Estimated surgical requirements in England after COVID-19: a modelling study using hospital episode statistics

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Introduction

The Covid-19 pandemic has led to rapid changes in the provision of healthcare in both primary and secondary care settings. Critical care bed capacity has increased substantially, requiring the re-deployment of staff and the repurposing of real estate and equipment. On 15th April 2020 National Health Service (NHS) England suspended all non-urgent elective surgery for a period of three months, in part to free up 30,000 inpatient beds and in part to facilitate re-deployment of staff to other clinical areas. At the peak of the pandemic, it is likely that the majority of the 375,000 surgical procedures carried out every month in the United Kingdom were cancelled. In most cases only emergency and some urgent surgical care will have continued. However, most cancer surgery and almost all non-cancer surgery is likely to have been postponed.

As the NHS response to the pandemic develops, there is a planned re-commencement of elective surgery with a particular focus on cancer surgery. However, this is complicated by evidence of high asymptomatic carrier rates in cohort studies from China, in which all patients developed pneumonia in the postoperative period, with high rates of critical care admission and subsequent mortality. The incremental risk of surgery in patients with COVID-19 infection is unknown. Thus the optimum strategy for re-starting non-emergency surgery safely is unclear, but this may include obligatory preoperative screening of all surgical patients, use of 'hot and 'cold' sites, routine staff testing and/or universal personal protective equipment.

The purpose of this modelling analysis is to provide clinicians, service managers and policy makers with evidence to plan the safe recommencement of surgical services in the post-COVID-19 era. The over-arching aim will be to define the total number of

cancelled surgical procedures due to the pandemic response and estimate the number of surgical procedures that will be re-started according to published NHS England strategy. This will allow us to estimate the resources required to facilitate this strategy. The specific aims are to estimate:

1. How many surgical procedures have been cancelled and how many surgical procedures could be expected in future under a number of scenarios.
2. How many bed days may be required under several scenarios, depending on preoperative covid-19 investigation strategies.
3. How many patients undergoing surgery will need critical care beds.
4. How many covid-19 investigations are required to safely restart surgery under several different strategies.
5. How much personal protective equipment is required to perform these surgical procedures.

Methods

Ecological study using aggregated Hospital Episode Statistics in England from NHS Digital, with statistical modelling of caseload and process measures according to several clinical scenarios. This study will use existing, aggregated data that is in the public domain. As such, no specific research ethics or regulatory approval is required.

Outcomes

The primary outcome measure will be the number of cancelled elective procedures per month, measured as both total number of operations cancelled and operations per 100,000 head of population.

The secondary outcome measures will be:

- Total bed days required for providing surgical care
- Total critical care resource required for surgical care, measured in terms of both the total number of admissions and number of bed days.
- Number of covid-19 investigations required for screening of surgical cases, measured in terms of total number of investigations under a number of different testing approaches.
- Amount of PPE required, and the indicative cost of this, measured in terms of total:
    - Gowns
    - Gloves
    - Masks (FFP3)
    - Visor

Identification of surgical procedures

We will use two approaches to identify surgical procedures for inclusion in the analysis. Firstly, we will use the list of urgent, non-urgent and emergency procedures published by NHS England on the 11th April 2020, to assist trusts in defining which procedures should be stopped. These are divided into five groups, and each specialty has a relevant list of procedures that would go under each class (1a and 1b will be grouped together for the purpose of this study):

1a – Emergency operations needed within 24 hours

1b – Urgent operations needed within 72 hours

2 – Surgery that can be deferred for up to 4 weeks

3 – Surgery that can be delayed for up to 3 months

4 – Surgery that can be delayed for more than 3 months.

Secondly, we will use a data-driven approach to identify urgent surgical procedures (predominantly cancer surgery) using a combination of waiting times and expert review of procedure coding.

Estimation of procedure volume

To determine the likely number of cancelled procedures, the number of procedures anticipated to be performed each year in each of the above categories will first be calculated using a three-step process:

Step 1: Categorisation of procedures where possible based on procedure description

Using an existing definition of surgery, we will categorise each procedure according to one of the four classes above. This will use three-character Office for Population Censuses Surveys Classification of Interventions and Procedures (OPCS) version 4.7 codes which are used to define procedures within the NHS. This will be performed by two researchers acting independently. Where there is disagreement, the decision will be reviewed by a senior

investigator. Ambiguous procedures (for example those that may be performed both electively and emergently) will proceed to step 2.

Step 2: Data driven approach to classify procedures where step 1 is ambiguous

Using data available within the Hospital Episode Statistics Admitted Patient Care data sets from 2014/15-2018/19, the following algorithm will be followed for each procedure to determine which class it falls into:

- All emergency admissions → class 1
- Using the mean waiting time, identify procedures typically performed within 4 weeks → class 2
- Using the mean waiting time, identify procedures typically performed within 12 weeks → class 3
- All other procedures → class 4.

A sensitivity analysis will be undertaken using the median time waited rather than the mean for this measure.

Step 3: Determine the monthly number of procedures by adjusting for seasonal variation

The distribution of elective and emergency activity within the NHS is likely not evenly spread over the calendar year. HES APC data is only released on an annual basis so cannot be directly used to determine monthly frequency of procedures. Using the monthly number of elective and emergency admissions reported per month to NHS England, each month will receive a weighting for elective care and emergency care. This will be used to divide up the number of procedures into a weighted number for the time period of the study (March to June) divided according to elective or emergency care in the four categories above.

We have access to Hospital Episode data up until 31st March 2019. We will report estimated volume of specified procedures until 31st March 2021. To adjust for the average change in procedure volume, the growth for each procedure will be calculated over a 5-year period and extrapolate using a linear growth assumption to calculate the expected number

procedures during the specified time period. Procedures will be grouped according to a previously developed categorisation based on the OPCS 4.7 code. The number of patients in differing age categories (0-14, 15-59, 60-74 and 75+ years) likely to be requiring surgery will be estimated As a breakdown of age by different acuity groupings is not available, we will present the different age categories on the basis of the most frequently occurring class. For example, if most procedures of a code are in class 2, then this will contribute to the overall age profile for class 2 procedures.

Modelling

It is anticipated that only those procedures typically performed within class one and two will have continued during the pandemic response. To calculate the number of cancelled procedures during April and May 2020 we will assume that all class one procedures will have continued and the following situations will be used to determine the likely volume of cancelled class two procedures:

- 20% class 2 operations continued
- 40% class 2 operations continued
- 60% class 2 operations continued
- 80% class 2 operations continued

We will use these data to present an estimate deficit of surgical activity on 1st June 2020.

We will then model the resumption of surgical activity for all class one and class two procedures over three months assuming linear increase in activity between 1st June and 31st August 2020.

We will repeat this analysis in an iterative fashion by adding in class three procedures on 1st September 2020 and class 4 procedures on 1st December 2020.

Estimates

Based on the models developed, the following estimates will be calculated with appropriate uncertainty measures.

Inpatient bed occupancy

Number of day case procedures and number of non-day case procedures, including pooled mean length of stay. This will be presented per month.

Critical care bed occupancy

Using information from previously reported observational studies (ISOS, SNAP-2 EPPICS), we will estimate the proportion of patients in each group likely to require a critical care bed and the total number of critical care bed days.

Covid-19 testing

Undergoing surgery with pre-existing COVID-19 infection is strongly associated with mortality, to a much larger degree that would ordinarily be expected. Various methods of preoperative screening for COVID-19 have been suggested, including screening all patients by use of a questionnaire, virology testing and chest computed tomography scans to detect abnormalities. Some hospitals have used a testing strategy during the pandemic that involves admitting patients one-day prior to surgery for testing and isolation. In South Korea, patients undergoing planned surgery have a viral swab one-week beforehand, self-isolate for one-week and then have a second swab one day before hospital admission.

We will estimate the number of COVID-19 PCR tests, CT scans and additional inpatient bed days required under the following testing strategies.

1. All inpatient surgery patients have two COVID-19 PCR tests prior to surgery
2. All inpatient surgery patients have two COVID-19 PCR tests and one extra day LOS
3. All inpatient surgery patients have two COVID-19 PCR tests, a CT chest and one extra day LOS

Personal Protective Equipment

Protecting the workforce has been a key component of the response to the COVID-19 pandemic. A high proportion of patients with COVID-19 have asymptomatic disease and there is a high false-negative rate with existing tests. It is anticipated that PPE will be required in most operating theatres particularly where patients are intubated or undergoing laparoscopic procedures. In contrast to critical care and ward environments, where one set of PPE can be worn for a shift caring for many patients, surgery will likely require a new set of PPE for each case. There will be multiple care providers requiring PPE. Distribution of PPE has been a persistent challenge during this crisis and providing surgical care may make this more complicated. We will estimate the volume of PPE required for surgical care based on the assumption of eight members of staff (two surgeons, two anaesthetists, one operating department practitioner and three scrub staff), each requiring one FFP3 mask, one fluid resistant gown, one visor and two pairs of gloves person, per surgical patient.

Procedure grouping	1 – Emergency	2 – 4 weeks	3 – 3 months	4 - > 3 months
Neurosurgical				
Spinal				
Hpb				

Table 1a. Average number of procedures per year across the last 5 years for each procedure grouping. 1a-1b will be based on the three categorisation approaches.