Circuit Breakers Ready Reckoners
Implementing (partial) Lockdown for 2 weeks over Half-Term

University of Warwick COVID modelling team.

20th September 2020

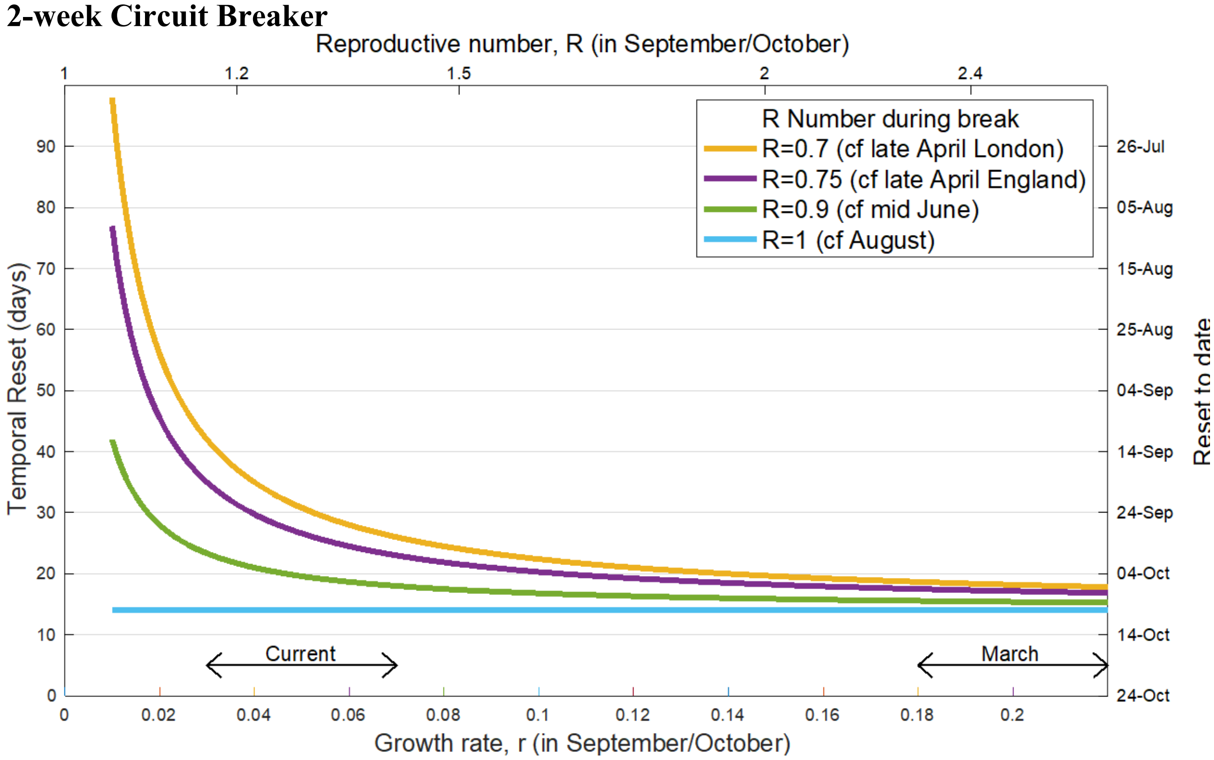
Here we consider the impact of a 2-week "circuit breaker" generally timed to align with school half terms (assumed to be 25th October), although other timings are considered.

ANALYTICAL CALCULATIONS

We use a simple analytical model to characterise the range of likely behaviours. Comparative figures from the full age-structured model are given below.

We assume that infection will continue to grow exponentially until the half term circuit breaker; during the break infection will decline and following the break the original growth will resume. The decline effectively takes us back to a time with fewer cases – here we calculate the size of this 'Temporal Reset' and the corresponding date.

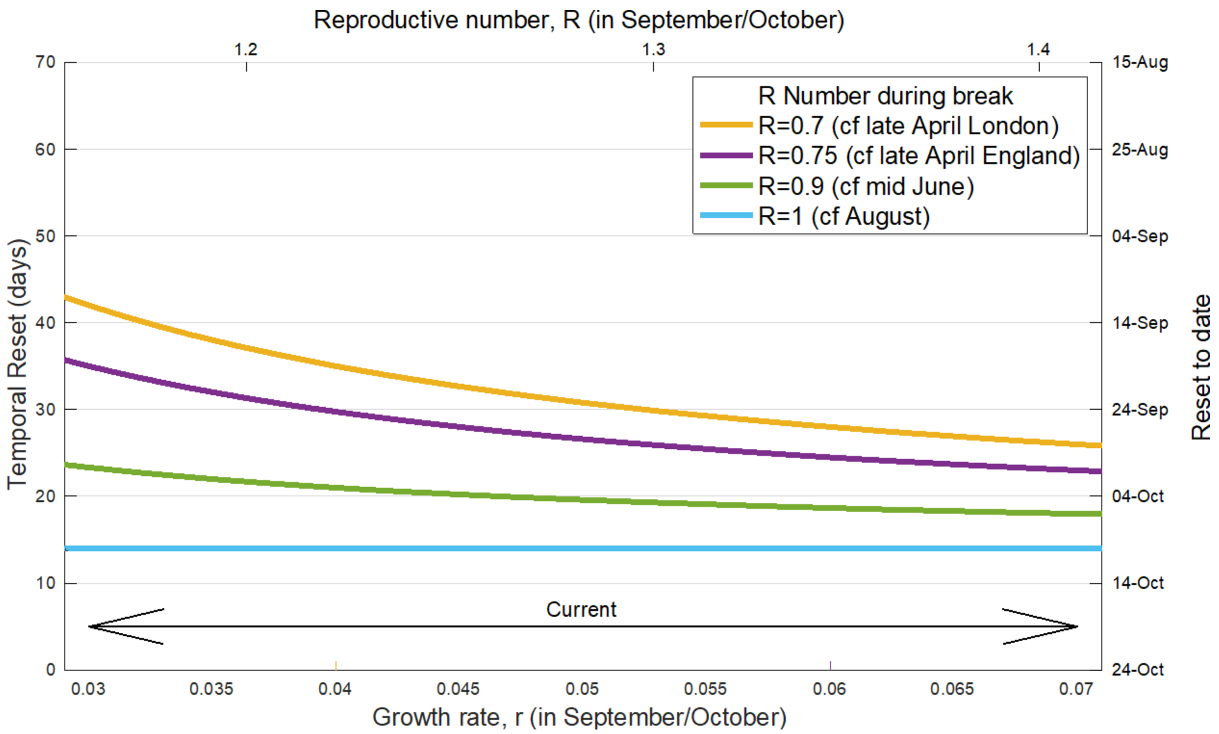
2-week Circuit Breaker



The top and bottom axes show the reproductive number (*R)* and the growth rate (*r*) respectively, between now and half term; the current estimated growth rate and the growth rate in March are shown for illustration. The right and left-hand axes show the size of the temporal reset and the corresponding date.

The four lines are different levels of non-pharmaceutical interventions during the 2-week Circuit Breaker, ranging from very strong controls leading to a reproductive number of around 0.7 (comparable to what was measured in London during the height of the April lock-down) to much weaker controls *R*~1 (comparable to the situation in August).

The greatest benefit occurs if we can keep *R* low during the next month, and then have a reasonable intensive break.



Focusing on the current estimated growth rate ($r \sim 0.03$ to 0.07), we see that the best we are likely to achieve is a 5-6 week reset (gold line), but it could be as little as 2 weeks (blue line) if there is not strong adherence to restrictions within the two-week circuit breaker.

Simple predictions:

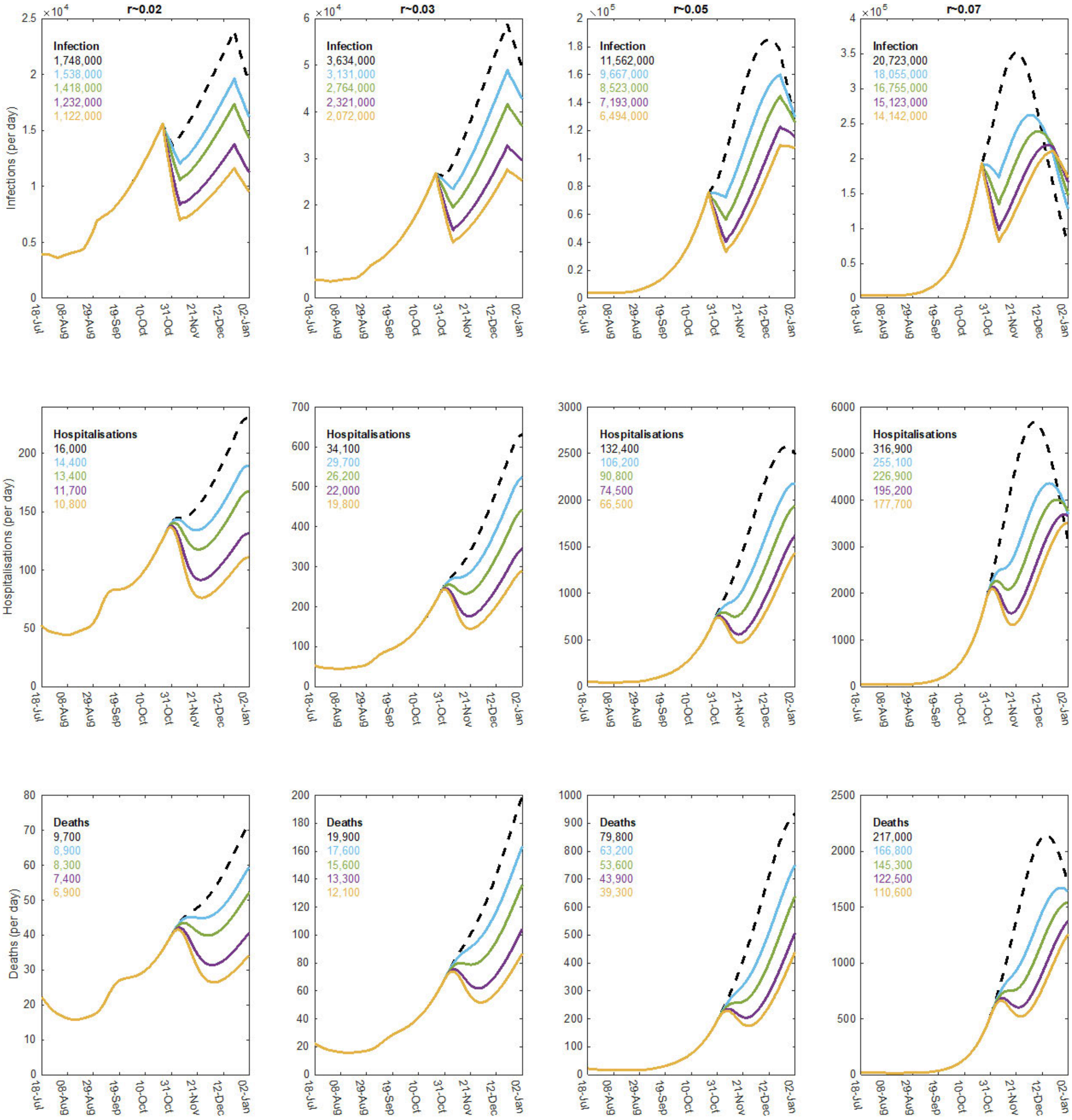
- A greater temporal reset is gained by a lower r before the circuit breaker, a lower R during the circuit breaker (faster rate of decline) and a longer duration break.
- The circuit breaker generates a proportional reduction in cases, and therefore the subsequent numbers of daily cases, hospitalisations and deaths will be similarly reduced.
- The scale of the reduction in cases is not influenced by the timing of the circuit breaker.
- Earlier circuit breakers however lead to a lower total number of cases, hospitalisations and deaths over short time-scales (eg between now and the end of the year) as the reduction occurs earlier and therefore acts over a longer period.

AGE STRUCTURED MODEL

While these simple analytical calculations are highly informative and provide some basic intuition, they cannot hope to capture the true non-linearities and complexities of the disease transmission process. We therefore turn to a more realistic framework to generate an assessment of the likely impact of a circuit breaker on quantities of public-health concern.

The SEIR-type age-structured model that has been developed by Warwick since the start of the outbreak, and has been fitted to a variety of UK data sources, is used to replicate the above findings. The growth-rate (r) of the outbreak from early September is fine-tuned to be one of four values ($r\sim0.02, r\sim0.03, r\sim0.05$ and $r\sim0.07$), noting that a 5% growth ($r\sim0.05$) is the mean of the latest SPI-M analysis. For each of these four growth rates (columns in figures below) we calculate the number of daily infected individuals, hospitalisations and deaths in England for the four different circuit-breaker assumptions used above. We also show the impact of no circuit breaker (dashed black line), which still includes half-term and Christmas holidays for school children. Each graph also gives the total number of infections, hospitalisations and deaths between now and the end of the year, as numerical values in the top left.

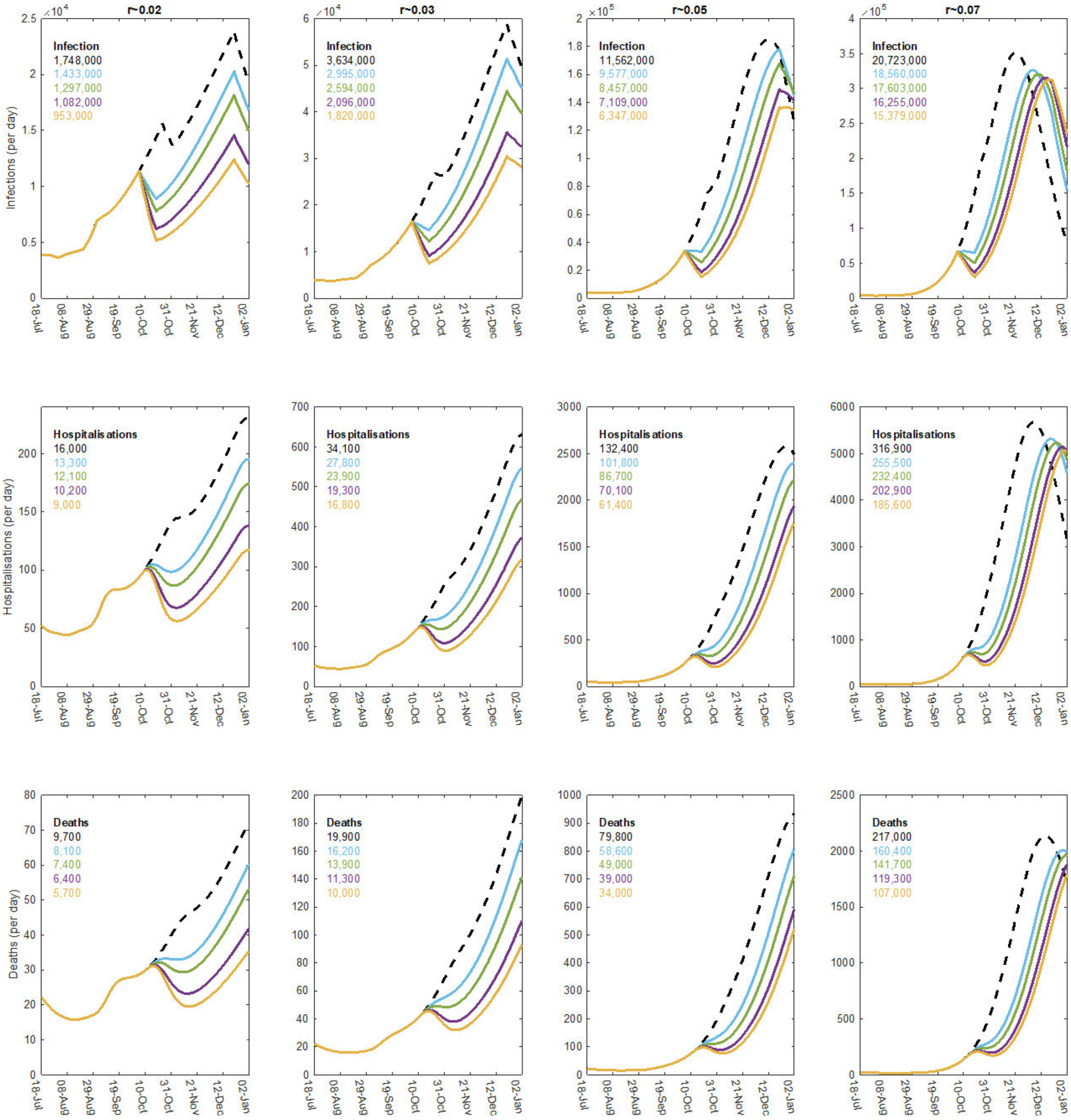
2-week circuit-breaker over half-term 25th Oct – 8th Nov.



If the growth rate r remains large (r~0.07 or R~1.4, right-hand column) then even severe social distancing during the 2-week circuit breaker will not prevent a major loss of life. Combining a low background growth rate with a strong circuit breaker would seem the most viable option.

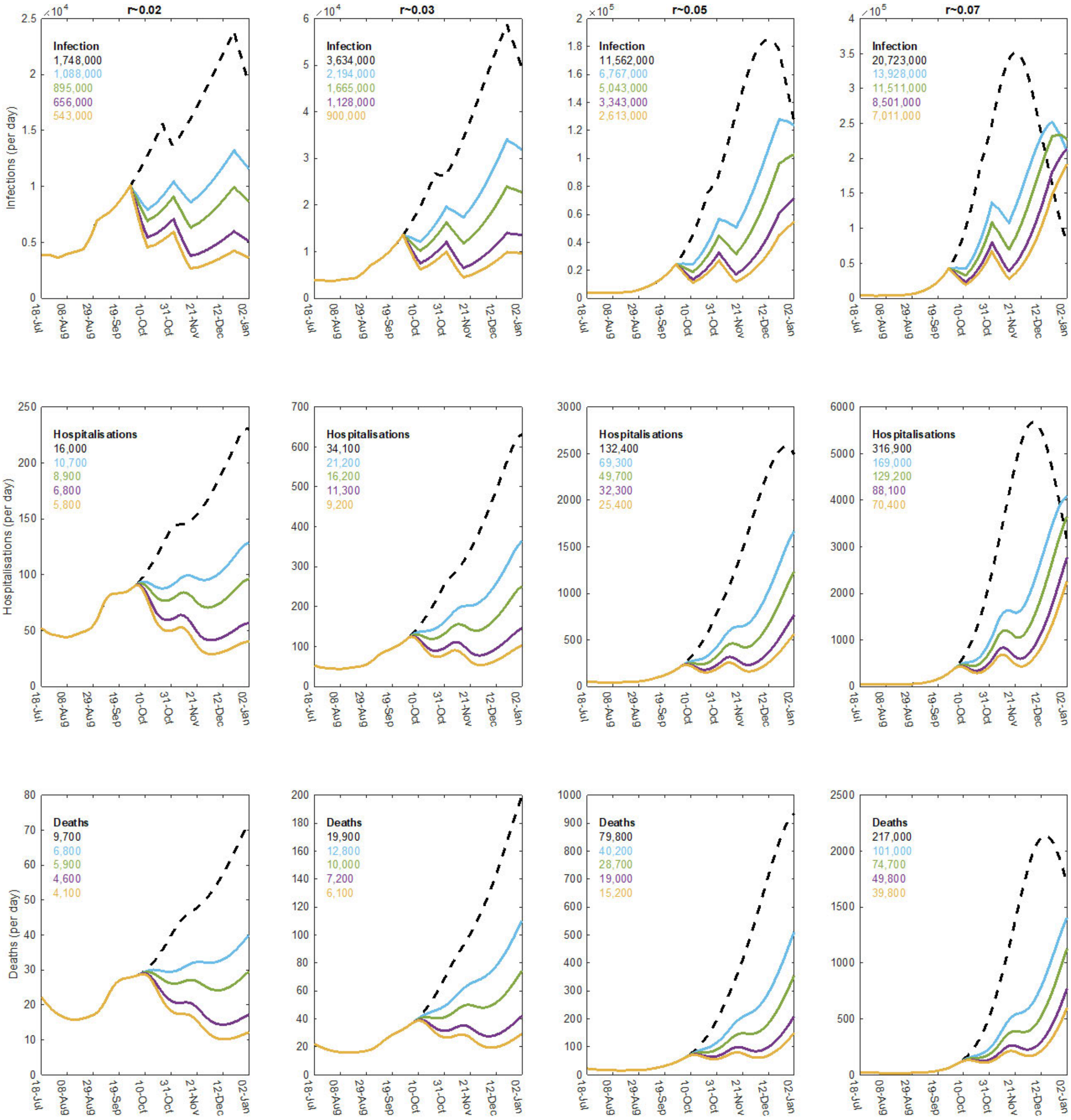
Early Circuit Breaker 4th-18th October

Analytical theory shows that the optimal timing for any circuit breaker intervention is as early as possible. This is generally supported by the full age-structured model (see below), the only exception is when the growth rate is large (r~0.07 or R~1.4, right-hand column) when the infection is clearly out of control and the number of deaths unacceptably high.



Double Circuit Breakers 28th Sept-11th Oct and 1st-15th November

If the underlying growth rate remains stubbornly high, it may be necessary to introduce multiple two-week circuit breakers to prevent substantial loss of life. This is illustrated below. In the worst cases, repeated breaks may be necessary every time the cases rise sufficiently high that excess pressure on hospital resources is predicted.



LIMITATIONS

We have assumed that the underlying behaviour (and hence the growth rate, *r*, and the reproductive number, *R*) remains constant outside of the circuit-breaker period. Recent trends have shown the growth rate to be increasing, but anticipating or predicting such changes is beyond the scope of any modelling. There is the potential that cooler temperatures and darker nights will lead to far more indoor mixing in the coming months, potentially increasing *r* further.

There is a simplifying assumption that behaviour will simple switch 'on' and 'off' as the circuit breaker takes effect. In practice some individuals are likely to compensate for the circuit breaker with increased contacts before and after; while others who are worried by the need for a 2-week break may limit their contacts over a longer time scale.

The majority of the results shown assume a homogeneous response across England. This generates clearer graphs and highlights the underlying principles. However, different regions are likely to have both different growth rates and different responses to the circuit breaker; this can only be factored into the models as data is accumulated (see Appendix 1).

It is difficult to predict the reduction that might be achieved during the circuit breaker. We have taken the steepest rate of decline observed in April as our upper bound. Increased mask use and the test-and-trace system could act to generate an even faster decline, but general apathy in the population or less severe measures would lead to a much lower decline. The type of stringent measures employed in Europe during the first wave could approximately double the rate of decline.

This model is not sufficiently resolved to discriminate between different forms of control measures (e.g. more working from home vs restrictions of leisure activities).

CONCLUSIONS.

A two-week circuit breaker, in which strong social-distancing measures are in place, could significantly help to reduce the impact of the winter wave of COVID-19.

Results of simple analysis is in good agreement with the trends from more complex models used for short and medium-term forecasting, giving extra support for our conclusions.

The circuit breaker is most effective when the underlying growth rate remains relatively low before the break, and strict controls are implemented during the break. Keeping *r* at or below 0.03 (equivalently *R* at or below 1.2) is critical if the circuit breaker is to be most effective.

If *r* reaches or exceeds 0.05, with no prospect of control, then multiple circuit breakers may be necessary to limit hospitalisations and deaths. At $r{\sim}0.05$, the action of a 2-week circuit breaker is cancelled by 2 weeks of 'normal' behaviour, suggesting that a 2-week on – 2-week off strategy might be needed to maintain control. The potential timing and duration (1-week, 9-days including 2 weekends, or 2-weeks) of multiple circuit breakers will need to be assessed in more detail.

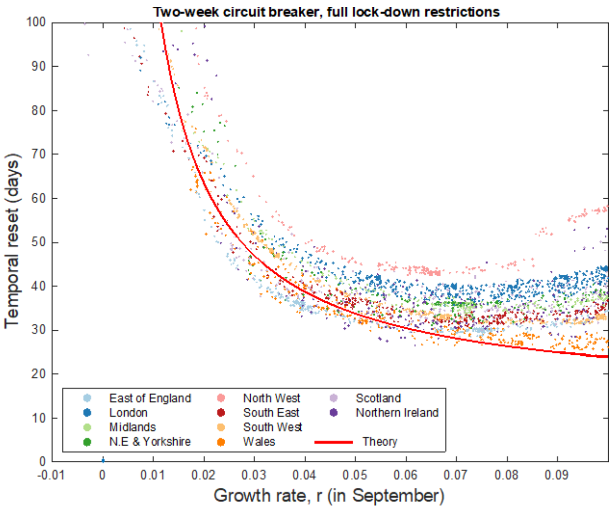
Due to the natural lags in the dynamics (often of multiple weeks), the impact of the circuit breaker on hospitalisation and deaths may not be apparent until the break is over.

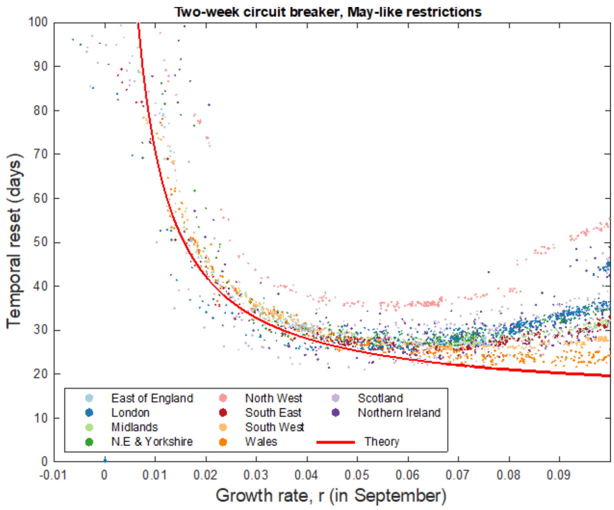
Short breaks (of a week or less) are likely to be far less effective as there is not sufficient time to limit infection (see Appendix 2).

APPENDIX 1. Regional Variability

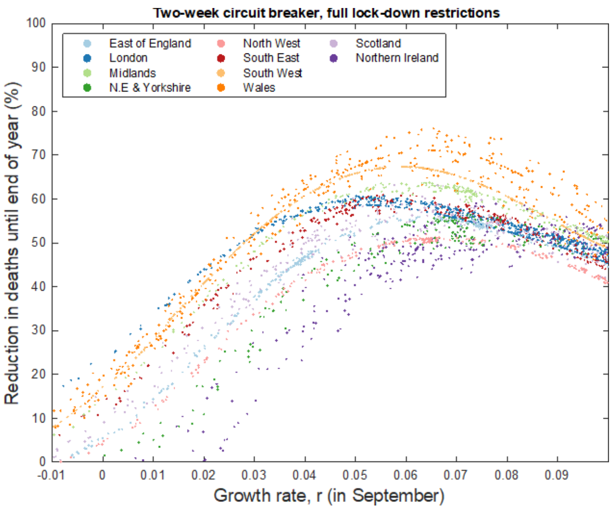
We now compute the dynamics of all 11 regions, across a sample of the posterior parameter set, to capture the potential variability in the system. Different growth rates in September are achieved by randomly perturbing the adherence to current measures.

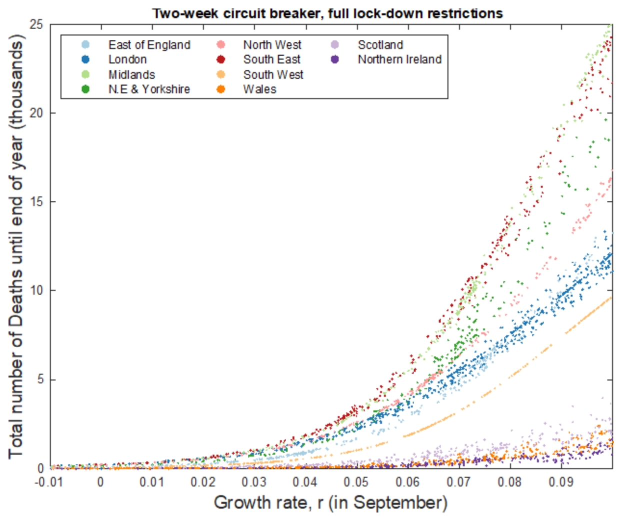
We first consider the Temporal Reset, and compare the results to the earlier analytical theory. Under full lock-down restrictions (left-hand figure, compare to gold curves in previous plots) and more moderate measures (right-hand figure, compare to purple curves) we obtain good agreement with the basic theory.



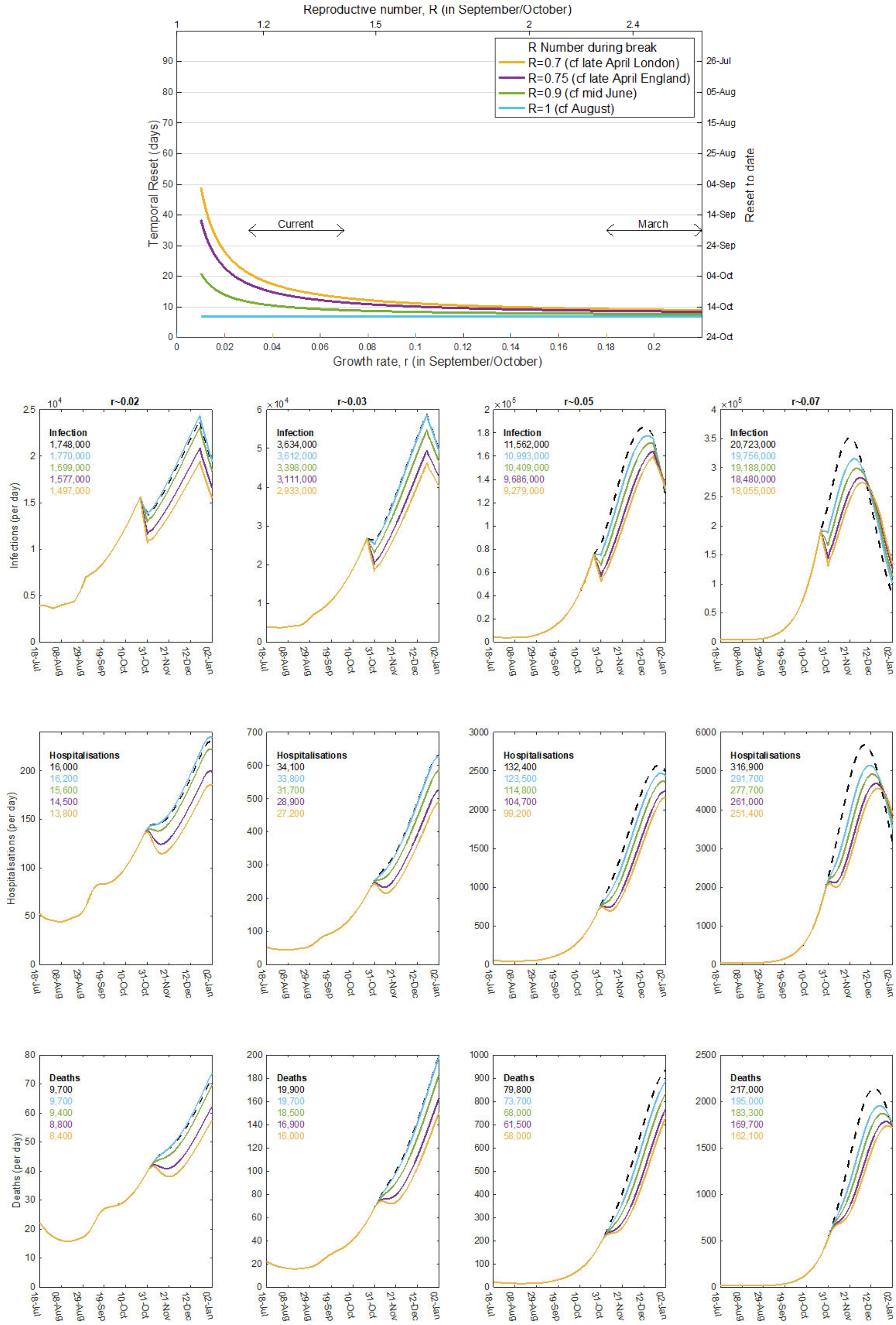


Looking at the relative number of deaths between now and the end of the year shows the impact of circuit-breakers. The relative reduction in deaths is greatest when *r* is around 0.05-0.07, but at this growth rate the number of deaths is unacceptably high. Some of the impact of an October circuit breaker is not evident in the number of deaths until far later, and therefore the total reduction may be significantly higher than shown, especially for low *r*.





APPENDIX 2. A 1-week Circuit Breaker in Half Term 25th Oct – 1st Nov.



From simple theory, a 1-week circuit breaker is expected to generate half the temporal reset compared to a 2-week break. This is generally supported by the full model, where a 1-week break is only half as effective as a 2-week break.