COVID-19 Briefing Report 3.

The potential impact of a Covid-19 outbreak in the UK on the healthcare delivery: With particular emphasis on secondary and critical care.

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About the author

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Summary

An excellent modelling study from a team across Exeter, Bristol and Warwick Universities, used a spatial model of infectious disease transmission to investigate possible scenarios for the spread of COVID-19 in the UK (Danon et al. 2020).

In a **moderate scenario** with an assumption of a **50% reduction in transmissibility over the summer months**, the epidemic in the UK would peak in the winter of 2020/21 over 340 days after person-to-person transmission in the UK starts. Nearly 70% of all people would be infected, and the peak daily incidence would be over **330 thousand new infections per day**.

In the **worst-case scenario** with an assumption of **no seasonal reduction in transmission**, the epidemic will peak at between 120 and 150 days. The best-guess estimate scenario suggests that over 45 million people in the UK will have been infected by then and the peak daily incidence would be about **1.2 million people per day**.

In the **best-case scenario** with a **complete halt to transmission** in the summer months, the outbreak would peak at about 100 days with only 0.5% of the population being infected and a peak daily incidence of just over **6.5 thousand cases per day**.

The NHS has about 6,000 intensive care beds with an escalation plan to almost double this number by halting routine surgery and diverting operating theatre resources and equipment. However, an epidemic will result in substantial sickness absence in health care workers who are at increased risk of infection as a result of occupational exposure. The moderate scenario would pose a significant challenge to the NHS, particularly in the Ambulance Service, Accident and Emergency departments and critical care. In the worst-case scenario, available capacity would be exceeded.

Introduction:

Covid-19 is currently causing a significant outbreak in south-east Asia and has resulted in more than two thousand deaths in China. So far, the number of deaths outside China has remained low, although Iran has just declared 2 deaths within its borders, and the number of cases outside of China

continues to accelerate. Like any viral respiratory disease outbreak, there is a strong possibility that this will affect a large number of people globally in the coming months. Here we will briefly outline the possible impact of the outbreak on the healthcare system if this were to happen in the UK. Significant steps to contain the outbreak have been taken and this, along with multiple other factors, will influence the total number of patients contracting the infection. The potential impacts on the healthcare system will range from mild to severe.

The NHS is a vast and unique organisation with 124,816 consultant physicians, 52,313 associate specialists, 58,879 doctors-in-training, 332,352 nurses and health visitors, 299881 clinical support staff, among other staff group (NHS Digital 2020) It caters for 24 million emergency attendances a year and on average, 13,058 patients are admitted via emergency department every day. There are 26,941 qualified permanent GPs in England (Baker 2019).

The outbreak and what could be possible:

There has been impressive and unprecedented coordination and sharing of health information about Covid-19 between different national and international health organisations. This includes structural information about the virus and daily epidemiological updates with the World Health Organisation (WHO) coordinating the international response.

The case fatality rate of Covid-19, at around 2%, is less that the SARS outbreak in 2003. Currently the Basic Reproductive Number (number of secondary cases generated from a single primary case) is about 2.2. In about 80% of people the virus causes a mild respiratory illness, but can also sometimes result in a mild gastrointestinal disturbance in some cases (Novel Coronavirus Pneumonia Emergency Response Team 2020). It is largely disseminated by exhaled respiratory droplets or by direct/ indirect contact with infected secretions.

Modelling studies have been published in attempts to forecast the behaviour of the epidemic. We will use the data from a recently published study (Pre-print) by Danon et al from the Universities of Exeter, Bristol and Warwick in our analysis (Danon et al. 2020). This study predicts that in the absence of a seasonal reduction in transmission, the CoVID-19 epidemic in the UK will peak between 126 and 147 days from the start of human-to-human transmission within the UK (i.e. around June). The authors incorporated seasonal changes in transmission under different scenarios. We have focused on the scenario with a 50% reduction of transmissibility during the summer months but have also examined the impact of other scenarios with a 0%, 25%, 75% and 100% reduction of transmissibility.

Table 1: Effect of seasonal changes in transmission rate, with assumption of reduction of transmission rate during summer, on the peak incidence from the time of first human-to-human transmission in the UK (Danon et al. 2020).

Table 1. The results of the simulations by Danon et al under five different scenarios of seasonality.

Seasonal term	Timing of peak	Incidence at peak	Attack rate
0	139	1,172,819	81.9
0.25	159	615,599	65.0
0.5	343	330,311	69.4
0.75	375	1,227,280	80.3
1.0	100	6547	0.53

The main emphasis of the current article is on secondary care impact, mainly on the care of the critically ill. There have been some changes in the treatment of severe acute respiratory failure in the last 12 years or so. Extra Corporeal Membrane Oxygenation is now well established in the UK and is delivered in a structured way from 5 centres. Ventilatory strategies, like prone positioning, have been adopted routinely worldwide with resulting better outcomes. However, the very high demand that might be experienced in an epidemic would put a considerable strain on resources as detailed below. Having drawn upon the experience of previous outbreaks, the NHS has a Pandemic Preparedness Plan in place, along with a well described Standard Operating Procedure for the provision of Critical Care in the NHS that takes into account both service and ethical considerations.

Impact on primary care:

In the course of an outbreak, various factors will impair the capacity of primary care to provide a service.

All healthcare staff, including those in primary care, will be at higher risk of contracting the infection than the general population, and they may, in turn, become vectors of transmission to vulnerable patients. To reduce this risk, Public Health England has advised the general public to avoid attending general practice in person if they believe they may be infected with the COVID-19 virus. In any case, clinical and non-clinical staff may still contract the disease from other sources.

School closures due to local outbreaks may force caregivers of school age children to stay at home, including healthcare staff.

Despite the PHE advice, many patients will probably present in general practice, exposing the staff to potential infection, either because they are unaware of the advice, are unaware that they might have the infection, or choose to attend anyway. This will cause considerable disruption to the service delivery as equipment and rooms will need cleaning.

Impact on secondary care:

Patient attendance in NHS secondary care has grown in recent years. An average of about 68,000 patients per day attended emergency departments in English Hospitals in 2018-19 and occupancy of the approximately 100,000 beds is 90% (Baker 2019).

Currently, public health policy states that anyone who feels unwell with suspected Covid-19 will have to be transported to the emergency department to be examined and also to obtain necessary diagnostic samples. We estimate that about 16,500 additional patients will need to be seen in A&E

departments per day, adding about 25% to the usual burden. This is based on the scenario by Danon et al, of a 50% reduction of transmissibility of Covid-19 during the summer (Danon et al. 2020). A peak incidence of 330,000 per day would lead to this estimate of 16,500 patients needing to attend emergency departments, given 5% of all infected people will be sick enough to seek medical help. If up to 25% of these cases will need admission (around 4,000 additional admissions per day), this will take bed occupancy to near saturation.

The best-case scenario will only see around 300 additional emergency attendances per day (5% of the peak incidence 6,547/day). However, the worst case scenario by Danon et al, with no seasonal reduction in transmission, would result in 1,227,280 new cases per day (Danon et al. 2020). This would give rise to an additional 61,000 emergency attendance per day (5% of the 1,227,280) which would nearly double the average attendance and pose severe challenges to the service.

Potential strategies to try and mitigate this problem include outreach services which aim to identify those who are infected and then avoid admission by the provision of timely home-based interventions.

Impact on critical care:

Available beds:

The UK has nearly 6000 critical care beds in 263 adult critical care units, including beds for neonatal intensive care as of December 2019 (Government Statistical Service 2019). The number of critical care bed periods have increased from 215,728 in 2010-11 to 271,079 in 2015-16, and there is 75% bed occupancy in the English ICUs in December (Intensive Care National Audit and Research Centre 2019) (Government Statistical Service 2019; NHS Digital 2012, 2016). However, in the "FICM Workforce Data Bank for Adult Critical Care" published in 2018, it has been mentioned that "2/5 of units have to close beds due to staffing shortages on at least a weekly basis" and "4/5 of units had to transfer patients due to lack of bed capacity"(Faculty of Intensive Care Medicine 2018). This discrepancy could have resulted from the fact that not all physical beds present in the clinical areas are actually funded for regular clinical care. However, the actual cause of this is unclear.

There is an escalation plan in the NHS for increasing the intensive care bed base by 100% as per publicly available resource, by converting appropriate non-ICU beds into ICU beds, or by using theatre space by stopping non-urgent elective surgery (NHS England 2013). This takes the potential available beds to nearly 12,000 in a severe outbreak. The standard operating procedure also outlines how staff with transferable skills could be utilised to provide care in the increased capacity bed base. Operational and ethical principles of managing a widespread severe outbreak have also has described widely in literature (Hick et al. 2014; Kain and Fowler 2019) .

Clinician workforce:

According to a workforce report published by the Faculty of Intensive Care Medicine (FICM) in 2018, there were 2,228 consultant physicians in critical care in the UK registered with FICM in the 2017 census (Faculty of Intensive Care Medicine 2018). However, around 90% work in a different specialty as well, reducing the total amount of time they spend in intensive care. In addition, there are around 400-450 trainee physicians working through a training programme to become consultants in this

specialty. There are a number of other junior doctors from other specialties rotating into intensive care as well.

Nursing numbers:

Total number of nurses in English, Welsh and Northern Irish ICUs were 17,767 in 2018 (band 5- 64.8%, band 6 – 24.7%, band 7 – 7.1%, band 8 – 1.2%). During this survey, there were 1,440 vacancies in nursing posts in intensive care (Horsefield 2018).

Potential demand on UK critical care:

As described above, epidemiological modelling has demonstrated a few potential scenarios of incidence of the disease in England and Wales. The actual number will depend on the transmissibility and control measures adopted. According to the scenario with 50% reduction in transmission rate during the year (the middle of 5 scenarios), there will be 330,311 cases per day at the peak incidence time, which will be in the winter of 2020-21. There will also be smaller peak of around 12,500 cases per day according to this scenario in July 2020.

We assume that 10% of the cases will potentially need critical care. This is on the basis of two case series of confirmed cases from China, one with 1,099 patients (Li et al. 2020) and the other with 4,021 patients (Yang et al. 2020) . The first of this (Yang et al) reported intensive care admission rate of 5%, and the other reported a rate of severe pneumonia of 25.5%. Given the fact that these are initial reports of rate of severity, and this may vary somewhat from one case series to the next, we took a rate of 10% to be a realistic guess of the rate of critical care admission. As it is estimated that around 5% of cases will have been diagnosed, the above scenario will result in around 16,500 cases being diagnosed at the peak (Read et al. 2020), this scenario could therefore result in 1,650 potential intensive care admissions per day. There is, however, a realistic possibility that the severely affected patient population will include elderly patients with co-morbidities and frailty. This will result in prior decision making about escalation of care, with a ceiling of care being ward based on the basis of possible medical futility (i.e. a significant number of patients will be deemed not suitable for intensive care admission). For example, specific cut off for clinical parameters of disease severity can be used in deciding on the group of patients most likely to benefit from intensive care therapy. With the median age of hospitalised patients being only around 56 years, and with most severely Covid-19 affected patients having one or more comorbidities, it is possible that not more than 40% patients will fall into the category of potential medical futility. This makes the potential number of patients needing intensive care admission per day at 990 (1,650 * 0.6).

It has been shown that median length of stay for critically ill patients with viral pneumonia could be 10days [IQR 6-22d] (Choi et al. 2012). This, along with a potential 990 admissions a day have a chance of overwhelming the system around the time of peak incidence. However, given the fact that there will be Covid-19 related admissions numbering in hundreds every day for weeks leading up to the peak incidence time, the saturation of the resources can be reached much earlier in this scenario.

The worst-case scenario in this model will have a far worse impact on the system. This will result in 61,364 (=1,227,280* 0.05) cases being diagnosed everyday with 6,134 (=61,364*0.1) needing intensive care or enhanced observation in the ward level. This scenario is very unlikely to occur, and the public health infection control responses will be proportionally more aggressive making it less

likely still. At the same time, the best-case scenario, under which, 100% reduction of transmission rate through the summer months of 2020 will be seen, there will be a far less severe outbreak with peak incidence of 6,547 per day. This will create ICU bed demand due to Covid-2019 of 33 cases a day (=6,547 * 0.05 * 0.1).

The table below summarises the above estimates:

Seasonal variation in transmission	Peak incidence	A & E attendance per day	Critical attendance per day
0% reduction (worst case scenario)	1,172,819	58,640	5,864
50% reduction (moderate scenario)	330,311	16,515	1,651
100% reduction (best case scenario)	6,547	327	33

Potential impact on medical and nursing staffing:

The staff working in hospital or critical care areas, and looking after patients with viral pneumonia are exposed to airborne viruses at a higher rate than the general population. Previous coronavirus outbreak (SARS) in 2003 made a significant number of healthcare professionals ill in Asia and North America. Aerosol generating procedures (e.g. endotracheal intubation, bronchoscopy, tracheostomy, nebulisation) are frequently needed for patients with viral pneumonia in and outside intensive care and are a major drivers for disease transmission within healthcare setting. As of 14th February, 1716 healthcare professionals were infected with Covid-19 in China, with 6 deaths reported among them (WHO 2020).

It has been estimated in "UK Influenza Pandemic Strategy 2011" that up to 50% of the healthcare workforce may require time off during a pandemic (Department of Health 2011). This is due to infection, quarantine, childcare, care of other dependants, or transport difficulties. Applying this to the above figures of available physician and nursing resource, we find that up to about **8,000 nurses and around 2,000 physicians in critical care will have to take time off during an outbreak**. This will, in turn, have an impact on how many of the above beds can be utilised to deliver intensive care therapies, as this requires continuous presence of skilled personnel at the bedside. However, this could be mitigated by borrowing nurses and doctors from other areas of hospital because some of the skillset could be transferrable.

Other staff groups:

Non-clinical staff in the hospitals are also vital in operational processes and it has been seen in other countries during previous epidemics that this group of healthcare workers are also at increased risk of infection. Sickness among staff groups, like administrative staff or porters, can impact on treatment delivery significantly. However, not enough data is available to predict the impact on these staff groups with any degree of precision.

There are 17,543 ambulance staff, working in the NHS (NHS Digital 2020). They will be responsible for transporting suspected cases from home to hospital, putting them at particularly high risk. As with others who have primary contact with patients, there is a risk they may occasionally be exposed with no prior knowledge of the potential for a hazardous contact and without the usual personal

protective measures taken. After transfer of an infectious patient, it may take a number of hours to clean the ambulance, thereby taking ambulances out of the service and reducing the system capacity. Depletion of the ambulance service capacity will not only delay transfer of patients from home to hospital, but also of critically ill patients from secondary to tertiary care facilities.

Personal Protective Equipment:

It is envisaged that the UK has adequate stockpiles of PPE in the event of a major outbreak. However, according to a WHO report, the demand for masks and respirators has gone up by 100 times, with associated cost increase up to 20 times. Therefore, in the scenario of high disease incidence, there may be serious strains put upon the adequate supply of PPE.

A **single fit testing session** (training session identifying the right mask size for a given healthcare professional ensuring that the mask will be effective) **may take up to 30 min** (NHS Greater Glasgow and Clyde 2019). Therefore, a hospital with 100 critical care, acute medicine and emergency department physicians (consultant and junior doctors), 150 emergency and ICU nurses along with 100 allied healthcare workers will have to spend **175 (=350 * 0.5) hours of training time** on this process that is vital for the safety healthcare workers.

Impact on highly specialised services:

ECMO:

Extra Corporeal Membrane Oxygenation (ECMO) is a treatment modality that has been around for nearly last 40 years but is being increasingly used across healthcare systems in a structured manner for patients in who conventional mechanical ventilation in ICUs were failing. The patient's blood is extracted via a large cannula and then passed through an oxygenator and then returned back to the patient's body again. Thus, even in patients in almost complete lung failure, this may keep the patient alive long enough for recovery to take place. In the UK, there are 5 nationally commissioned ECMO centres (Czapran et al. 2019). The service could take up to 200-300 patients a year with additional surge capacity. Of all the patents needing advanced respiratory support, 0.3%-0.4% needed ECMO in 2016-17 (Adult ECMO Integrated impact Assessment Report for Service Specification, URN1707, NHS England). Although small in proportion, this group of severely ill patients had a survival to discharge rate of 81% (Patel BV1, Barrett NA2 2018). To put this in context, around 30%-40% of severe respiratory failure patients on mechanical ventilation usually survive to hospital discharge.

Despite the fact that the total number of commissioned beds in the UK is around 50 or less, there is a surge capacity plan in place for this service which may include standing down cardiac theatres during a severe outbreak, as equipment used in a cardiac theatre could potentially be used to deliver ECMO – The number of beds this would make available is, however, publicly not available.

In the case series describing the care of 1,099 patients (Yang et al. 2020), 5 (8%) of about 65 ventilated patients needed ECMO. This is higher than the rate (0.3-0.4%) in the UK. While the higher rate could be a cause for concern, one would assume that a very well run, criteria led referral to UK ECMO centres would probably mean that this rate would be lower in UK practice.

Prone positioning during mechanical ventilation:

Another change that has taken place in the treatment of severe acute respiratory failure in patients on mechanical ventilation is the use of prone positioning. Following the publication of the PROSEVA trial in 2013, showed that mortality was almost halved in this group of patients by adopting prone ventilation in a systematic way (Guérin et al. 2013). Although employing prone ventilation requires more training and practice by critical care teams, the accumulation of supportive evidence has led to it being adopted more widely. This may reduce the case-fatality rate previously observed for critically ill patients with severe respiratory failure in the recent epidemics.

Conclusion:

The range of possible impacts that the Covid-19 may have on the UK population and the healthcare system as a whole is very wide and uncertain. In the best-case scenario, only a small number of patients will need secondary hospital care and this small additional burden can be handled relatively easily. However, the greatly increased demand and depletion of staff taken ill themselves in some of the most severe scenarios would exceed the capacity of the service to deliver optimal care to the most severely ill patients. A centrally coordinated approach to managing these patients will be critical.

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