Modelling the course of the COVID epidemic and the impact of different interventions

Background:

1. Modelling the course of the COVID epidemic depends on assumptions about the value of Rt (the reproductive number) at different time points in the future. The Executive has previously indicated that maintenance of Rt at less than 1 should be viewed as a key objective. However, Rt has been persistently above 1 since early July and is currently around 1.5, and it inevitably follows from this that there has been an increase in COVID cases and other markers of the epidemic (covered in the separate R paper).

2. The value of Rt is determined by the extent of contacts between individuals (number, proximity and duration) and the impact of any mitigations which are in place (hand hygiene, face coverings, ventilation and effectiveness of the TTP system). It is also likely to be influenced by seasonal factors. In the case of the TTP system, this includes the rapidity with which close contacts are advised to self-isolate and the degree of compliance with that advice.

3. Rt at the outset of the epidemic was approximately 2.8, and the impact of full lockdown with the degree of compliance seen at that time was to reduce Rt to approximately 0.7. There will only be a reduction in the number of cases and other aspects of the epidemic if Rt is reduced to less than 1, and the decrease in the epidemic will be greater the further Rt is below one and the longer that is maintained.

4. Modelling from a range of UK groups suggests that full lockdown as before with schools open would result in Rt a little less than 1. Full lockdown with schools closed and the hospitality sector open (and current mitigations) would also result in a value of Rt a little less than 1. It is not considered likely that Rt can be less than 1 with both schools and hospitality open.

5. Any relaxations compared with full lockdown will raise Rt a little, with society working fully as normal equating to an R value of 2.8.

6. In terms of the TTP system, it is estimated that if 80% of contacts can be advised to self-isolate within 48 hrs of a symptomatic individual requesting a test, and if they comply with advice to self-isolate for 14 days, Rt can be reduced by approximately 30%. The implication of this is that an efficiently working TTP system would reduce Rt from 2.8 to around 1.9 – 2.0, and that ongoing restrictions are therefore likely to be required until a high level of population immunity is achieved.

Compliance:

7. Available evidence shows that compliance with all aspects of existing restrictions is declining (see attached Cognisense survey results), particularly in younger segments of the population and those from lower social classes. There are likely to be multiple reasons for this, but in particular younger people do not perceive themselves to be at significant risk of adverse outcomes if they are infected and perceive the restrictions as placing overly onerous demands on their lives.

8. UK evidence suggests that compliance with advice by TTP to self-isolate is relatively poor (see attached paper on CORSAIR study), and there is little reason to believe that adherence is better in NI.

9. Ensuring good compliance with restrictions over the next 6 months should be a key objective, and communication, enforcement, co-production and use of appropriate incentives are all likely to play a role in this. The extent to which this can be achieved is uncertain, and a detailed discussion of methods of doing so is beyond the scope of this paper.

Approaches to modelling:

10. It is necessary to define the key objective for the health care system in relation to epidemic control as this will define the context for modelling. Various options have been discussed internationally, including COVID elimination (as in New Zealand). For the purpose of this paper, the key objective identified is to maintain the number of COVID patients in general acute medical beds as less than 20% of capacity (320 hospital inpatients). The rationale for this is provided in Annex 1.

11. The impact of non-pharmaceutical interventions (NPIs) is not expected to be fully apparent until between 2-3 weeks after implementation, subject to adherence by the population. With a sustained increase in the number of confirmed infections and hospitalisations, to avoid being overwhelmed action in the form of additional NPIs is therefore required a minimum of 21 days before the HSC would otherwise reach that point. For the purposes of this paper, our definition of overwhelmed describes "a situation in which the rate of COVID-19 hospitalisations results in multiple NHS Trusts having to operate beyond their contingency capacity for COVID, placing a significant burden on the well-being of staff, and affecting the treatment of other acute, non-COVID patients."

12. As of today (07/10/20) there are 113 hospital inpatients with community acquired COVID, of whom 13 are in critical care and approximately 100 in general acute medical beds. The doubling time is 7-8 days, and this would imply that the ceiling may be reached within 10 - 14 days. The impact of recent restrictions has not as yet been seen, but given that cases have continued to double in the last 7 days and that cases in the over 60s have more than doubled there seems little reason to assume that the increase in hospital admissions and inpatients will not continue for the foreseeable future.

13. During a comparable period in wave 1, R was significantly above 2 and decision to move to complete lockdown was made on 28th March. There had been some changes in behaviours in the days leading up to, the impact of which is difficult to quantify. The table below shows the trajectory of COVID inpatient numbers for community acquired disease. Inpatient numbers peaked 10 days after the introduction of full lockdown. In the second half of the table recent numbers are shown to indicate the current trajectory:

Date	Inpatients	Admissions	7 day average inpatients	7 day admissions
24/03/2020	63	9	39.7	70
25/03/2020	79	26	48.3	90
26/03/2020	95	23	58.9	107
27/03/2020	115	34	71.1	130
28/03/2020	149	39	86.6	156

29/03/2020	169	26	104.1	174
30/03/2020	188	36	122.6	193
31/03/2020	219	46	144.9	230
01/04/2020	244	42	168.4	246
02/04/2020	265	35	192.7	258
03/04/2020	258	36	213.1	260
04/04/2020	280	34	231.9	255
05/04/2020	273	25	246.7	254
06/04/2020	279	32	259.7	250
07/04/2020	290	35	269.9	239
08/04/2020	284	23	275.6	220
09/04/2020	275	28	277.0	213
10/04/2020	251	10	276.0	187
11/04/2020	254	19	272.3	172
12/04/2020	255	22	269.7	169
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26/09/2020	41	2	37.3	34
27/09/2020	45	7	39.7	39
28/09/2020	51	10	42.6	46
29/09/2020	63	15	46.4	52
30/09/2020	63	7	49.7	52
01/10/2020	68	9	53.3	54
02/10/2020	73	14	57.7	64
03/10/2020	70	9	61.9	71
04/10/2020	84	17	67.4	81
05/10/2020	92	13	73.3	84
06/10/2020	105	20	79.3	89
07/10/2020	113	12	86.4	94

14. Modelling has been conducted for a range of scenarios, including reducing Rt to 0.7 or 0.9 for varying periods of time (1, 2, 3, or 4 weeks). The purpose of this is not to make a proposal but to illustrate for Executive the impact of different decisions. Other scenarios can be modelled if requested.

15. An intervention to decrease Rt to 0.7 (equivalent to complete lockdown) is more effective if it lasts longer, and if it is introduced earlier. A one week difference in the timing of intervention could result in 250 vs. 350 hospitalised patients.

16. A three week intervention to reduce Rt at an appropriate time would ensure that hospitals are not at risk of being overwhelmed until late December. A four week intervention would ensure under these assumptions that the hospital system would not be at risk of being overwhelmed until January.

17. A single intervention is unlikely to be sufficient to protect the hospital system through the winter. Under all of the models considered an additional intervention or interventions would be required early in 2021 at the latest.

18. When emerging from a period of intervention, restrictions will be required to ensure that Rt remains at 1.2 under these scenarios. This implies more restriction or significantly better compliance than at present.

Alternative approaches:

19. Measures to increase hospital capacity would allow an increased epidemic level to be managed, but this would inevitably be associated with increased deaths and might be limited by the need of staff to self-isolate if infected or contacts.

20. Intensive efforts to ensure shielding of the elderly and vulnerable could reduce pressures on the hospital system. However, this would require considerable sacrifice on the part of those shielding and those protecting them over at least a six month period.

Conclusion:

21. In order to ensure that the capacity of the hospital system is not overwhelmed an intervention to reduce Rt to 0.7 will be required, starting in the near future.

Annex 1: Hospital capacity in the context of COVID

Our hospitals have an overall capacity of roughly 3500 beds. Of these, many are dedicated to specialties such as stroke, cardiology, nephrology, neurology, major trauma or cystic fibrosis. There are 1600 beds that could be termed general medical and which are most likely to be used for covid patients. The overall number of beds fluctuates in response to staffing pressures, for example in response to the impact of staff self-isolating.

At peak in the first wave there were 322 Covid inpatients. At that time, given the large degree of uncertainty about what the impact of the pandemic would be, the HSC had taken steps to release as much capacity as possible. In practice, this meant that almost all routine elective activity had stopped. Many staff had also been redeployed to areas such as critical care in order to increase our capacity. At the same time, public concern about the pandemic led to significantly reduced numbers of patients attending hospital. Due to a combination of these factors, the system was able to deal with the first surge. Nevertheless, staff working some aspects of the service, such as critical care, were under intense pressure throughout the first surge.

As we move into a second surge, the situation is very different. Firstly, all of our hospitals are currently under significant pressure. Most hospitals are running at more than 85% capacity, with some over 90%. There are already trolley waits in EDs and ambulances queuing outside. This level of pressure does not usually manifest until later in the year. There is therefore a concern around how they system will deal with rising pressures over the winter period alongside increasing numbers of Covid+ patients.

There is also clear evidence that length of stay for Covid+ patients is longer than average length of stay (LOS). Recent figures from the HSCB suggest that LOS for Covid patients is 11.56 days, compared to 5.95 average. As numbers of Covid+ patients increase, this will therefore reduce capacity further.

Community Care

The position in relation to community care is also relevant. When there are outbreaks in care homes, this can impact on the ability of these sites to accept patients on discharge from hospital and increase the length of stay in hospital. With widespread community transmission and a rolling programme of testing in care homes, we are also seeing increased numbers of staff having to self-isolate across community services – which is impacting on capacity and the ability to facilitate discharge. We expect this challenge to continue to grow. In the first surge more than 21,000 hours of staff time were provided to independent sector care homes from the HSC to help maintain services. Indications from Trusts are that it will be extremely challenging to maintain this level of support to the independent sector.

Critical Care

The Department currently receives a daily update from the Critical Care Network for Northern Ireland (CCANNI) setting out the position in each unit. With the experience of the first surge period, it is clear that the provision of critical care remains a key stress point within the system.

As a region, Northern Ireland has a funded capacity of 70 critical care beds. Critical care beds are extremely staff intensive, particularly with regard to nursing staff. To increase critical care beds by 15, requires more than 100 additional nurses. In order to open these beds, nurses therefore have to be moved from other parts of the HSC, with a severe impact on other activity, particularly on elective surgical activity. Furthermore, as the number of critical care beds being used to treat Covid+ patients increases, the capacity of the region to provide critical care support for complex surgery decreases. A small increase has a major impact.

HSC Bed Capacity Risk Levels

The impact of NPIs is expected to be between 2-3 weeks of implementation, subject to adherence by the population. With a sustained increase in the number of confirmed infections and hospitalisations, action in the form of additional NPIs is required 21 days before the HSC is overwhelmed.

Our definition of overwhelmed describes "a situation in which the rate of COVID-19 hospitalisations results in multiple NHS Trusts having to operate beyond their contingency capacity for COVID, placing a significant burden on the well-being of staff, and affecting the treatment of other acute, non-COVID patients."

While every effort will be made to maintain elective procedures, it is acknowledged that elective and non-essential procedures will likely need to be cancelled to provide the necessary bed and staffing capacity to treat COVID-19 patients within the forecasting period.

The Department has set the following risk levels in terms of overall bed capacity:

Impact of Covid demand – Risk Levels

(Expressed as percentage of General Medical Beds)

Green (<5%)	Covid and non-covid services able to be maintained.
Amber (5-15%)	Level of covid demand putting pressure on non-covid services. Some routine services de-prioritised.
Red (20%)	Covid demand having significant adverse impact on hospital services/covid contingency exceeded.

20% of beds roughly equates to 320 beds. At this point, multiple Trusts are reporting that they are at amber, with a rising numbers of Covid+ patients and an increasing impact on non-Covid services.