A Best Practice Guideline for Backlog Modelling to Inform Policy Decisions During a Pandemic and Beyond

Conflicts of interest:

• Moderator / Karin Cerri: KC is a full-time employee of Johnson and Johnson Medical

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• Speaker 3 / Alexander Carter: AC reports no conflicts.

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A Best Practice Guideline for Backlog Modelling to Inform Policy Decisions During a Pandemic and Beyond

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• Speaker 2 / Jonathan Clarke, MA(Cantab), MB, BChir, MRCS(Eng), MPH, PhD, FRSA : Postdoctoral Fellow, Department of Mathematics, Imperial College London, London, UK

• Speaker 3 / Alexander Carter, BSc(Hons), MSc: Senior lecturer, Department of Health Policy, London School of Economics & Political Science, London, UK
Poll Question

What is your job?
Introduction

As of August 31, 2021, the World Health Organization (WHO) declared over 215 million confirmed cases of COVID-19 and approximately 4.5 million deaths globally. Modelling estimations predicted that 28 million medical operations would be cancelled globally over 12-week peak disruption caused by COVID-19.

Policy strategy

1) increase supply
2) reduce demand
3) provide regional/national strategies

Supply constraints during the pandemic raised important questions about the use of capacity modelling to inform policy:

- As with cost-effectiveness modelling, should capacity modelling address trade-offs between resources/costs and outcomes?
- What is the quality of published capacity models, and how do they fare against modelling-based checklists and guidance documents?
The panel will answer these questions in four steps

1. Assess the backlog in elective surgery due to COVID19 and its impact on patients and healthcare systems,

2. Review existing policies and outcomes of efforts to resolve hospital backlogs,

3. Summarize methods and results from published capacity (backlog) models, and

4. Recommend approaches to improving the quality of capacity models for policy shaping.
Poll Question

Should cancer be automatically prioritised over chronic surgical disease when managing the elective backlog?
The impact of COVID on hospital backlog

Reallocation of resources to treat patients severely affected by COVID 19, including deprioritization of non-urgent care and provision of "essential services", created a backlog in cases across multiple specialty areas.

Colorectal cancer
Upper gastrointestinal cancer and benign disease
Total hip and knee arthroplasty
Surgical outcomes during COVID

- The first surge was associated with significantly higher in-hospital mortality (IHM) for all emergency surgical patients.
- Overall IHM was 3·6% and was not significantly increased by surgical intervention (p=0·11).
- Higher Clinical Frailty Scale (CFS >7 aOR 30·83, CI 7·56-125·76) greatest predictor of IHM.

5300 patients
54 global institutions
24 countries
The impact of COVID on hospital backlog*

Colorectal cancer

- **Diagnostic services** (initial months of the pandemic): 48% to 72% decrease in new cancer diagnoses in 2020\(^5,6,7\).

- **Care pathways** disruption: 486,563 surgeries cancelled over 12 weeks in 2020 representing 35.9% of the global overall surgical volume\(^2\) (modelling).

- **4-month treatment delay**: survival reduction of \(\geq 20\%\) for Stage 3 patients, regardless of age\(^9\);

- **Some localities** reported the following implications on the need for emergency interventions:
  - 2020 vs 2019: **twice as many** patients with large bowel obstructions, increasing the need for emergency surgeries\(^5\);
  - **emergency operations**: higher rates of complications and postoperative morbidity and mortality than in the **elective setting**\(^5,10\).
Predicting endoscopic activity recovery in England after COVID-19: a national analysis

Kai Man Alexander Ho, Amitava Banerjee, Mark Lawler, Matthew D Rutter, Laurence B Lovat

Figure 2: Trends in number of endoscopy procedures from January, 2018, to October, 2020

Figure 3: Number of patients on procedure waiting lists at the end of the month from January, 2018, to October, 2020

A Colonoscopy

Lancet Gastroenterol Hepatol 2021; 6: 381-90
Global Change in Elective Colorectal Cancer Practice due to COVID-19


**Global Reach**
- 191 surgeons
- 159 hospitals
- 46 countries

**High Bed Stress Associated with National Mortality**

**Diagnostics Change**
- 74% Limited
- 19% Stopped
- 40% Limited
- 41% Limited

**Non-Surgical Rx**
- Increased use of rectal CRT when resections cease or extended delay to surgery
- 52% Limited
- 19% Stopped

**Surgical Technique**
- 7% of centers ceased operating
- 29% Decreased
- 19% Stopped
- 54% Increase on left side
Global Change in Elective Colorectal Cancer Practice due to COVID-19


**Predictors of Practice Change**

![Box plots showing changes in hospital bed stress and critical care bed stress.

Degree of practice change significantly associated with increasing hospital and critical care bed stresses.

Low stress hospitals still markedly limiting services, with rising critical care stress the biggest risk factor for complete service cessation.

Hospital or critical care bed stresses, mortality and national guidelines unable to fully account for variation.

**Change Score Domains**
- Diagnostic endoscopy
  - CT
  - MRI
  - PET
- Therapeutic endoscopy
  - Rectal NeoAdj Rx
  - Colon NeoAdj Rx
- Surgical delays
- Operator seniority
- Laparoscopy use
- Stoma formation rates
## Upper gastrointestinal cancer

- 394 fewer new cancers were detected per week in the UK\(^8\), representing \textbf{52\% increase in missed cases}\(^7\);
- \textbf{Canceled surgeries} globally over 12 weeks: \textbf{498,885}, representing \textbf{39.6\% of the overall surgical volume}\(^2\) (modelling);
- \textbf{Diagnostic endoscopies} decreased by 28\% during the initial COVID-19 outbreak in England and reached a low of 20\% of prior year volume.\(^3\)\(^3\)

There is mixed evidence on whether \textbf{time to surgery impacts overall survival or disease-free survival} in patients with early or advanced stages of \textbf{gastric cancer} \(^1\)\(^1\), \(^3\)\(^4\).
Global Change in endoscopic cancer diagnostics during COVID-19 in England

• Nationally – OGD activity fell by 88.7% in April 2020.
  • (49877 vs 5638 in April 2019).

• 750 oesophageal and gastric cancers undiagnosed across England between Jan and April 2020

• Of these 213 would have been treated curatively

Reports in the literature suggested that delayed surgery may:

- Prolong and intensify pain\textsuperscript{13};
- Induce higher morbidity and mortality rates for hip surgery\textsuperscript{13};
- Induce muscle wasting from decreased mobility and increase pain for knee surgery\textsuperscript{13,24};
- Increase anxiety and emotional distress\textsuperscript{15}.

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The impact of COVID on hospital backlog

*Total hip and knee arthroplasty*

- Patients awaiting surgery: 885,286 to 1,028,733 in England as of November 2020\textsuperscript{12}.
- Global cancellation of elective orthopedic surgeries: at least 6 million during the 12 weeks, representing 82\% of the standard surgical volume\textsuperscript{2}.
Determinants of burnout and other aspects of psychological well-being in healthcare workers during the Covid-19 pandemic: A multinational cross-sectional study

Max Demming, Ee Teng Goh, Benjamin Tan, Abhiram Kanneganti, Melanie Almonte, Alasdair Scott, Guy Martin, Jonathan Clarke, Vilnesag Soundaresan, Sheraz Malik, Jan Probyłowicz, Yong Huai Chan, Ching-Hui Sue, [---]. James Kinross [view all]

Published: April 16, 2021 - https://doi.org/10.1371/journal.pone.0238666

Significant predictors of burnout:
- Patient-facing roles
- Redeployment
- Bottom quartile SAQ score
- Anxiety and depression.

Significant factors inversely correlated with burnout included:
- Tested for SARS-CoV-2
- Top quartile SAQ score

93,000 NHS vacancies
Submission to the Health and Social Care Select Committee inquiry into clearing the backlog caused by the pandemic

Introduction

The King’s Fund is an independent charitable organisation working to improve health and care in England. Our vision is that the best possible health and care is available to all. We aim to be a catalyst for change and to inspire improvements in health and care by:

- generating and sharing ideas and evidence
- offering rigorous analysis and independent challenge
- bringing people together to discuss, share and learn
- supporting and developing people, teams and organisations
- helping people to make sense of the health and care system.

This is timely and important inquiry. Effective waiting lists were growing and performance targets were missed even prior to the start of the COVID-19 pandemic. Since then, the pandemic has had a significant impact, with waiting lists growing and waiting times exceeding benchmarks in both elective and emergency care. Even in the pandemic, patients faced challenges in accessing high quality care in other areas such as mental health services, and as with other care, many of these challenges have worsened due to COVID-19.

At least, longer waiting will mean interventions and interventions for patients, for the first time, it will matter; personal choice and control. These improvements will also be a fundamental change. Not least, it is essential that we avoid an expectation that volume-native services in a way that is a broader and deeper work, and as a result, they are not appropriate. The King’s Fund believes that these challenges, in a way that is broader and deeper, will be a significant improvement in the way services are delivered.

Key points

- The main task of clearing the waiting list backlog will be one of the biggest challenges facing the NHS in the years ahead. Effective partnerships between local health and care organisations will be crucial to making this happen.
- The recovery will challenge all parts of the NHS, from hospitals delivering care to primary care working with local demand, to increased pressures on community, ambulance and mental health trusts as they support patients to work until the pandemic has passed. The Fund has already seen moves to improve the efficiency and effectiveness of existing services.
3.54. The NHS provides an excellent testbed for assessing new innovations, but such assessments have not always been done as quickly as they could be. The NHS needs to prepare for implementation of these developments right now.
Policy interventions to resolve backlog

The frameworks for resuming elective services and attenuating the backlog of case volume in oncology and orthopedics share some commonalities: deploy pre-COVID strategies to shorten the waiting lists for elective care, adopt policy strategies to increase the supply and reduce the demand of services\textsuperscript{18}.

Increase supply\textsuperscript{18}

- Paying for increased activity;
- Increasing capacity through the private sector, using existing capacity more efficiently;
- Giving patients a choice to redirect to a different hospital to reduce waiting lists.

Reduce demand\textsuperscript{3}

- Short term - prioritization or triage schemes, eliminating waste (unnecessary tests and treatments);
- Short term - Setting mandatory targets with direct incentives for meeting them;
- Medium-long term - investing in health promotion and primary care to prevent the need for treatment;
- Medium-long term - encouraging hospital competition.
Poll Question

Did the appropriate backlog models come too late to inform policy decisions to prevent/battle backlogs early on?
Modelling-based approaches to managing hospital backlog

In early 2020, healthcare organizations globally sought to understand the implications of the COVID-19 pandemic on their clinical pathways. At Imperial College London we undertook several early analyses to support local decision making.

Case study 1: How should hospitals manage the backlog of patients awaiting surgery following the COVID-19 pandemic? A demand modelling simulation case study for carotid endarterectomy

Guy Martin, Jonathan Clarke, Sheraz Markar, Alexander W. Carter, Sam Mason, Sanjay Purkayastha, Ara Darzi, James Kinross
doi: https://doi.org/10.1101/2020.04.29.20085183

Case study 2: New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England: a retrospective observational study

Jonathan Clarke, Alice Murray, Sheraz Rehan Markar, Mauricio Barahona, James Kinross, PanSurg Collaborative

doi: 10.1136/bmjopen-2020-042392.
Case Study 1: How should hospitals manage the backlog of patients awaiting surgery following the COVID-19 pandemic? A demand modelling simulation case study for carotid endarterectomy

- **Aim:**
  - To better understand the tradeoff between cessation of Carotid endarterectomy (CEA) surgical services and the required expansion of capacity after resumption of services.

- **Setting:**
  - CEA surgical pathways in the UK in the first wave of the COVID-19 pandemic.

- **Rationale:**
  - CEA is a time-sensitive surgical procedure, which is most effective if delivered within 2 weeks of a cerebrovascular accident and is not effective after 12 weeks.
  - Redeployment of surgical teams and use of operating theatres as ICUs reduced capacity for CEA surgery.
Modelling-based approaches to managing hospital backlog

Case Study 1: How should hospitals manage the backlog of patients awaiting surgery following the COVID-19 pandemic? A demand modelling simulation case study for carotid endarterectomy

Compartmental model based on:
- No change in daily rate of patients requiring CEA (74/week)
- 3 month total cessation of CEA procedures

Two varying parameters:
- Time taken to return to baseline capacity
  - Range: 0-19 weeks
- Increase above baseline capacity to resolve backlog
  - Range: 0– 100%

Outcomes:
- % of patients receiving surgery within 2 weeks
- % of patients receiving surgery within 12 weeks
Modelling-based approaches to managing hospital backlog

**Case Study 1:** How should hospitals manage the backlog of patients awaiting surgery following the COVID-19 pandemic? A demand modelling simulation case study for carotid endarterectomy.
Case Study 1: How should hospitals manage the backlog of patients awaiting surgery following the COVID-19 pandemic? A demand modelling simulation case study for carotid endarterectomy

• Conclusions:
  • Simple compartmental model to support important clinical tradeoffs
  • Framed around actions and outcomes relevant to clinicians
  • Does not propose a single optimum
  • Gives an idea of the scale of the potential backlog and the relative impact of different actions
Modelling-based approaches to managing hospital backlog

Case Study 2: New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England

- **Aim:**
  - To identify the extent to which collaboration between surgical centres may be used to reduce backlog in planned surgical care

- **Setting:**
  - Planned surgical care for common, low-risk procedures in the National Health Service in England.

- **Rationale:**
  - Much of the surgical backlog involves a small number of low-risk procedures
  - Pooling of resources between surgical centres may allow for surgical capacity to be maintained while providing COVID-19 care
Modelling-based approaches to managing hospital backlog

Case Study 2: New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England

- Examined 7,811,891 planned surgical admissions
- April 2017 – March 2018
- 26 procedures accounted for > 50% of all operations
- 61.7% of operations were in ‘low-risk’ individuals
- Patients travelled an average of 11.7km for surgery

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Total number of cases</th>
<th>Patient risk Low risk (%)</th>
<th>Medium risk (%)</th>
<th>High risk (%)</th>
<th>Mean distance travelled (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower GI endoscopy</td>
<td>937 616</td>
<td>74.8</td>
<td>17.9</td>
<td>7.3</td>
<td>9.9</td>
</tr>
<tr>
<td>Upper GI endoscopy</td>
<td>650 133</td>
<td>68.9</td>
<td>22.1</td>
<td>9.0</td>
<td>9.4</td>
</tr>
<tr>
<td>Lens extraction/ replacement</td>
<td>395 445</td>
<td>33.5</td>
<td>45.5</td>
<td>17.5</td>
<td>10.9</td>
</tr>
<tr>
<td>Excision of skin lesion</td>
<td>215 809</td>
<td>55.0</td>
<td>29.5</td>
<td>15.5</td>
<td>12.7</td>
</tr>
<tr>
<td>Injection/aspiration joint</td>
<td>142 562</td>
<td>71.6</td>
<td>20.9</td>
<td>7.5</td>
<td>12.6</td>
</tr>
<tr>
<td>Vitrrectomy</td>
<td>132 938</td>
<td>39.9</td>
<td>44.1</td>
<td>16.1</td>
<td>13.2</td>
</tr>
<tr>
<td>Cystoscopy</td>
<td>130 114</td>
<td>58.4</td>
<td>26.2</td>
<td>17.4</td>
<td>11.8</td>
</tr>
<tr>
<td>Insertion of central venous catheter</td>
<td>109 864</td>
<td>24.3</td>
<td>38.3</td>
<td>37.4</td>
<td>14.0</td>
</tr>
<tr>
<td>Coronary angiography</td>
<td>105 620</td>
<td>58.2</td>
<td>30.0</td>
<td>13.6</td>
<td>13.9</td>
</tr>
<tr>
<td>Dental extraction</td>
<td>101 435</td>
<td>91.6</td>
<td>5.8</td>
<td>2.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Knee replacement</td>
<td>79 773</td>
<td>53.3</td>
<td>34.4</td>
<td>12.3</td>
<td>13.4</td>
</tr>
<tr>
<td>Bladder catheterisation or irrigation</td>
<td>71 552</td>
<td>42.5</td>
<td>32.7</td>
<td>24.8</td>
<td>12.8</td>
</tr>
<tr>
<td>Injection to bladder</td>
<td>68 167</td>
<td>34.3</td>
<td>29.8</td>
<td>35.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Spinal facet joint injection</td>
<td>84 154</td>
<td>70.4</td>
<td>21.8</td>
<td>7.7</td>
<td>14.0</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>61 700</td>
<td>80.5</td>
<td>13.8</td>
<td>5.7</td>
<td>11.8</td>
</tr>
<tr>
<td>Lymph node biopsy</td>
<td>60 674</td>
<td>34.8</td>
<td>34.4</td>
<td>30.8</td>
<td>14.9</td>
</tr>
<tr>
<td>Epidural or spinal injection</td>
<td>60 656</td>
<td>69.2</td>
<td>22.6</td>
<td>8.1</td>
<td>12.9</td>
</tr>
<tr>
<td>Inguinal hernia repair</td>
<td>58 943</td>
<td>72.6</td>
<td>19.9</td>
<td>7.5</td>
<td>10.9</td>
</tr>
<tr>
<td>Spinal nerve root injection</td>
<td>58 212</td>
<td>77.0</td>
<td>17.5</td>
<td>5.5</td>
<td>16.2</td>
</tr>
<tr>
<td>Knee meniscectomy/meniscal repair</td>
<td>57 871</td>
<td>93.2</td>
<td>5.9</td>
<td>0.6</td>
<td>12.4</td>
</tr>
<tr>
<td>Hysteroscopy</td>
<td>52 300</td>
<td>90.9</td>
<td>6.4</td>
<td>2.7</td>
<td>9.9</td>
</tr>
<tr>
<td>Carpal tunnel release</td>
<td>48 245</td>
<td>70.7</td>
<td>22.2</td>
<td>7.1</td>
<td>11.0</td>
</tr>
<tr>
<td>Application/removal of internal fixation of bone</td>
<td>40 771</td>
<td>84.6</td>
<td>11.9</td>
<td>3.5</td>
<td>15.7</td>
</tr>
<tr>
<td>Dental clearance</td>
<td>43 463</td>
<td>82.3</td>
<td>11.7</td>
<td>5.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Partial breast excision</td>
<td>41 827</td>
<td>50.1</td>
<td>31.4</td>
<td>18.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Bone marrow biopsy</td>
<td>38 369</td>
<td>39.8</td>
<td>34.8</td>
<td>25.5</td>
<td>15.6</td>
</tr>
<tr>
<td>Primary joint resurfacing</td>
<td>37 854</td>
<td>59.3</td>
<td>30.1</td>
<td>10.5</td>
<td>14.0</td>
</tr>
<tr>
<td>Cystoscopy + resection of bladder lesion</td>
<td>37 458</td>
<td>17.7</td>
<td>29.8</td>
<td>52.5</td>
<td>11.2</td>
</tr>
</tbody>
</table>
Case Study 2: New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England

- Markov Multiscale Community Detection applied to an LSOA similarity matrix
- Three stable partitions identified over different scales
Case Study 2: New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England

Division of England into 45 (panel A), 16 (panel B) and 7 (panel C) surgical communities (in colour), according to Markov stability. Sustainability and transformation partnership (STP) boundaries are overlaid (black lines).
Modelling-based approaches to managing hospital backlog

Case Study 2: New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England

The absolute percentage difference between the number of patients undergoing surgery resident within a surgical community (demand) and the number of procedures performed by hospitals within the community (supply) for configurations of 45 (panel A), 16 (panel B) and 7 (panel C) surgical communities. Areas in blue represent those surgical communities where procedures performed on patients outnumber those performed by the local providers.
Modelling-based approaches to managing hospital backlog

**Case Study 2:** New geographic model of care to manage the post-COVID-19 elective surgery aftershock in England

- **Conclusions:**
  - Many planned surgical procedures involve low-risk patients, and are provided close to a patient’s home.
  - Provision of planned surgical services through collaboration between providers may help to reduce the backlog.
  - Disagreement exist between ‘data driven’ communities and administrative boundaries which may inform the collaboration between providers.
  - Mismatches between supply and demand within localities indicates larger surgical communities may be more effective.
A literature search was conducted to identify mathematical models to optimize hospital backlog. Models were assessed using a checklist from the ISPOR task force on optimization methods emerging good practices, which focuses on constrained optimization methods in health services research.

**Modelling**
- Problem structuring
- Mathematical formulation
- Model development
- Model validation

**Optimization**
- Optimization method
- Optimization/sensitivity analyses
- Reporting of results
- Decision making
## Modelling-based approaches to managing hospital backlog

<table>
<thead>
<tr>
<th>STAGE</th>
<th>STEP</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODELLING</td>
<td>Problem structuring</td>
<td>Specify the objective(s) and constraints, identify decision variables and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>parameters, and list and appraise model assumptions</td>
</tr>
<tr>
<td></td>
<td>Mathematical formulation</td>
<td>Present the objective function(s) and constraints in mathematical notation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>using decision variables and parameters</td>
</tr>
<tr>
<td></td>
<td>Model development</td>
<td>Program the model in software to estimate the objective function(s) and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>constraints using decision variables and parameters as inputs</td>
</tr>
<tr>
<td></td>
<td>Model validation</td>
<td>Ensure the model is appropriate for evaluating different combinations of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decision variables and parameters</td>
</tr>
</tbody>
</table>
## Modelling-based approaches to managing hospital backlog

<table>
<thead>
<tr>
<th>STAGE</th>
<th>STEP</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTIMIZATION³⁰</td>
<td>Select optimization method</td>
<td>Choose an appropriate optimization method and algorithm based on the characteristics of the problem.</td>
</tr>
<tr>
<td></td>
<td>Perform optimization/sensitivity analysis</td>
<td>Use the optimization algorithm to search for the optimal solution and examine the performance of the optimal solution for reasonable sets of parameters.</td>
</tr>
<tr>
<td></td>
<td>Report results</td>
<td>Report the results of the optimal solution and sensitivity analyses.</td>
</tr>
<tr>
<td></td>
<td>Decision making</td>
<td>Interpret the optimal solution and use it for decision making.</td>
</tr>
</tbody>
</table>
The identified **13 models** are a mix of optimization and forecasting models; an overview of results from the **modelling checklist for these publications is as follows:**

### Problem structuring
1. Narrative description: \( \frac{5}{13} \), 20-24
2. Narrative description, objective and decision variables: \( \frac{1}{13} \), 25
3. Full overview of the problem structure: \( \frac{2}{13} \), 26, 27
4. Complete overview of problem structure, separate overview of variables, input parameters, and assumptions: \( \frac{5}{13} \), 4, 28-31

### Mathematical formulation
1. Mathematical notation for the variables, parameters, and the model itself: \( \frac{2}{13} \), 28, 30
2. Narrative description of the model: \( \frac{11}{13} \), 4, 21-27, 31

### Model validation
1. Not perform or report validation: \( \frac{6}{13} \), 20-25
2. Internal validation: \( \frac{2}{13} \), 28, 26
3. Both internal and external validation: \( \frac{5}{13} \), 4, 27, 29-31
As the model builders had more insights into the available data and the purpose of the model, it was not possible to assess the suitability of the method choice.

**Forecasting models**

- Supply and demand modelling, wherein differences between supply and demand resulted in backlog per cycle\(^{20,21,25,26,31}\);

- Linear regression models that used national data sets to forecast expected surgical volume over time, with introduction of backlog scenarios to quantify postponed surgeries\(^{22,23}\);

- Linear forecasting was used in one study, combined multiple operational/supply constraints to predict the total financial impact of delayed surgeries\(^{27}\).
Overview of model review: optimization checklist

As the model builders had more insights into the available data and the purpose of the model, it was not possible to assess the suitability of the method choice.

**Optimization models**

- Discrete event simulation to model the workflow in an ambulatory center³;
- Machine learning models/tools to maximize efficiency of operation room time and/or predict surgical resource requirements²⁴,³⁰; and
- State-transition models (cohort or individual-patient) to quantify disability-adjusted life years (DALYs) or due to delayed surgeries²⁸,²⁹.
Overview of model review: optimization checklist

Performing an optimization/sensitivity analysis

Sensitivity analysis was inconsistently reported and not routinely robust

4/13 studies do not report any form of sensitivity analysis\(^{20, 23-25}\);

3/13 studies did not run a stochastic sensitivity analysis; however, they did perform scenario analyses\(^{22,27,30}\);

4/13 models ran a complete stochastic sensitivity analysis\(^{4,21,26,29}\);

2/13 models reported both stochastic sensitivity analysis and different scenarios\(^{28,31}\).
Finally, each model describes the optimal solution or forecast and interprets how this can be used for decision-making. When assessing how each model is used for decision-making, there are two different approaches.

**First approach:** the model is built for a specific problem and gives a practical application, such as optimizing the operating room workflow or surgical demand forecasting, and evaluates model performance/validity after its implementation 20,24-26,30;

**Second approach:** takes a broader approach to model structure, allowing consideration of a broad set of policy challenges, where the model allows for different scenarios to assess those policies4,20-23,28,29,31.
Policy recommendations for future model development

Further policy recommendations for developing these mathematical models: based on the evaluation of existing models for optimal backlog management due to COVID-19 and using the current ISPOR task force on optimization methods.

Model the flow of patients across settings

Consistent with other models in health economics, it is possible to model current treatment methods versus new policies and/or treatment methods. There are clear similarities between modelling methods.

Mathematic notations to describe the model

Provide mathematic notations to describe the model, because currently only two out of the thirteen models use mathematical notation to describe their model, which limits reproducibility.

Internal and external validation of models

Validation encompasses essential steps in model development and some improvement can be made in this domain – only six out of thirteen models reported validation methods and findings.
Policy recommendations for future model development

Currently, outcomes are varied and include reduction in hospital backlog over time and DALY minimization due to delayed surgeries\(^{24,29}\). The report of the ISPOR task force on best practice modelling suggests approaches for modelling disease pathways, as well as for comparing effects of different treatment options in terms of life years and costs\(^{32}\). Variation may be appropriate based on local health priority.

As the goal of (elective) surgeries is to improve population health, patient-centered measures such as life years, quality-adjusted life years (QALY), or DALYs should be used when feasible, with consideration of financial constraints and/or assessment of incremental cost-effectiveness or cost-utility ratios (ICER or ICUR). These approaches would provide decision makers with outcomes in common units, thereby facilitating comparison across disparate specialty areas, provider organizations and/or geographies\(^{30,23}\). Additional measures which reflect broader societal burden may be considered, as needed.
Poll Question

What is the most appropriate output / outcome measure for backlog modelling?
The pandemic has caused a **massive increase in hospital backlog**, especially in **elective surgeries** where most were cancelled or delayed. This is likely to result in clinical, medical resource use and economic impact, as well as potential quality-of-life loss for patients whose surgery is postponed.

**Conclusions**

Guidelines and consistency are required for hospital backlog modelling to be part of the solution and recognize these models in health care. The **ultimate goal** is to achieve what health economic modelling has done in payer decisions for the introduction of new medicines into markets, where the cost is set off against the gain in quality of life or more broadly by incorporating the patient perspective and evaluating the economic or societal impact.
Bibliography


Bibliography


