SPI-M-O: Update on planning and reasonable worst-case scenarios

Date: 29 July 2020

Summary

1. Three variants of a COVID-S scenario were agreed between SPI-M-O, SAGE, Cabinet Office's Civil Contingencies Secretariat, and COVID-19 Taskforce. These all involved an increasing profile of incidence, based on agreed doubling times, from the end of July to the end of November 2020, reflecting a difficult autumn followed by a large winter peak. After this point, measures are implemented that reduce non-household contacts to 25%, 35%, and 50% of normal, pre-lockdown levels and kept in place until March 2021.

2. Three modelling groups submitted reports looking at these scenarios; Faculty/NHS, Imperial, and Warwick and all groups showed similar profiles across the time period. One of these models for the scenario where measures reduced non-household contacts to 50% of normal, pre-lockdown levels whilst maintaining all school contacts from 1 December 2020 was chosen as the reasonable worst-case scenario (RWCS).

3. Key general messages:

    - All three model outputs discussed for the RWCS follow the same profile but have differing levels of starting incidence in mid-July and, consequently, different levels of those recovered by 1 December 2020, leading to different peak shapes.

    - All three models suggest that the RWCS, with non-household contacts limited to 50% of pre-March 2020 levels, is insufficient to suppress R below 1 in all regions in early December 2020, albeit to different extents.

    - Warwick's model assumes higher levels of estimated current daily incidence than the other two models and, consequently leads to a larger winter resurgence, which is contained by subsequent measures, likely as a result of widespread exposure to the virus and resulting immunity.

    - Imperial's more pessimistic outcome where measures in the scenario do not bring the second wave under control, despite starting incidence around that currently estimated, and the scale of the sustained pressure on the health and care system, mean that this model and scenario have been chosen as the revised RWCS.

Planning Scenarios

4. HM Government requires estimates of the future epidemic that allow for short, medium, and longer-term planning for a range of operational considerations, including NHS capacity. It is challenging to model this with any degree of certainty as trajectories will be highly dependent on the timing and nature of policy decisions that are taken and the behaviour of individuals over the time range considered. It will also be affected by random fluctuations, which will become more significant when incidence is low. To reflect these fundamental uncertainties, it is important to consider a range of scenarios covering a reasonable set of assumptions.

5. **It is important to note that these scenarios are not forecasts or predictions. They do not represent the full range of possible outcomes and no likelihood is attached to any of these scenarios at this stage. The timings of peaks in infection and demand on healthcare, in particular, are subject to significant uncertainty.**

6. Three scenarios have been agreed by the Cabinet Committee COVID-S to cover the range of potential outcomes:
    - an optimistic scenario where UK incidence continues to decline with the greatest risk posed by importation from overseas
    - a significant winter resurgence where incidence is broadly controlled until autumn 2020, when incidence increases exponentially before being rapidly brought under control by policy measures
    - a pre-winter peak combined with a significant winter resurgence

7. The last of these scenarios will act as the basis for the revised reasonable worst-case scenario (RWCS). This will be modelled from mid-July 2020 until the end of March 2021 for the UK, the four nations, and regions of England. The specifications and assumptions that follow have been commissioned by the Cabinet Office to produce a RWCS that aligns with the previously agreed COVID-S scenarios:

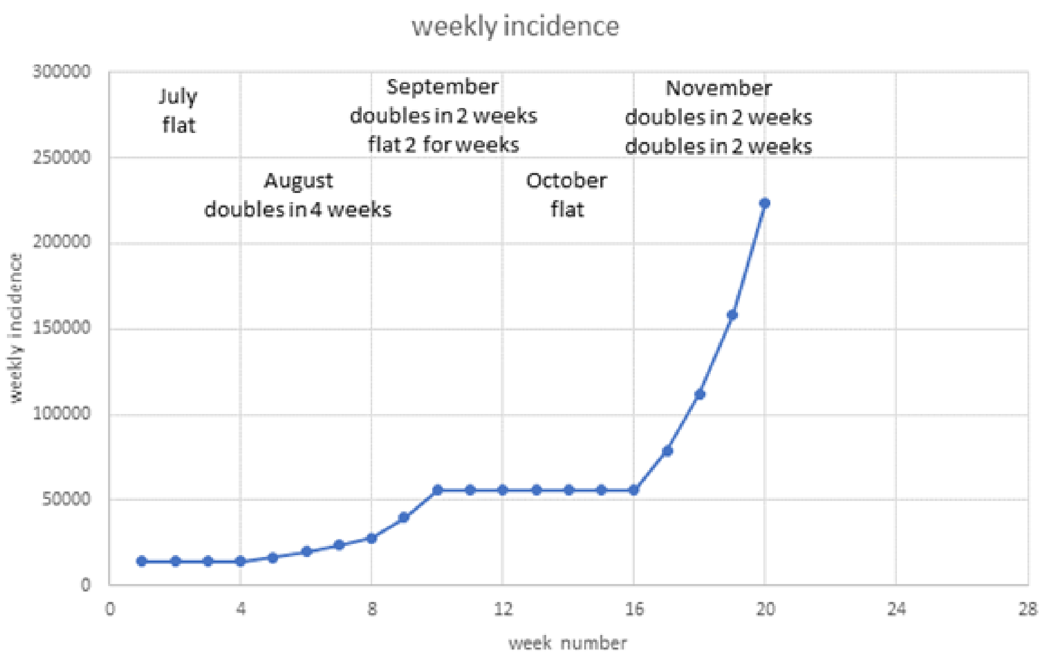
    - Incidence continues as per current trends until the end of July 2020 with all non-household contact assumed to be approximately 70% of "normal" pre-lockdown levels[1]
    - Incidence doubles once by the end of August 2020

[1] Current contact rates are significantly lower than 70% of their pre-lockdown levels. To remain consistent with current trends, this element of the commission has not been followed.

- Incidence doubles during the first two weeks of September, after which policy measures reduce R to around 1, until the end of October.
- A two-week doubling time for incidence returns throughout November
- At the end of November, policy measures are put in place which:
    i. SCENARIO A: All non-household contacts are reduced to 25% of their normal (pre-lockdown) levels
    ii. SCENARIO B: All non-household contacts are reduced to 35% of their normal (pre-lockdown) levels
    iii. SCENARIO C1: All non-household contacts (including school contacts) are reduced to 50% of their normal (pre-lockdown) levels
    iv. SCENARIO C2: All non-household contacts are reduced to 50% of their normal (pre-lockdown) levels; all school contacts are maintained.
- These measures are sustained until the end of March 2021
- An improved standard of care during this period with generalised use of dexamethasone is also assumed

8. This means there is a general pattern that all models will follow from mid-July to the start of December (Figure 1). Scenarios A, B, C1 and C2 only differ from Week 20 of the scenario onwards.

Figure 1: Illustrative example of the increase in weekly incidence for reasonable worst-case scenario commission from mid-July to end of November.



9. Scenario C2 will be used as a revised RWCS. It is good resilience practice for Government and local planners to use a RWCS for planning purposes. Such a scenario lays out a plausible scenario that is stretching and challenging and, if planned against, should ensure readiness for most potential manifestations of the risk. **However, we cannot rule out future incidence and, as a result future demand, being higher than this.**

10. This scenario is only one of several possible that could be deemed as a reasonable worst-case scenario, all of which could be different and challenging in their own ways. The one agreed by COVID-S reflects a difficult autumn followed by a large winter peak, but a different scenario could happen, for example, a larger, earlier autumn peak, or a delayed / insufficiently stringent policy response. Timings of changes in incidence rates are very uncertain, and a peak or peaks could happen sooner than that set out here, or the duration of any period of levelling off could be different. **SPI-M consider a worse scenario than that agreed by COVID-S is a realistic possibility.** The outbreak could manifest in different ways, and this is a reasonably, bad scenario to plan for. Local planners should be able to respond to this scenario and also be able to flex those plans if the outbreak develops in a different way, particularly earlier.

11. SPI-M-O highlight that, mechanistically, it is highly unlikely the epidemic would progress evenly across the UK in the manner laid out here. Instead, it is more likely that numerous localised outbreaks would “spill over” into regional ones that would become national level. With enough regionalised outbreaks, local services would likely be overwhelmed leading to the need for a national response. Recognising unsynchronised loss of control in several different places as they elide into national loss of control will be much more difficult than recognising the kind of synchronised progression specified in the commission. The necessary models, parameters, and data for presenting such scenarios would require significant further development and would likely still to be unable to account for the huge variety of ways this scenario could happen.

12. The commission for this RWCS was designed to consider the whole UK. As policy responses to the epidemic are likely to differ between the devolved nations, it would be expected that each of Scotland, Wales, and Northern Ireland would have different trajectories over time; devolved administrations will want to take this into account when considering this paper.

Key Insights from modelling

13. As per SPI-M-O's normal operating mechanism, we have commissioned alternative views from several models and groups to understand what differences may occur and why, when modelling the same scenario. Model outputs were presented for the UK from Imperial College London and Warwick University, and for England from Faculty/NHS that considered how scenarios A-C affect the numbers of infections, various hospital metrics such as new hospitalisations and bed occupancy, and deaths from mid-July 2020 to March 2021.

14. As expected, all model outputs show that the different proportions of non-household contacts stipulated led to different rates of decline, with the fastest in Scenario A where the UK returns to something close to severe non-pharmaceutical interventions (NPIs) such as a lockdown, and the slowest decline occurs in Scenario C2 where half of pre-lockdown non-household contacts are maintained with schools opened. Including only 50% of school contacts (C1) versus 100% (C2) made little difference to the scale of the second wave.

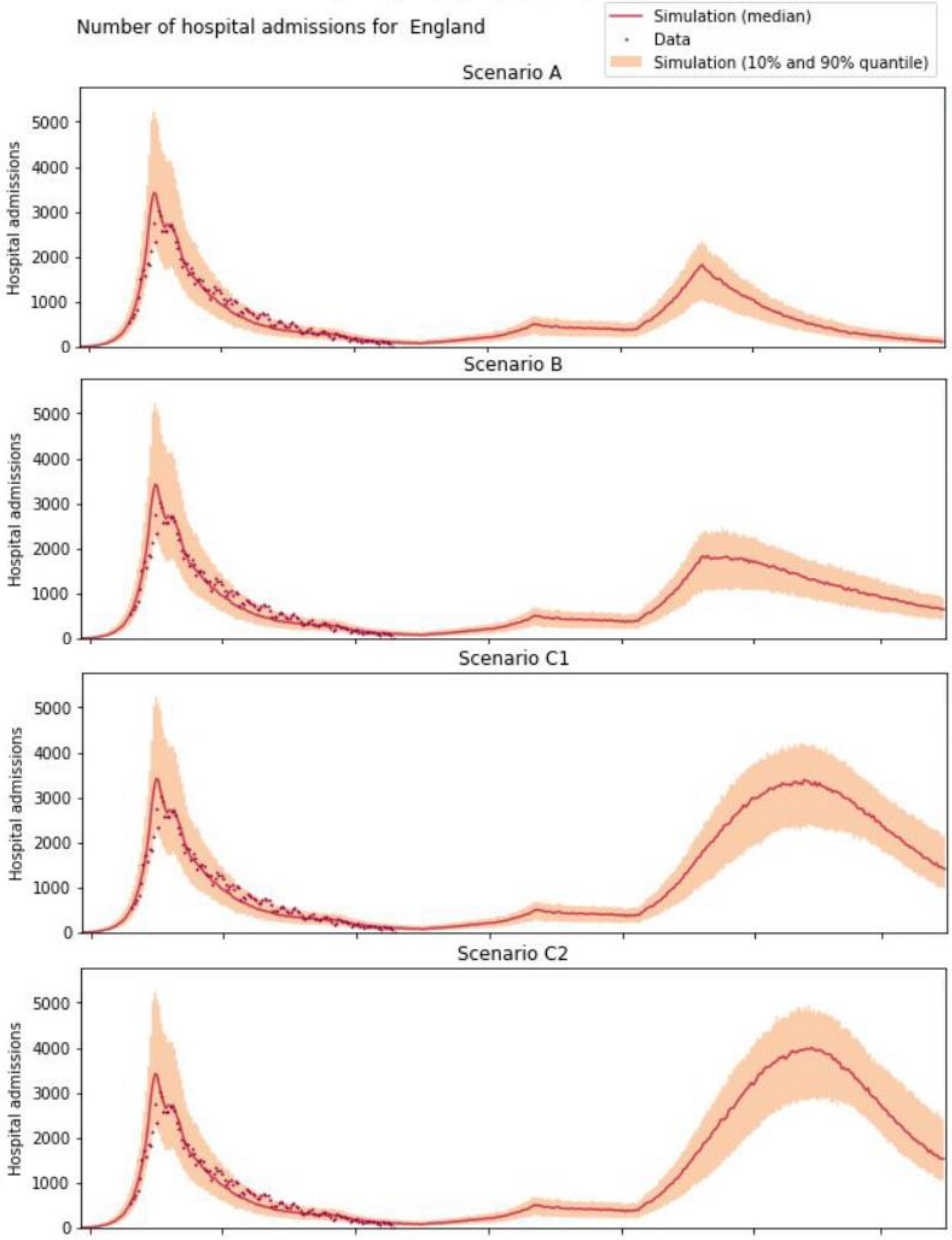
15. All three models follow same profile but have differing levels of starting incidence in mid-July and, consequently, different levels of those "recovered" by 1 December 2020, leading to different peak shapes. Faculty and Imperial' models suggest that Scenario C, with non-household contacts limited to 50% of pre-March 2020 levels, is insufficient to suppress R below 1 in all regions in early December 2020, whilst Warwick sees even this smallest intervention bringing transmission into decline.

Faculty/NHS

16. Faculty/NHS's model is an agent-based model, run in collaboration with University of Oxford Big Data Institute, and developed to simulate the spread of COVID-19 in a city, and to analyse the effect of intervention strategies. The results from this model showed the same profiles as other two models after interventions were implemented, including that having 100% of school contacts after 1 December 2020 (scenario C2) did lead to a slight increase in transmission compared to only 50% (scenario C1) (Figure 2).

17. Faculty/NHS's model produces similar results to both the Imperial and Warwick models, but it cannot provide the various breakdowns for the devolved administrations necessary for the RWCS. It has successfully acted as a sense check for the other two models.

Figure 2: Model outputs from Faculty/NHS for England Hospital admissions from January 2020 to March 2021 under different RWCS.

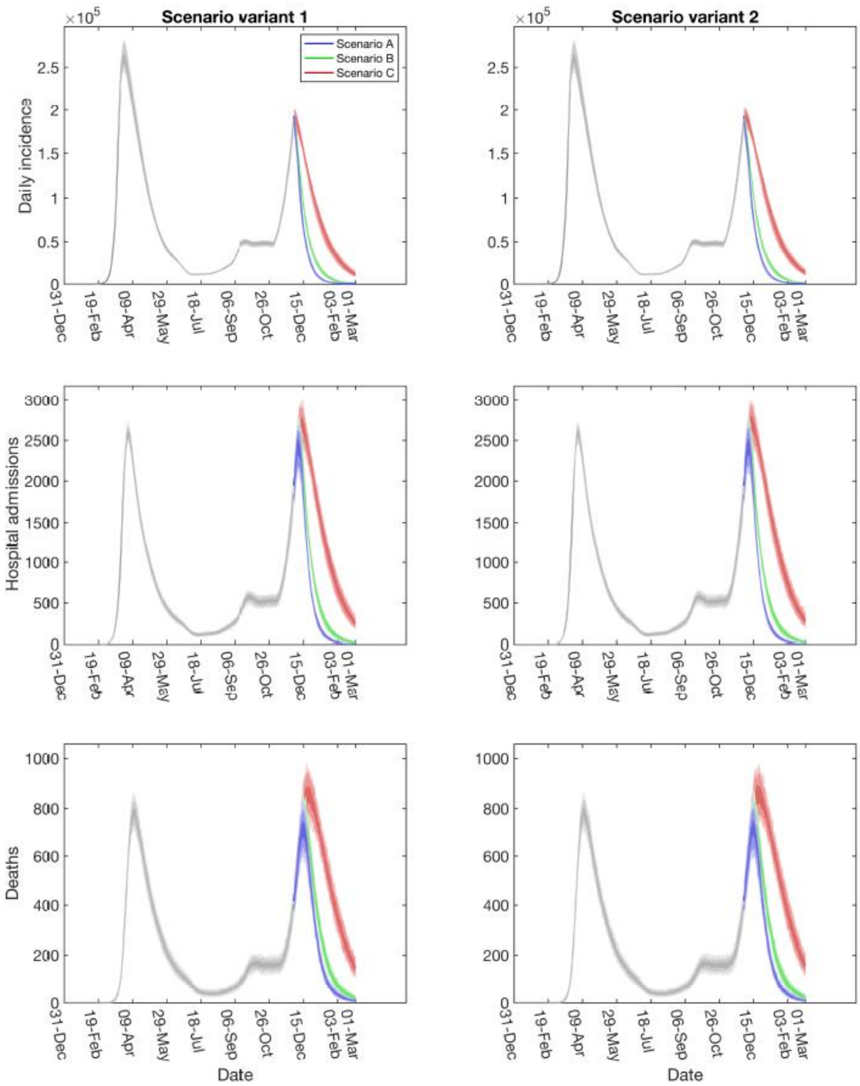


Warwick

18. Warwick's model uses an adherence parameter that scales POLYMOD contact matrices for changes in interactions in various settings as the result of social distancing policies. The model assumes that a full lockdown as happened in the UK at the end of March 2020 reduces non-household contacts to 30% of their normal levels based on CoMix Survey data. Using this as a benchmark for the POLYMOD matrices, it is possible to scale the adherence parameter to match contacts as specified by the commission.

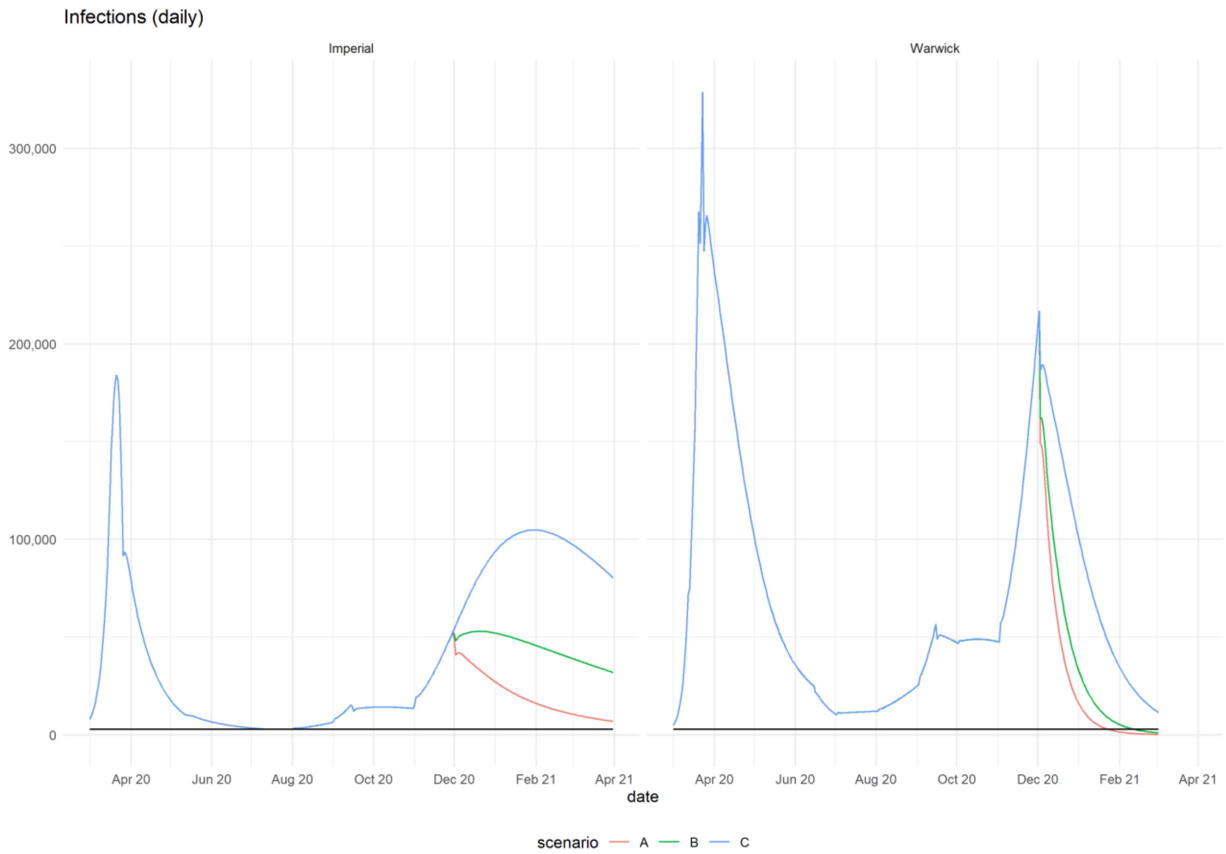
19. As with the Faculty/NHS model, Warwick do not see large differences in the metrics predicted between scenario variant 1, where school contacts are in proportion with other non-household contacts, and scenario variant 2, where all school contacts continue (Figure 3).

Figure 3: Warwick model outputs for UK daily incidence, hospital admissions, and deaths from January 2020 to March 2021 under different scenarios, including with 50% of normal pre-lockdown school contacts (scenario variant 1) and 100% of normal pre-lockdown school contacts (scenario variant 2)



20. The Warwick model assumes higher levels of estimated current daily incidence than the other two models and, consequently leads to a larger winter resurgence. This is due to model fitting to PHE blood donor data that reached an estimated 16% seropositivity rate in the population of London on 21 to 22 May, which implies higher incidence in the population than other data sources. This high incidence also means that many more people get infected than in the other two models and that the interventions in Scenario C reducing non-household contacts to 50% of pre-lockdown levels, controls the second wave, possibly through extensive exposure to the virus and consequent widespread immunity in the population.

Figure 4: Total incidence modelled compared between the Imperial and Warwick from March 2020 to March 2021 for Scenarios A, B, and C2, showing their different magnitudes. The black line indicates ONS estimates of incidence from COVID Infection Survey between 13 and 19 July 2020.



21. Warwick estimates that this second wave for Scenario C2 from 1 September 2020 to 1 March 2021, would lead to approximately a further 63,000 deaths. As discussed in previous RWCS documents, the Warwick model use PHE line list data for deaths and equivalent figures for devolved administrations. PHE line list death data is the number of confirmed COVID-19 deaths for hospitals, care homes and the community and it does not include deaths which are not captured in those headline data.

22. The model predicts a larger second peak in daily deaths despite a smaller incidence due to a very small shift in infections in older people leading to a large increase in deaths.

Imperial

23. Imperial's model uses a stochastic compartmental model to simulate transmission of SARS-CoV-2 in the community and through UK care homes. It has been fitted to the first wave and projects forward different scenarios that start with a daily incidence estimate of approximately 2,600. Imperial use "levels of pre-lockdown transmission" to approximate the scenarios and their non-household contacts. Respectively Scenarios A, B, and C2 equate to 24%, 28%, and approximately 33% of pre-lockdown transmission levels. In the Imperial model, 33% of pre-lockdown transmission equates to a doubling time of two weeks in November, so there is, effectively, no change in population mixing behaviour from the start of December. They also fit to ONS deaths data, and so may have a higher first peak than those seen in Warwick's model.

24. As with all modelling results, differences between the scenarios were only seen after 1 December 2020. Scenario C leads to a second peak of daily deaths in the UK that is just over half that of the first wave in March to June 2020 (Figure 5). This second wave in Scenario C, however, is much wider than the first, suggesting these interventions only bring the second wave under control after a very substantial further number of infections and consequent immunity; if the scenario continued under these assumptions, the number of deaths would decline very slowly. Already, the scenario estimates a very high number of daily deaths in March 2021; this suggests that total number of cumulative deaths for the whole second wave could be considerably higher, if more stringent measures were not put in place. Only the most stringent of the commissioned scenarios A brought this second wave under control and R_t below 1 on December 1.

25. This has implications for the NHS; failing to control this transmission in Scenario C could lead to huge demand for ICU and general hospital beds, with occupancy levels slightly higher than those seen during the peak of the Spring wave, and this demand would be sustained over a longer period (Figure 6).

Figure 5: Imperial (left) daily UK deaths by scenario, compared with Warwick (right). The difference in first wave deaths is due to Imperial fitting to ONS deaths, while Warwick use PHE line list.

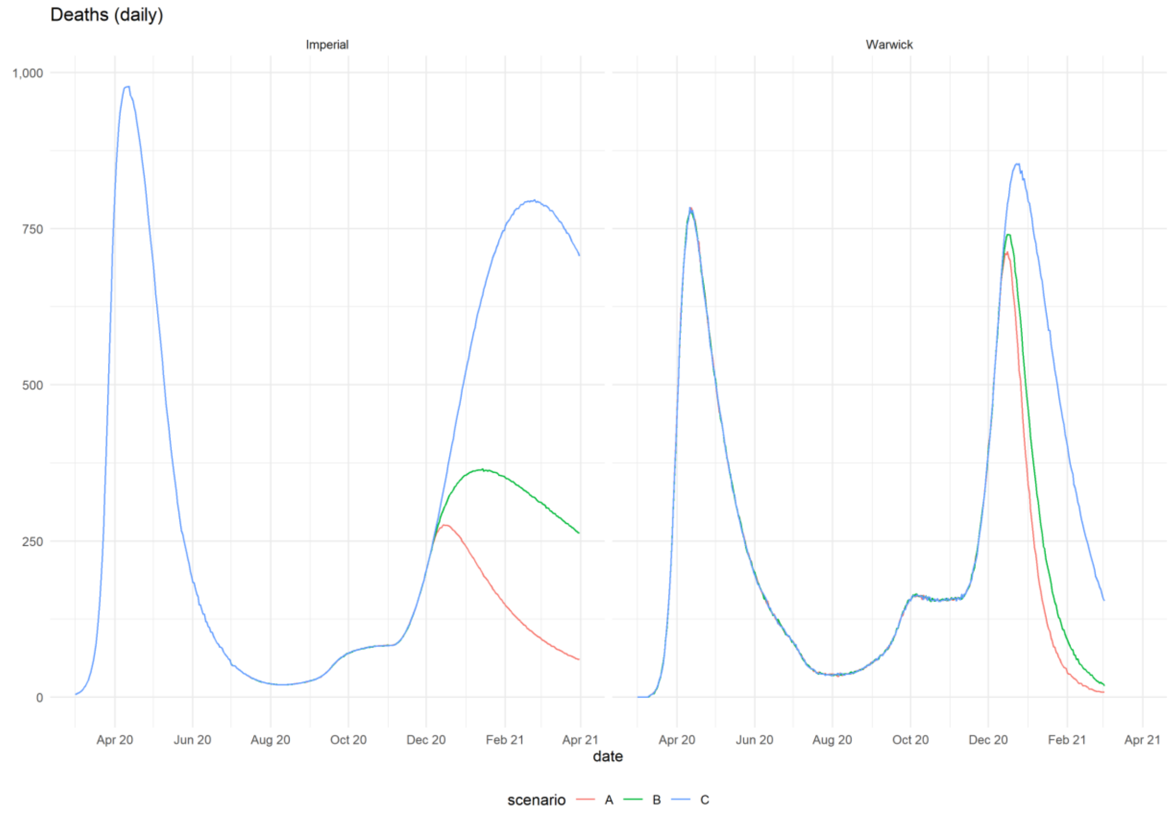
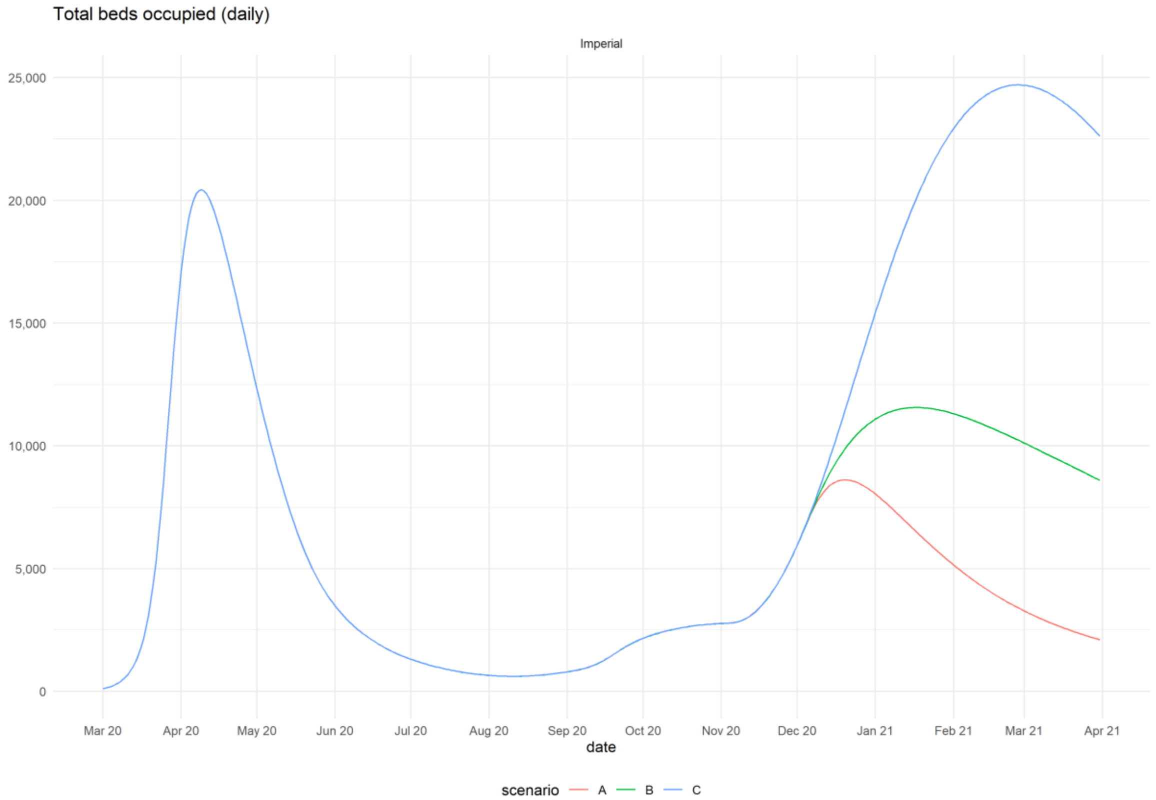


Figure 6: Imperial predicted daily UK hospital bed occupancy by scenario



26. **Due to the pessimistic outcome of this modelling by Imperial where measures in Scenario C do not bring the second wave under control despite starting incidence around that currently estimated, and the scale of the sustained pressure on the health and care system, this model and scenario have been chosen as the revised RWCS by SPI-M-O.**

27. As this model shows, a weak response to this second wave has significant implications for the health and care sector, including the NHS. Failing to control transmission as in Scenario C, could lead to huge peak demand in ICU and general hospital beds at levels even higher than those seen during the peak of the Spring wave, and this demand would be sustained over a longer period.

28. The model makes a variety of assumptions including:

    - Mortality in hospitalised COVID-19 patients treated with dexamethasone is reduced by 17%, based on the 0.83 rate ratio adjusted for age and level of case as measured in the RECOVERY study.
    - Case isolation, household quarantine and contact tracing were assumed to reduce transmission outside of the households by 40% in all scenarios.
    - Levels of non-household contacts were transformed into a fraction of pre-lockdown transmission by using contract matrices (CoMix survey and POLYMOD study).
    - Immunity is maintained over the course of the epidemic

29. Imperial's model explicitly estimates incidence and subsequent metrics based on the community and hospital transmission. From the first wave of the epidemic, it is known that care homes accounted for a significant proportion of deaths, and their effect needs to be considered in this revised reasonable worst-case scenario as far as practicable.

30. A different model from Imperial, based on a microsimulation structure instead of this stochastic compartmental one, suggested that the division between deaths in care homes and hospitals accounted for approximately a one third to two thirds split respectively during the first wave of the UK epidemic. This model now estimates that, in a second wave, the split would likely be one fifth to four fifths. This sense-check from the Imperial microsimulation model means a 25% uplift in incidence has been applied to the model's output, in order to represent care homes as far as possible; 25% has been chosen as lower incidence in care homes is anticipated than that seen in the first wave due to a smaller susceptible population and improved mitigations but higher than those estimated in the Imperial microsimulation model.

31. Imperial estimates that this second wave of the RWCS, could lead to another 65,000 deaths, 350,000 new and newly confirmed patients admitted to hospital, and, at the peak, over 5,500 ICU beds occupied.

Severity parameters and average length of stay estimates for the RWCS model

32. Data from the RWCS model allow for estimation of the proportions of the numbers of people infected with SARS-CoV-2 that require hospitalisation or ICU admission or go on to die, and assumptions around the mean length of stay in various hospital settings. The estimates for age group-specific proportions and average length of stay from the RWCS model are available in Table 1. **These are only one set of estimates provided by one model; previous iterations of the RWCS have shown how varied these estimates can be depending on different modelling methodologies and underlying data used.**

Table 1: UK Severity parameters and mean length of stay (LoS) in days by five-year age group and care home (CH) workers and residents for the RWCS model[1]

Age band	Proportion of infected people who are hospitalised	Proportion of hospitalised cases needing ICU	Proportion of infected people who die	Proportion of hospitalised cases who die	Mean LoS in hospital without ICU (days)	Mean LoS in hospital with ICU (days)	Mean LoS in hospital (days)
0 to 4	0.1%	6.0%	0.0%	1.2%	9.2	20.5	9.9
5 to 9	0.0%	5.5%	0.0%	1.3%	9.2	20.4	9.9
10 to 14	0.1%	5.2%	0.0%	1.3%	9.2	20.4	9.8
15 to 19	0.2%	5.3%	0.0%	1.4%	9.2	20.4	9.8
20 to 24	0.4%	5.9%	0.0%	1.6%	9.2	20.3	9.9
25 to 29	0.8%	7.3%	0.0%	2.0%	9.2	20.3	10.0
30 to 34	1.3%	10.1%	0.0%	2.7%	9.2	20.2	10.3
35 to 39	1.8%	15.3%	0.1%	4.1%	9.2	20.1	10.9
40 to 44	2.2%	22.4%	0.1%	6.5%	9.1	19.9	11.6
45 to 49	2.9%	29.2%	0.3%	10.0%	9.1	19.7	12.2
50 to 54	4.2%	33.9%	0.7%	14.5%	9	19.5	12.6
55 to 59	5.0%	35.2%	1.1%	20.1%	8.9	19.1	12.5
60 to 64	6.6%	32.1%	2.1%	26.0%	8.7	18.7	11.9
65 to 69	7.1%	24.4%	2.9%	31.3%	8.5	18.2	10.9
70 to 74	8.0%	14.2%	4.0%	35.6%	8.3	17.8	9.6
75 to 79	8.9%	6.6%	5.3%	39.2%	8.1	17.4	8.7
80+	8.2%	1.5%	6.0%	43.3%	7.9	17.3	8.0
CH workers	3.1%	22.1%	0.3%	8.3%	9.1	19.8	11.4
CH residents	8.5%	1.5%	9.7%	43.3%	7.9	17.3	8.0
Average	**2.4%**	**20.5%**	**0.7%**	**23.3%**	**8.7**	**19.0**	**10.8**

33. Further summary severity estimates can be found in Tables 2 and 3. **Note:** these do not take into account the effect of dexamethasone.

Table 2: Severity estimates for stages of COVID-19[1]

Risk	**Proportion (range)**
Proportion of infections which have symptoms	66%
Infected people hospitalised	2.4% (0.0% – 8.9%)
Hospitalised (non-ICU) patients transferring to ICU (HDU/ITU)	20.5% (1.5% – 35.2%)
All hospitalised patients dying	23.3% (1.2% – 43.3%)
Overall infection fatality rate	0.7% (0.0% – 9.7%)

Table 3: Average length of stay for COVID-19 hospitalisation phases[1]

Period	**Mean length of stay in days (range)**
Hospital (non-ICU) admission to transfer to ICU (HDU/ITU)	2.0
Hospital (non-ICU) admission to death or discharge *without* an ICU (HDU/ITU) admission	8.7 (7.9 – 9.2)
ICU (HDU/ITU) stay	10.6 (8.9 – 12.1)
Hospital (non-ICU) admission to death or discharge *with* an ICU (HDU/ITU) admission†	19.0 (17.3 – 20.5)

† Includes step-down care in hospital (non-ICU) following ICU stay but prior to discharge of 6.4 days.

Devolved nations

34. The epidemics in the UK nations of Scotland, Wales and Northern Ireland have generally had lower disease incidence than that seen in England and their devolved administrations have implemented different policies over its course. Due to the low first wave incidence and the RWCS basis of doubling times, these nations see small peaks from the end of November. This may or may not become the case, but this is not something that planners should assume will happen. There is potentially significant variability in the devolved

nations due to very low case numbers currently, and so these scenarios for Scotland, Wales, and Northern Ireland are likely highly uncertain.

35. Summary estimates for impacts of this RWCS on the devolved nations can be seen in Figure 7 and Table 4, and SPI-M-O will work with devolved administration analysts to support interpretation of these data.

Figure 7: RWCS daily direct COVID-19 deaths for Scotland, Wales and Northern Ireland, actual data to end of June, RWCS estimation from 1 July 2020 to 31 March 2021.

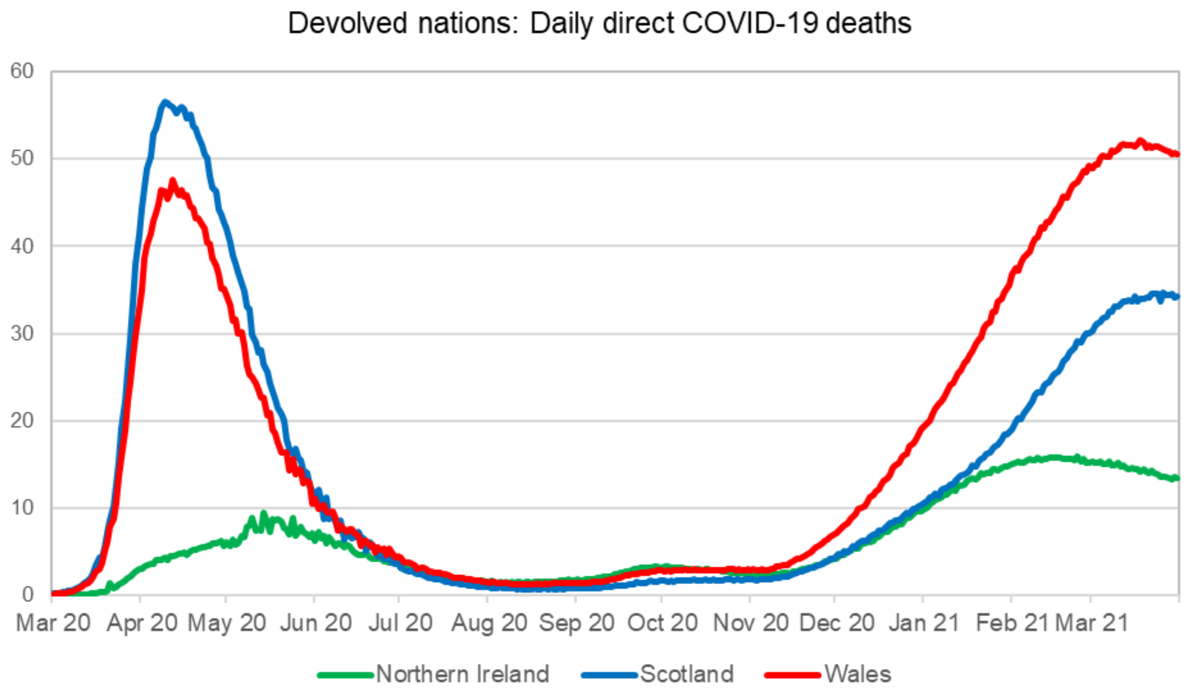


Table 4: Key RWCS headline data based on epidemiological modelling for each devolved nation, to support planning decisions from 1 September 2020 to 31 March 2021.

	England	**Scotland**	**Wales**	**Northern Ireland**
Number of direct COVID-19 deaths This is the number of **confirmed** COVID-19 deaths for hospitals and the community, with a 25% uplift to reflect care home deaths. It does not include deaths which are not captured in headline data, additional COVID-19 deaths that could occur due to lack of NHS capacity, or other excess deaths	77,000	2,600	4,400	1,900
Number of cases requiring hospitalisation	323,000	11,000	18,000	7,000
Peak daily ICU occupancy	5,000	300	400	100

[1] Endnote added for release: Following discussion of these papers at SAGE 49, a technical error was identified, affecting a small number of values in the summary tables. The correct values are given below. Please note that this error only affected these summary tables, and not the underlying model outputs used by the Cabinet Office Civil Contingencies Secretariat and circulated to central and local planners.

Table 1: Corrected values (changes shown in italics)

Age band	Proportion of infected people who are hospitalised	Proportion of hospitalised cases in need of ICU	Proportion of infected people who die	Proportion of hospitalised cases who die
CH resident	*8.4%*	1.5%	*9.6%*	43.3%
Average	2.4%	*20.6%*	*0.8%*	*22.9%*

Table 2: Corrected values (changes shown in italics)

Hospitalised (non-ICU) patients transferring to ICU (HDU/ITU):	*20.6%* (1.5% – 35.2%)
All hospitalised patients dying:	*22.9%* (1.2% – 43.3%)
Overall infection fatality rate:	*0.8%* (0.0% – *9.6%*)

Table 3: Corrected values (changes shown in italics)

ICU (HDU/ITU) stay:	*10.7* (8.9 – 12.1)
Hospital (non-ICU) admission to death or discharge with an ICU (HDU/ITU) admission:	*19.1* (17.3 – 20.5)