution	(1: 0.29, 2: 0.35, 3: 0.15, 4: 0.14, 5: 0.05, 6: 0.02)
Household secondary attack rate	25%
Overdispersion of secondary cases distribution	0.32
Proportion asymptomatic	0.2
Relative infectivity of asymptomatics	0.35
Number of social contacts per day	Household size, Polymod (within and outside household proportions)
Reduction in global contacts per day due to social distancing	70%
Onset to isolation and test booking	Gamma(mean = 2.62, sd = 2.38)
Testing delay (test to result and tracing)	Specimen to report delay, Exponential distribution, mean 1.5 days
Tracing delay	Exponential distribution mean 1.5 days
Probability of successfully tracing a contact	70%

References

[1] Lucas, Davis, et al. (2020). *Engagement and adherence trade-offs for SARS-CoV-2 contact tracing.* Phil. Trans. *B (in press).* Preprint

Individual model report and code: https://zenodo.org/record/4266056#.X6pZ3q6nyog

[2] Using a household structured branching process to analyse contact tracing in the SARS-CoV-2 pandemic. Fyles M, Fearon E et al 2020. Submitted to RS Phil Trans B. 2020. (Considered at SPI-M June 3, 2020).

[3] West LE et al. Adherence to the test, trace and isolate system: results from a time series of 21 nationally representative surveys in the UK (the COVID-19 Rapid Survey of Adherence to Interventions and Responses [CORSAIR] study). https://www.medrxiv.org/content/10.1101/2020.09.15.20191957v1