Covid vaccine impact forecast

Sam Moore, Ed Hill, Mike Tildesley, Louise Dyson, Matt Keeling

1 Summary

This document presents updated results from the model developed to predict the impact of vaccination on COVID-19 cases, hospitalisations and deaths. It is based on an age-structured model developed for long, medium and short term predictions, with the addition of a 2-dose vaccination schedule. The model has also been updated to include the effect of the new more infectious Covid strain that has been identified in the UK. All results presented are for England, simulated for 7 English regions separated and then combined, though the model may also be used to give results for the rest of the UK. The vaccine assumptions are closely based on the timings and quantities of vaccine available (as given by SPI-M), but does not account for the logistics of delivery.

Findings:

- We present a range of different scenarios for the vaccination period up until full release of NPIs. Even in the best case assumptions for vaccine efficacy, vaccination alone proves insufficient to allow complete NPI release within the year without significant further disease burden.
- With the new aggressive covid strain, likely transmission efficacies prove insufficient to prevent further infection outbreaks across the population. This means that the proportion of individuals that do not accept the vaccine together with the proportion for whom it is ineffective in protecting, may still account for significant further severe disease even after the program is completed.
- We see that even with the highest possible uptake and fastest vaccination program, full relaxation by the time schools return in September would still result in significant further disease. Relaxation to much reduced measures allowing schools to operate by then seems realistic however.

2 Base assumptions

Schedule:

- 1M doses Pfizer vaccine delivered across December at 0.25M per week.
- 1M doses per week starting from 1st January then increasing to 2M doses per week by the last week in January comprising of 10% Pfizer and 90% Oxford vaccine.
- 2M doses per week continued until everyone over 18 is vaccinated with 2 doses.

We additionally test scenarios of 1M doses per week from January with no increase and an increase to 3M doses from February.

We vaccinate the population in priority order according to the JCVI guidelines with a 12 week delay between doses.

Uptake: Throughout we assume 95% uptake in care homes, 85% in the general population above 50 and 75% in adults below 50 for the first dose This drops to 75% for the over 50s and 66% for the under 50s for the second dose.

Efficacy: We sub-divide into the effects of protection against symptoms (disease efficacy) and reduction in transmission – we assume that transmission blocking acts by stopping infection. Disease efficacy is taken as 70% and 88% after dose 1 rising to 88% and 94% after dose 2 for the Oxford and Pfizer vaccine respectively. Transmission efficacy is taken to be 48% rising to 60% for both. Protection is lagged by 14 days after the dose is delivered.

We additionally test scenarios with disease efficacy reduced by 66% or increased to 95% after dose 1, as well as a range of transmission efficacies between 0 and 75%.

NPIs: The effect of NPIs is matched in simulation up until the current lockdown. We then test scenarios in which lockdown is effective in reducing R to 0.8 or 1.2. This level is maintained until 22nd February, and then released in a linear manner up until complete removal of NPIs from 1st July or the start of 2022.

3 Results

In figures 1, 2, 3 and 4 we present a range of different scenarios for the vaccination period up until full release of NPIs. Even in the best case assumptions for vaccine efficacy, vaccination alone proves insufficient to allow complete NPI release within the year without significant further disease burden. With the new aggressive covid strain, likely transmission efficacies prove insufficient to prevent further infection outbreaks across the population. This means that the proportion of individuals that do not accept the vaccine together with the proportion for whom it is ineffective in protecting, may still account for significant further severe disease even after the program is completed. We conclude that vaccination must be combined with other interventions in order to provide an escape strategy.

It is also noticeable that large peaks may only by avoided by more gradual NPI release, however, this does not greatly affect the total deaths/hospitalisations over time. The disease efficacy is seen to have greatest impact on reducing deaths and hospitalisations (and fortunately the vaccines are believed to excel in this characteristic). Transmission efficacy is seen to be mainly effective in slowing the epidemics progress, rather than reducing its overall reach.

3.1 Can vaccination deliver an escape by September?

Under our default efficacy assumptions the best that may be done to allow complete release of NPIs as soon as possible would be by increasing both uptake and delivery speed to the greatest possible extent. In figure 5 we consider uptake increased to 95% for both doses together with the optimistic delivery speed of 3M doses per week from February. It is seen that a gradual relaxation up until September will still result in significant further disease burden even under this best case. Unfortunately, with the new aggressive strain, a 60% transmission efficacy is insufficient to prevent further infection outbreaks across the population. This means those that the 5% that still do not receive the vaccine and the $\approx 12\%$ for whom it is ineffective will still account for significant further severe disease.

We do conclude with a note of optimism in figure 6 however. Here we relax NPIs down to the lowest level we have seen so far in the outbreak, as seen in late summer last year, and show that to do so by September, while respecting our base rollout and efficacy assumptions for the vaccine, would result in only very minimal further disease burden. This suggests that a return to schooling as normal in the next academic year is quite achievable.

Deaths: R=0.8 in Lockdown

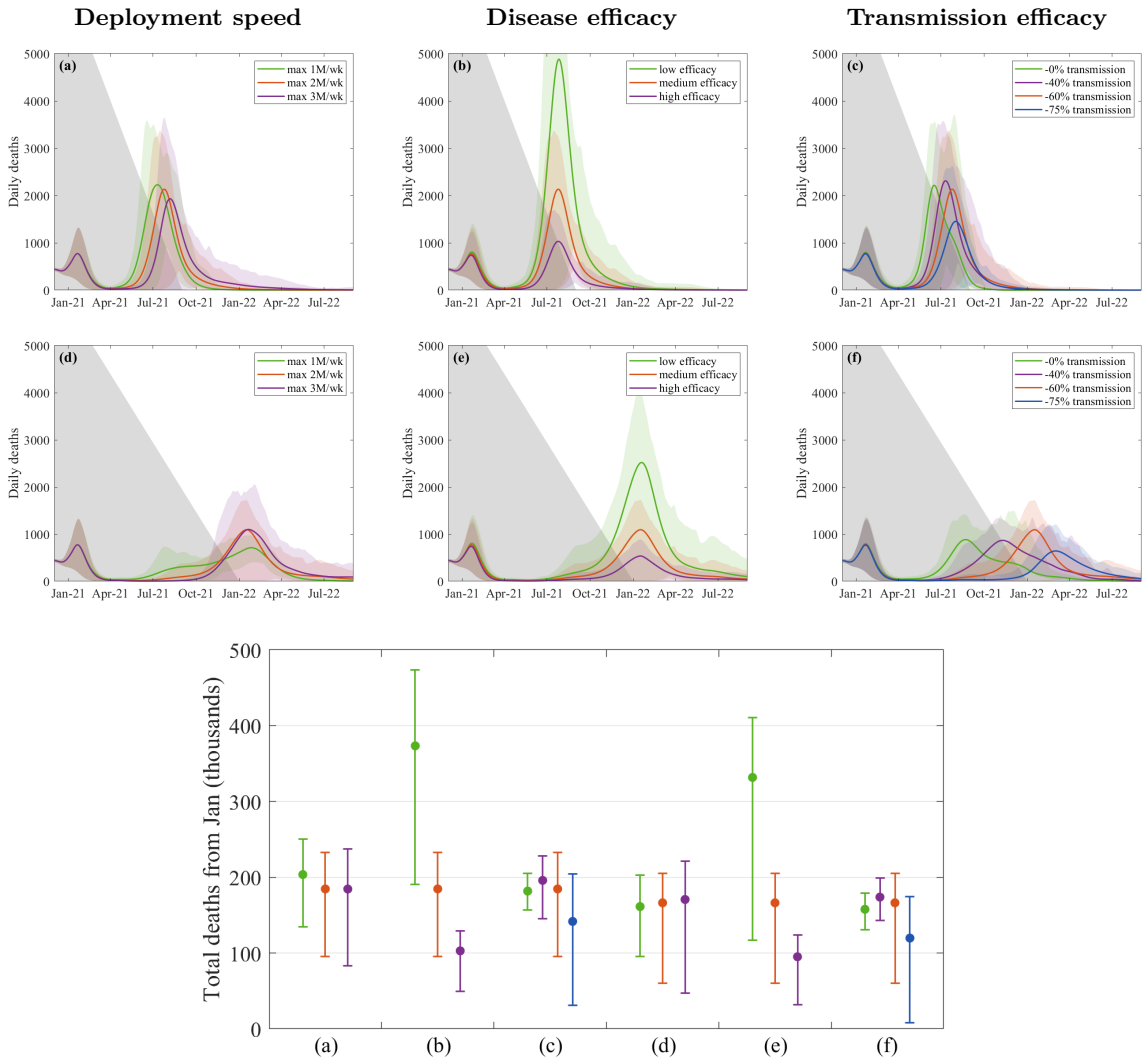

Figure 1: Forecasted deaths assuming current lockdown is effective in reducing R to 0.8, maintained until 22nd February, and then released in a linear manner up until: complete removal of NPIs from 1st July in panels (a)-(c) and from the start of 2022 in panels (d)-(f) (as represented by the grey shading). Differing from the default scenarios: in (a) and (d), deployment speed is tested at an additional pessimistic scenario limiting to 1M doses per week, and an optimistic scenario at 3M doses per week from February; in (b) and (e) we present an additional pessimistic overall efficacy at two thirds of the default and optimistic efficacy with 95% protection after 1 dose; and in (c) and (f) we test varying protection against infection (with efficacy against disease maintained at the default). The bottom panel compares the total deaths from Jan-21 onwards for each scenario considered.

Deaths: R=1.2 in Lockdown

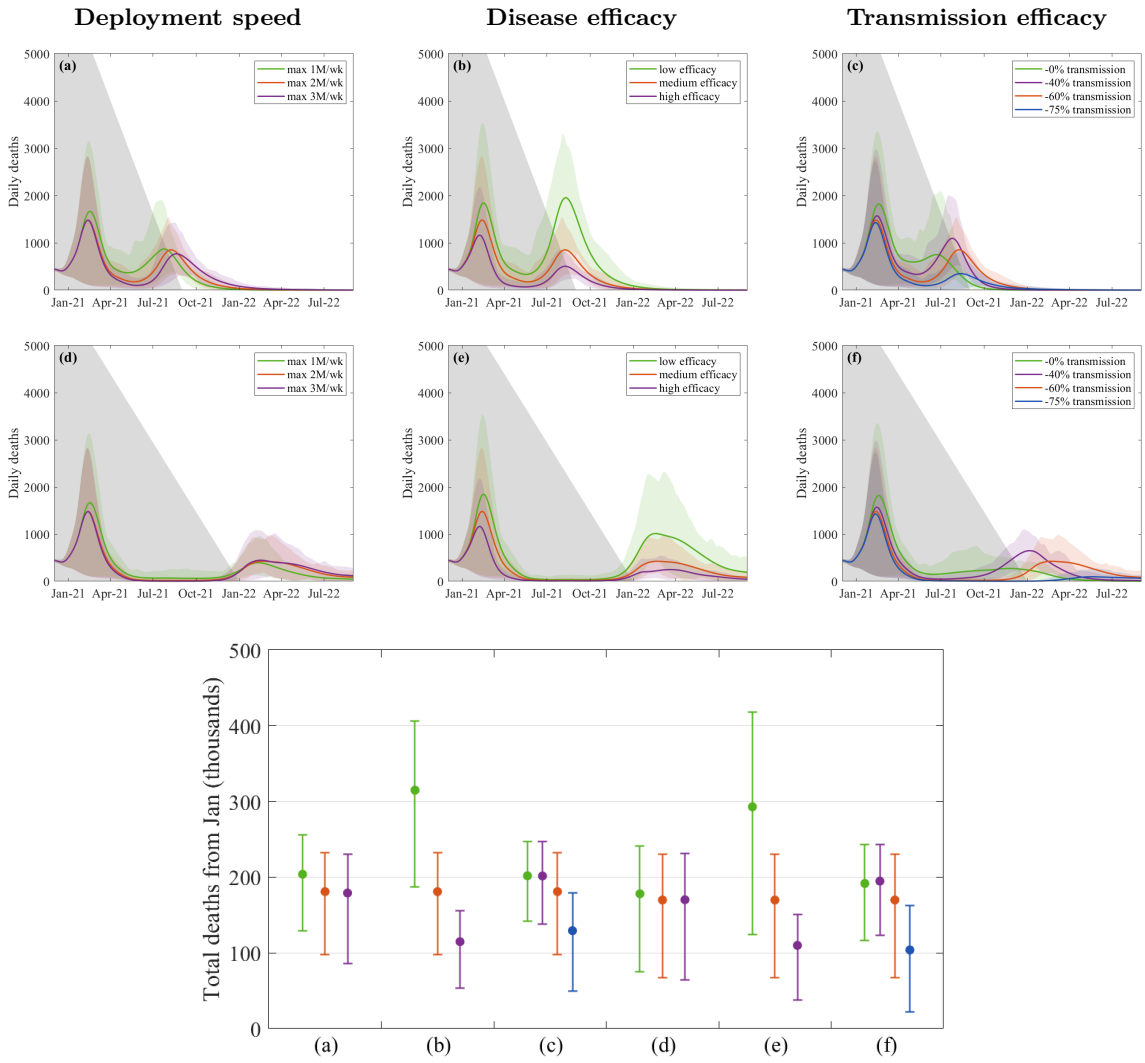

Figure 2: Forecasted deaths assuming current lockdown is only effective in reducing R to 1.2, maintained until 22nd February, and then released in a linear manner up until: complete removal of NPIs from 1st July in panels (a)-(c) and from the start of 2022 in panels (d)-(f) (as represented by the grey shading). Differing from the default scenarios: in (a) and (d), deployment speed is tested at an additional pessimistic scenario limiting to 1M doses per week, and an optimistic scenario at 3M doses per week from February; in (b) and (e) we present an additional pessimistic overall efficacy at two thirds of the default and optimistic efficacy with 95% protection after 1 dose; and in (c) and (f) we test varying protection against infection (with efficacy against disease maintained at the default). The bottom panel compares the total deaths from Jan-21 onwards for each scenario considered.

Hospital occupancy: R=0.8 in Lockdown

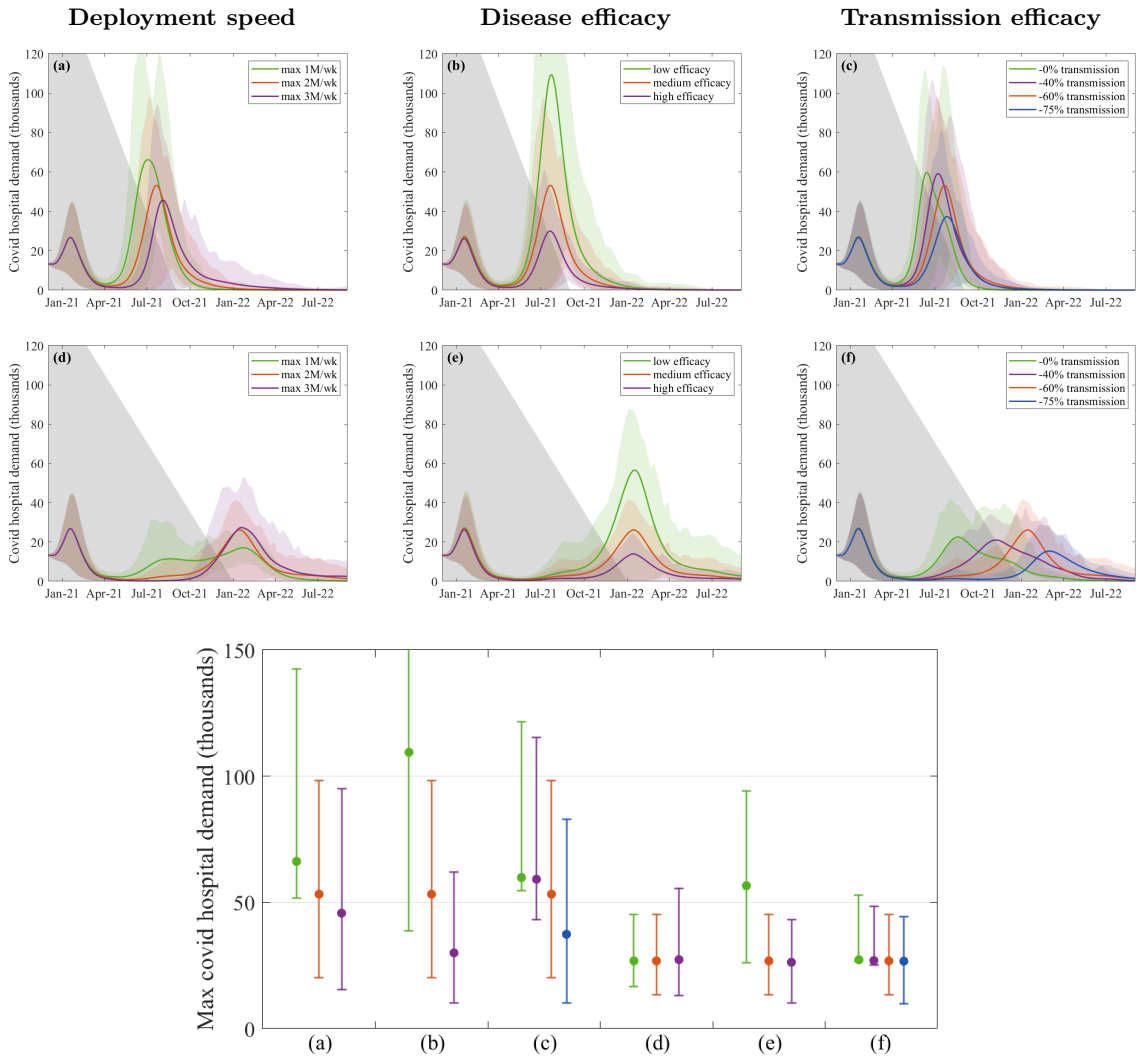

Figure 3: Forecasted Covid related hospital occupancy assuming current lockdown is effective in reducing R to 0.8, maintained until 22nd February, and then released in a linear manner up until: complete removal of NPIs from 1st July in panels (a)-(c) and from the start of 2022 in panels (d)-(f) (as represented by the grey shading). Differing from the default scenarios: in (a) and (d), deployment speed is tested at an additional pessimistic scenario limiting to 1M doses per week, and an optimistic scenario at 3M doses per week from February; in (b) and (e) we present an additional pessimistic overall efficacy at two thirds of the default and optimistic efficacy with 95% protection after 1 dose; and in (c) and (f) we test varying protection against infection (with efficacy against disease maintained at the default). The bottom panel compares the peak hospital occupancy from Jan-21 onwards for each scenario considered.

Hospital occupancy: R=1.2 in Lockdown

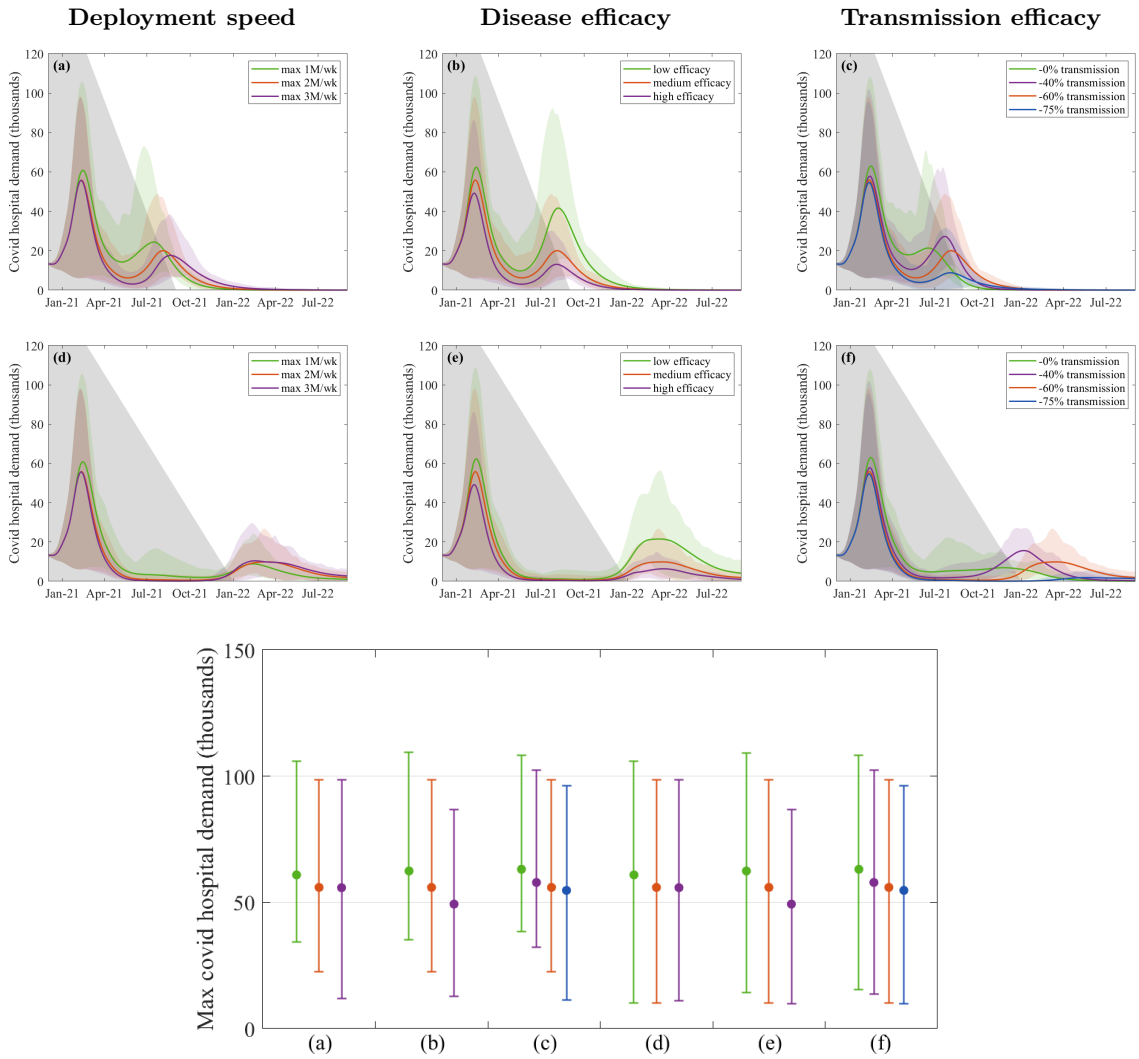

Figure 4: Forecasted Covid related hospital occupancy assuming current lockdown is only effective in reducing R to 1.2, maintained until 22nd February, and then released in a linear manner up until: complete removal of NPIs from 1st July in panels (a)-(c) and from the start of 2022 in panels (d)-(f) (as represented by the grey shading). Differing from the default scenarios: in (a) and (d), deployment speed is tested at an additional pessimistic scenario limiting to 1M doses per week, and an optimistic scenario at 3M doses per week from February; in (b) and (e) we present an additional pessimistic overall efficacy at two thirds of the default and optimistic efficacy with 95% protection after 1 dose; and in (c) and (f) we test varying protection against infection (with efficacy against disease maintained at the default). The bottom panel compares the peak hospital occupancy from Jan-21 onwards for each scenario considered.

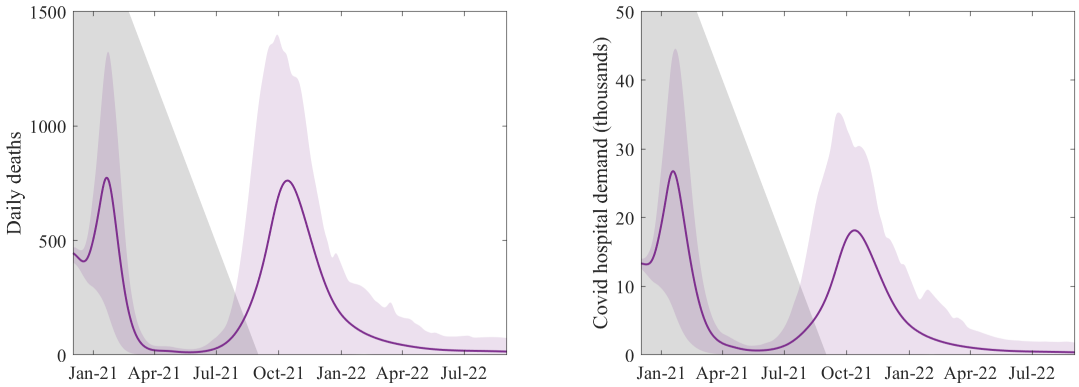

Figure 5: A "best we can manage" scenario is considered with 95% uptake for both doses and 3M per week dose delivery from February. We assume current lockdown is also effective in reducing R to 0.8, maintained until 22nd February, and then released in a linear manner up until complete removal of NPIs from 1st September, when school restart. Vaccine efficacy assumptions are left in line with the base scenario.

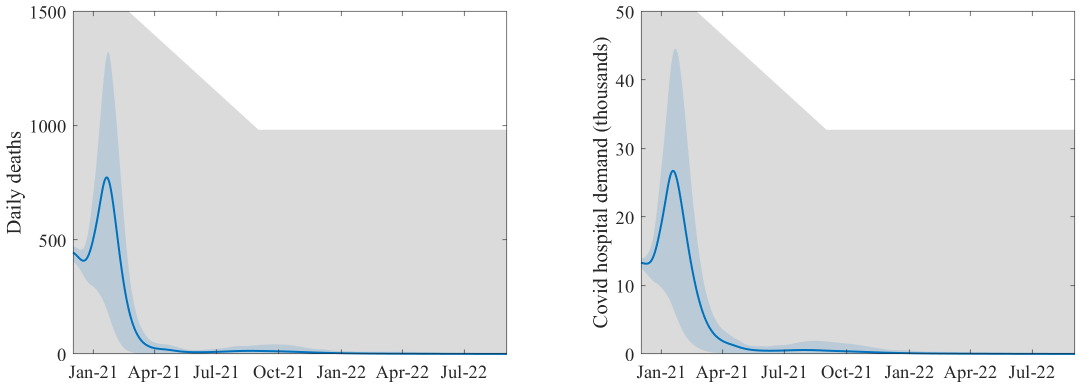

Figure 6: Here we consider relaxing NPIs down to the lowest level we have seen so far, comparable to this September past. We assume current lockdown is also effective in reducing R to 0.8, maintained until 22nd February, and then released in a linear manner to this low level of NPI from 1st September, when school restart. Vaccine rollout and efficacy assumptions are both left in line with the base scenario.