

TITLE PAGE

Title: Cancelled operations in the UK – a 7 day cohort study of planned adult inpatient surgery in 245 NHS hospitals

Authors:

D. J. N. WONG ^{*1,2}

S. K. HARRIS ³

S. R. MOONESINGHE ^{1,2}

on behalf of the SNAP-2: EPICCS collaborators ⁴

* Corresponding author, postal address: 35 Red Lion Square, London WC1R 4SG, UK; e-mail: dwong@rcoa.ac.uk; telephone number: +44(0)7833678225

¹ UCL/UCLH Surgical Outcomes Research Centre (SOuRCe), Department of Applied Health Research, University College London, 1-19 Torrington Place, London WC1E 7HB, UK

² Health Services Research Centre, National Institute of Academic Anaesthesia, Royal College of Anaesthetists, Churchill House, 35 Red Lion Square, London WC1R 4SG, UK

³ Bloomsbury Institute of Intensive Care Medicine, University College London, Gower Street, London WC1E 6BT, UK

⁴ A full list of collaborators and their affiliations is included in the Supplementary Material.

ABSTRACT

Background: Cancellation of planned surgery impacts substantially on patients and health systems. This study describes the incidence and reasons for cancellation of inpatient surgery in the UK National Health Service (NHS).

Methods: We conducted a prospective observational cohort study over 7 consecutive days in March 2017 in 245 NHS hospitals. Occurrences and reasons for previous surgical cancellation were recorded. Using multilevel logistic regression, we identified patient- and hospital-level factors associated with cancellation due to inadequate bed capacity.

Results: We analysed data from 14,936 patients undergoing planned surgery. 1,499 patients (10.0%) reported previous cancellation for the same procedure; contemporaneous hospital census data indicated that 13.9% patients attending inpatient operations were cancelled on the day of surgery. Non-clinical reasons, predominantly inadequate bed capacity, accounted for a large proportion of previous cancellations. Independent risk factors for cancellation due to inadequate bed capacity included requirement for postoperative critical care (OR = 2.92, 95% CI: 2.12–4.02, $p < 0.001$) and the presence of an Emergency Department (ED) in the treating hospital (OR = 4.18, 95% CI: 2.22–7.89, $p < 0.001$). Patients undergoing cancer surgery (OR = 0.32, 95% CI: 0.22–0.46, $p < 0.001$), obstetric procedures (OR = 0.17, 95% CI: 0.08–0.32, $p < 0.001$), and expedited surgery (OR = 0.39, 95% CI: 0.27–0.56, $p < 0.001$) were less likely to be cancelled.

Conclusions: A significant proportion of patients presenting for surgery have experienced a previous cancellation for the same procedure. Cancer surgery is relatively protected but

bed capacity, including post-operative critical care requirements, are significant risk factors for previous cancellations.

KEYWORDS

Surgery; Health Services Research; Cancellations;

INTRODUCTION

Last-minute cancellation of surgery can have significant adverse consequences on patient experiences and outcomes.¹⁻³ In the UK, operational pressures faced by the National Health Service (NHS) feature prominently in news reports and the medical literature, especially during the winter season when there is an increased rate of emergency admissions.^{4, 5} During the 2017/18 winter, NHS England went so far as to recommend that all hospitals cancel elective surgery during January, to mitigate against the competing pressure on emergency services.⁶ Cancellations are, however, not just a winter problem, and may be due to other factors including unexpected changes in health affecting fitness for surgery, inadequate patient preparation and logistical reasons such as staffing issues or equipment failure.⁷⁻¹³ Elective surgical cancellation rates appear to be rising, even after accounting for seasonal fluctuations.¹⁴

The rates of surgical cancellations attributable to different risk factors are not known: current collated reports of cancellations at a national level do not record causes, and studies which have looked at this issue have been predominantly small samples or single centre evaluations.⁷⁻¹³ We therefore undertook a national study to explore the incidence of cancellations, and risk factors for cancellation at patient and hospital level. We focused in particular on cancellations of planned surgery due to insufficient bed capacity.

METHODS

This was a planned analysis of data collected as part of the Second Sprint National Anaesthesia Project: EPIdemiology of Critical Care provision after Surgery (SNAP-2: EPICCS) study – a prospective observational study into perioperative risk and critical care provision for adult inpatient surgery.¹⁵ We report our findings in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.¹⁶ All hospitals in the United Kingdom undertaking adult surgery were approached to participate via their Quality Audit and Research Coordinator (QuARC): this is a network of anaesthetists managed by the Health Services Research Centre (HSRC) based at the Royal College of Anaesthetists.¹⁷ All patients undergoing inpatient surgery (defined as a procedure requiring the care of an anaesthetist and requiring an overnight stay in hospital) during a one week period, 21–27 March 2017, were eligible for recruitment. Ethical approval was obtained from the Health Research Authority (South Central - Berkshire B REC, reference number: 16/SC/0349). Permission to collect patient identifiable data without consent was granted through Section 251 exemption from the Confidentiality Advisory Group for England and Wales (CAG reference: 16/CAG/0087), and the NHS Scotland Public Benefit and Privacy Panel for Health and Social Care (PBPP reference: 1617-0126). Individual Health and Social Care Trust research and development department approvals were obtained for sites in Northern Ireland.

Patient demographic and perioperative variables were collected prospectively by local clinicians providing clinical care (see Supplementary Material, Case Record Form). Only patients undergoing planned surgery have been included in this analysis: we have defined

this as cases classified as elective or expedited according to the criteria established by the National Confidential Enquiry into Patient Outcome and Death.¹⁸ Clinicians recorded whether these patients had experienced a previous cancellation for the same surgical procedure, and the reason for this earlier cancellation, categorized as follows: insufficient bed capacity; clinical reasons; reasons not known; or other reasons which were reported as free-text. Free text responses were classified into the following categories: administrative error, patient did not attend, equipment problem, personal reasons (e.g. patient no longer wishing to undergo surgery), staff unavailable, and insufficient theatre capacity. The primary outcome was previous cancellation of the same operation due to inadequate bed capacity (“historical cancellations”). Each hospital additionally reported the number and reasons for day-of-surgery cancellations for each day of the recruitment period (“contemporaneous cancellations”), and described structural characteristics in an organisational survey.¹⁹

Statistical Analysis

We report the incidence of historical cancellations in patients who proceeded to surgery during the period and incidence of contemporaneous cancellations during the study. We also report the reasons for both types of cancellations. Descriptive statistics for normally distributed continuous data are reported with the mean and standard deviation (SD), and for non-normally distributed data with the median and interquartile (IQR) range. Continuous data were assessed for normal distribution using histogram plots and the two-sided Kolmogorov-Smirnov test. For all analyses, a p-value of <0.05 was considered statistically significant.

Multilevel regression modelling of historical cancellations

We modelled reported previous cancellations due to insufficient bed capacity in a two-level (patients nested within hospitals) multivariable logistic regression model with random intercepts for hospitals. Multilevel regression modelling considers the fact that cancellations may cluster within hospitals during the study period and therefore may have correlated errors^{20, 21}. The random intercept introduced in our model allows for the cancellations to be more frequent in one hospital than another, and reduces bias in the estimates of other model coefficients. We performed a complete cases analysis (excluding cases with missing data) as we considered the proportion of cases with missing values to be negligible (1.0% of total cases).²² The predictor variables were chosen *a priori* based on clinical plausibility and face validity for influencing cancellations, and to adjust for potential differences due to case-mix. Hospital level continuous variables (hospital bed numbers, critical care bed capacity, general surgical bed capacity) were standardized by subtracting the mean and dividing by the standard deviation before entering the model. Patient-level variables included: age (categorised into three groups: 18–64, 65–79 and ≥80 years)²³; American Society of Anesthesiology Physical Status (ASA) grades (I or II, III, and IV or V)^{23, 24}; urgency of operation (NCEPOD-Expedited vs. NCEPOD-Elective); operative severity (Minor, Intermediate, Major, Xmajor and Complex, as defined by AXA-PPP procedure codes)^{23, 25}; surgical specialty (categorized into eight groups, Supplementary Material); whether the patient was admitted to hospital prior to surgery, whether the surgery was as part of a cancer pathway, and whether postoperative critical care admission was required.

Hospital-level variables included: hospital size (as measured by the total number of hospital beds); critical care bed capacity (the proportion of critical care beds within total hospital beds); general surgical bed capacity (the proportion of general surgical ward beds within total hospital beds); presence of an emergency department; provision of tertiary services (any one from a list of 16 tertiary services, see Supplementary Material), and provision of enhanced care ward beds. Critical care beds were defined as Level 2 or Level 3 beds according to Intensive Care Society and Faculty of Intensive Care Medicine definitions.^{26,27} Enhanced care ward beds were defined as areas within the hospital with bed capacity to provide any subset of critical care interventions outside of the traditional Intensive Care or High-Dependency Unit (ICU/HDU).^{19,28}

Model performance was assessed by computing the Area Under the Receiver Operating Characteristic Curve (AUROC), which can take values between 0.5 and 1.0, where <0.7 identifies a model with poor performance, 0.7–0.8 indicates acceptable performance, 0.8–0.9 indicates good performance, and >0.9 indicates high performance. We report the estimated Odds Ratios (OR), Wald 95% Confidence Intervals (CI) of these ORs and associated p-values of the fixed-effects components for our final mixed-effects model.

Contemporaneous day-of-surgery cancellations

In addition to the historical cancellations data reported by individual patients, we also collected the number of day-of-surgery cancellations due to insufficient bed capacity for each day of patient recruitment reported at each hospital. This aggregated contemporaneous data was collected to estimate the incidence of cancellations during the one week of patient data collection. We then used this aggregated data to perform a

sensitivity analysis to confirm that the hospital-level associations detected in our multilevel logistic regression model were similar to those estimates in the patient level data on previous cancellations. This was performed using a zero-inflated Poisson regression model in which the response variable (cancellations per day) was regressed against the same hospital-level variables as in our earlier model, with additional variables for the day-of-the-week (see Supplementary Material for the full model).

Analyses were performed using the R Statistical Computing language (R version 3.4.2, R Foundation for Statistical Computing, Vienna, Austria), with the following packages enabled: `tidyverse`, `lme4`, `sjPlot`, `tableone`, `pvc1`. Multilevel logistic regression models were constructed using the `glmer` command; zero-inflated Poisson models were constructed using the `zeroinfl` command. Code for all analyses are available on request.

RESULTS

Hospital and Patient Characteristics

Of 263 hospitals across the UK invited to participate in the SNAP-2: EPICCS study, 245 hospitals submitted patient data (response rate = 93.2%). These hospitals operated within 156 English NHS Trusts, Scottish and Welsh NHS Health Boards, and Northern Irish Health and Social Care Trusts, this study therefore reports data from 90.2% of UK secondary care organisations offering adult surgical services. During the one-week recruitment window, data were collected on 14,936 patients who underwent elective or expedited inpatient surgery, and complete data for analysis were available for 14,796 cases (Figure 1).

There were 1,499 patients (10.0%) who had their surgery cancelled at least once for the same procedure. Patients previously cancelled because of insufficient bed capacity were older, had higher ASA grades, were more likely to be undergoing Xmajor or complex surgery, and more likely to require postoperative critical care (Table 1). The most common single cause of previous cancellation was for clinical reasons (33.3%); however, insufficient bed capacity (31.0%), and insufficient operating theatre capacity (12.7%) and other potentially avoidable non-clinical reasons accounted for approximately 50% of cancellations (Table 2).

Multilevel logistic regression modelling of historical cancellations

Our multilevel logistic regression model (Table 3) exhibited good discrimination (AUROC = 0.82, 95% CI: 0.81–0.84). The only patient-level predictor (Figure 2) identified in our

model which increased the likelihood of cancellation was the requirement for postoperative critical care (OR = 2.92, 95% CI: 2.12–4.02, $p < 0.001$).

In contrast, surgery for the treatment of cancer (OR = 0.32, 95% CI: 0.22–0.46, $p < 0.001$), obstetric procedures (OR = 0.17, 95% CI: 0.08–0.32, $p < 0.001$), and NCEPOD-Expedited surgery (OR = 0.39, 95% CI: 0.27–0.56, $p < 0.001$) were associated with reduced odds of previous cancellation.

Hospital-level predictors (Figure 3) associated with cancellation were: presence of emergency departments (OR = 4.18, 95% CI: 2.22–7.89, $p < 0.001$), and the presence of enhanced care ward areas (OR = 1.62, 95% CI: 1.13–2.33, $p = 0.009$).

Contemporaneous day-of-surgery cancellations

During our one-week study period, a total of 3,724 cases were cancelled or rescheduled on the day-of-surgery, and 22,993 operations proceeded ahead. We therefore estimate that 13.9% of cases that week were cancelled on the day of surgery. Of these contemporaneous cancellations, 377 cases (10.1%) were due to insufficient bed capacity, and 1,029 cases (27.6%) were cancelled for clinical reasons. In the remaining 2,110 cases (56.7%) no reason for the cancellation was specified. A sensitivity analysis conducted via zero-inflated Poisson regression using this contemporaneous data confirmed the hospital-level associations identified in the multilevel logistic regression model (Supplementary Material).

DISCUSSION

Principal findings

In this national one-week study, 10% of patients attending hospital for planned inpatient surgery had previously experienced at least one cancellation for the same procedure.

Multilevel logistic regression modelling demonstrated the association between treatment in a hospital with an emergency department and an increased risk of cancellation. Patient-level risk factors for cancellation included the need for a postoperative critical care bed; however, cancer surgery, expedited surgery and obstetric procedures were less likely to be cancelled. A large proportion of previous cancellations were due to non-clinical factors such as capacity or other hospital factors, and approximately 30% were due to clinical reasons.

Study strengths and limitations

To our knowledge, this study provides the most comprehensive UK data for rates and reasons for surgical cancellations to date, with data from more than 90% of UK secondary care organisations offering adult surgical services. Our findings are therefore likely to be generalisable across the NHS and immediately relevant to healthcare policymakers, but may have limited generalisability outside of the UK. Previous research on this topic has been limited to single-centre reports.⁷⁻¹³ Estimates of the incidence of cancellations from these older studies therefore vary widely, ranging from 0.15% to 39.0% of planned surgical cases.^{8, 12} Acknowledged difficulties with defining the denominator of how many operations are performed in the UK²⁹ means that it is difficult to estimate the proportion of operations

which are cancelled using administrative data. NHS England publishes time-series statistics of elective surgery cancellations for non-clinical reasons, including the absolute number of cancellations and these numbers as a percentage of the number of total hospital admissions each quarter.³⁰ Our data correlate well with the number of cancellations recorded by NHS England during the same period in 2017 while additionally recording all causes of cancellations, not just non-clinical. Therefore, the comprehensiveness of our sample, along with the provision of denominator data, provides for the first time, robust national data which may be used to generate and test hypotheses to address the issue of surgical cancellations.

Limitations of this study include its 1 week cohort design, as the rates and reasons for cancellations in a week in March may not necessarily represent those occurring throughout the year. It is well-known that surgical cancellations follow a seasonal variation, with substantially higher cancellations occurring during the winter months.¹⁴ Time-series methods of analysing cancellations have previously been suggested for tracking and monitoring variation in cancellation within individual institutions over time for the purpose of measuring hospital-level service quality³¹. Ideally, we would have liked to collect data over a longer duration in order to model cancellations over time, however, maintaining the quality and granularity of the data we wanted is likely to have been infeasible across the almost 250 hospitals in our study.

We also could not distinguish between clinical cancellations due to inadequate preoperative preparation, (for example, failure to stop anticoagulants or poor patient optimisation); or unpreventable acute illness (for example respiratory tract infection).

Finally, as we modelled historical cancellations in patients who eventually underwent surgery, we may not have captured patients who had planned surgery cancelled but then subsequently presented for emergency surgery or died; thus, we may have underestimated both the incidence and the impact of cancellations in our methodology. Future studies or audits of avoidable cancellations should consider these issues in design.

Clinical implications

Our study highlights that a substantial proportion of patients who undergo inpatient surgery are cancelled at least once, representing both an opportunity cost to the NHS, and distress and potential harm to patients.¹⁻³ Cancellations prolong surgical waiting lists, and may represent inefficient use of resources.⁸ Prolonged patient suffering, worsened patient experience, and delays resulting in worsened clinical outcomes have all been reported consequences to cancellations.¹⁻³ Furthermore, patients affected by cancellations may experience negative psychological impacts on levels of anxiety and mood, and may suffer personal economic hardship from repeatedly planning time away from work.

Our findings suggest that clinicians prioritise cases appropriately when clinical resources are limited. However, it is of interest that patients treated in hospitals with enhanced care wards are more likely to be cancelled. We propose that hospitals with insufficient critical care capacity to meet demand, have attempted to mitigate against cancellations or poor quality care through the development of enhanced ward facilities; however, these may yet not completely solve the capacity problem.

Our data may be used to guide developments in the structures of surgical services. For example, ring-fencing of beds for elective surgery is a recommendation from the Getting It Right First Time national review of orthopaedic and cardiothoracic surgery services in England although it is not clear if this approach would generalise more widely.^{32, 33} Service redesign of this type may be further supported by our finding that despite maternity units generally providing a high volume service including both emergency and planned surgery, obstetric patients are much less likely to be cancelled; this is likely to be because most hospitals have dedicated wards and operating theatres for obstetric patients.^{34, 35} However, the challenges of implementing a ring-fenced solution in a hospital which also provides emergency care cannot be underestimated, as the impact of ring-fencing might impact on other hospital workflows. Other solutions to these issues may include seasonal planning, where fewer planned procedures are scheduled for the Winter months, and instead clinical capacity diverted to emergency care and outpatient clinics. This is similar in nature to the action taken by NHSE during January of this year; however, earlier planning may support a reduced number of late cancellations. Similarly, increasing dedicated emergency surgical capacity in hospitals with emergency departments may allow for the provision of emergency surgery without encroaching on capacity to undertake elective operations. This could be through the provision of beds on dedicated emergency surgery units and / or greater emergency operating theatre capacity. There is substantial evidence that avoiding delay in emergency cases is of patient benefit, and national guidelines now recommend prompt surgery in, for example, hip fractures and emergency laparotomies.³⁶⁻³⁸

Our study highlights an area of opportunity for improvement through structured auditing of cancellations data at local level. Analysis of non-clinical reasons for cancellation

according to a similar categorization used in this study may enable hospitals to focus on specific areas where interventions may reduce the risk of cancellation. While some hospital information technology systems already collect and encode such data routinely,^{10, 12} it is by no mean ubiquitous. Further, the quality of preoperative assessment and optimisation, and of communication between patients and hospitals before surgery, could be more closely investigated to help develop strategies to mitigate against late cancellation for clinical reasons.

Finally, our findings suggest that patients who are deemed by their clinicians to require postoperative critical care may have their procedures postponed in the event of critical care beds being unavailable. It is known that the UK has fewer critical care beds per capita than many other high- and middle-income countries,^{39, 40} and these findings may suggest inadequate surgical critical care capacity in the UK. Lack of critical care capacity has also been as the principal reason for cancellation of surgery in hospitals where unusually high levels of expedited cases were postponed.⁴¹ Operational research which uses mathematical modelling to forecast patient flows and therefore reduce cancellations due to critical care bed shortages has had some success in mitigating these risks.^{42, 43}

However, the issue of which patients require critical care after surgery is not straightforward. Critical care support may be required for specific interventions (for example ventilator or vasopressor support) or to facilitate enhanced monitoring and nursing surveillance at a time of high perioperative risk. Possibly due to the heterogeneity of the critical care “intervention”, guidelines recommending which patients require this resource are based predominantly on expert opinion rather than trial data; furthermore,

different guidelines and specialties have different views on how patients should be prioritised for postoperative critical care admission.^{44, 45} For example, it is routine to send patients to critical care after elective cardiac surgery, but not necessarily after elective major bowel surgery which has higher postoperative mortality and complication rates.^{46, 47} Recent large-scale studies also raise the issue of whether critical care is of benefit to all patients, or whether in fact some may be harmed by inappropriate intervention.^{48, 49} There therefore needs to be research into which patients would benefit most from critical care, so as to make best use of this limited resource. While there are ethical and practical challenges around conducting randomised trials in this field,^{46, 48, 50} novel statistical techniques designed for inferring causation in observational studies may provide a solution—to that end, the main analysis of the SNAP-2: EPICCS study will attempt to address this question.¹⁵

Conclusion

A large number of surgical cancellations occur within the UK, and in the majority of cases these are due to non-clinical reasons. Structural modifications, in particular around service reconfiguration to separate emergency and elective care, as well as seasonal planning, should be modelled and evaluated for clinical and cost effectiveness.

Details of authors contributions

Study conception, ethics application: DJNW, SKH, SRM. Data collection: The SNAP-2: EPICCS collaborators. Data preparation: DJNW. Data analysis and interpretation: DJNW, SKH, SRM. Manuscript preparation, revisions and final manuscript approval: DJNW, SKH, SRM. SRM is the Chief Investigator and the guarantor.

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Research Matrix (SWARM), South Yorkshire Hospitals Audit and Research Collaboration (SHARC), Southcoast Peri-operative Audit and Research Collaboration (SPARC), Welsh Anaesthetic Audit Research & Engagement Network (WAAREN), West Midlands Trainee Research Anaesthesia & Intensive Care Network (WMTRAIN).

Declaration of interests

SRM is Associate National Clinical Director for elective care at NHS England.

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TABLES

Table 1

Table 1: Patient characteristics.

	Previously cancelled due to insufficient beds		Overall
	No	Yes	
N	14333	463	14796
Age (median [IQR])	60 [42 – 72]	64 [50 – 74]	60 [43 – 72]
Sex = Male (%)	5875 (41.0)	202 (43.6)	6077 (41.1)
ASA (%)			
<i>I or II</i>	10452 (72.9)	318 (68.7)	10770 (72.8)
<i>III</i>	3567 (24.9)	132 (28.5)	3699 (25.0)
<i>IV or V</i>	314 (2.2)	13 (2.8)	327 (2.2)
NCEPOD-Expedited (%)	2835 (19.8)	40 (8.6)	2875 (19.4)
Patient admitted before surgery (%)	2786 (19.4)	60 (13.0)	2846 (19.2)
Operative severity (%)			
<i>Minor</i>	690 (4.8)	16 (3.5)	706 (4.8)
<i>Intermediate</i>	2311 (16.1)	49 (10.6)	2360 (16.0)
<i>Major</i>	5544 (38.7)	155 (33.5)	5699 (38.5)
<i>Xmajor</i>	3582 (25.0)	137 (29.6)	3719 (25.1)
<i>Complex</i>	2206 (15.4)	106 (22.9)	2312 (15.6)
Specialty (%)			
<i>Gastrointestinal surgery</i>	2211 (15.4)	84 (18.1)	2295 (15.5)
<i>Gynaecology/urology surgery</i>	2126 (14.8)	55 (11.9)	2181 (14.7)

<i>Neuro/spinal surgery</i>	3022 (21.1)	90 (19.4)	3112 (21.0)
<i>Obstetrics</i>	1534 (10.6)	11 (2.4)	1548 (10.4)
<i>Orthopaedic surgery</i>	3806 (26.4)	139 (30.0)	3946 (26.5)
<i>Thoracic/cardiac surgery</i>	622 (4.3)	46 (9.9)	668 (4.5)
<i>Vascular surgery</i>	348 (2.4)	13 (2.8)	361 (2.4)
<i>Other specialty</i>	2148 (14.9)	55 (11.9)	2203 (14.8)
Required postoperative critical care (%)	1532 (10.6)	105 (22.6)	1637 (11.0)
Cancer surgery (%)	2535 (17.5)	38 (8.2)	2575 (17.2)

Table 2

Table 2: Reasons for previous cancellations.

Reported reasons	Count (n)	%
Clinical reasons	499	33.3
Non-clinical reasons		
<i>Lack of beds</i>	465	31.0
<i>Insufficient operating theatre capacity</i>	190	12.7
<i>Personal reasons</i>	36	2.4
<i>Equipment problem</i>	34	2.3
<i>Staff unavailable</i>	33	2.2
<i>Administrative Error</i>	24	1.6
<i>Patient did not attend</i>	7	0.5
Not known	211	14.1
Total	1499	100

Table 3

Table 3: Multilevel logistic regression model.

	Previously cancelled due to insufficient bed capacity		
	Odds Ratio	95% CI	p-value
Patient-level Fixed Effects			
Age			
Age 18-64		Reference	
Age 65-79	1.01	0.81 – 1.26	0.946
Age ≥80	1.13	0.81 – 1.57	0.474
ASA Grade			
ASA I or II		Reference	
ASA III	0.85	0.67 – 1.09	0.204
ASA IV or V	0.88	0.47 – 1.66	0.694
NCEPOD-Expedited surgery	0.39	0.27 – 0.56	<0.001
Patient admitted before surgery	0.77	0.56 – 1.06	0.110
Operative Severity			
Minor		Reference	
Intermediate	0.70	0.39 – 1.27	0.239
Major	1.05	0.61 – 1.82	0.863
Xmajor	1.03	0.58 – 1.83	0.920
Complex	0.95	0.52 – 1.73	0.863
Specialty			
Gastrointestinal surgery		Reference	
Gynaecology/Urology	0.89	0.64 – 1.25	0.508
Neuro/Spinal	0.97	0.58 – 1.61	0.897
Obstetrics	0.16	0.08 – 0.32	<0.001
Orthopaedics	1.09	0.79 – 1.49	0.599
Thoracics/Cardiac	1.51	0.92 – 2.49	0.102

Vascular	0.86	0.45 – 1.66	0.657
Other surgery	0.91	0.63 – 1.32	0.621
Cancer Surgery	0.32	0.22 – 0.46	<0.001
Postoperative Critical Care Planned	2.92	2.12 – 4.02	<0.001
Hospital-level Fixed Effects			
Hospital size	0.98	0.80 – 1.20	0.843
Proportion of critical care beds	1.07	0.88 – 1.30	0.485
Proportion of general surgical beds	0.88	0.72 – 1.08	0.234
Tertiary services offered	1.08	0.72 – 1.62	0.696
Emergency Department present	4.18	2.22 – 7.89	<0.001
Enhanced care wards present	1.62	1.13 – 2.33	0.009

FIGURES

Figure 1

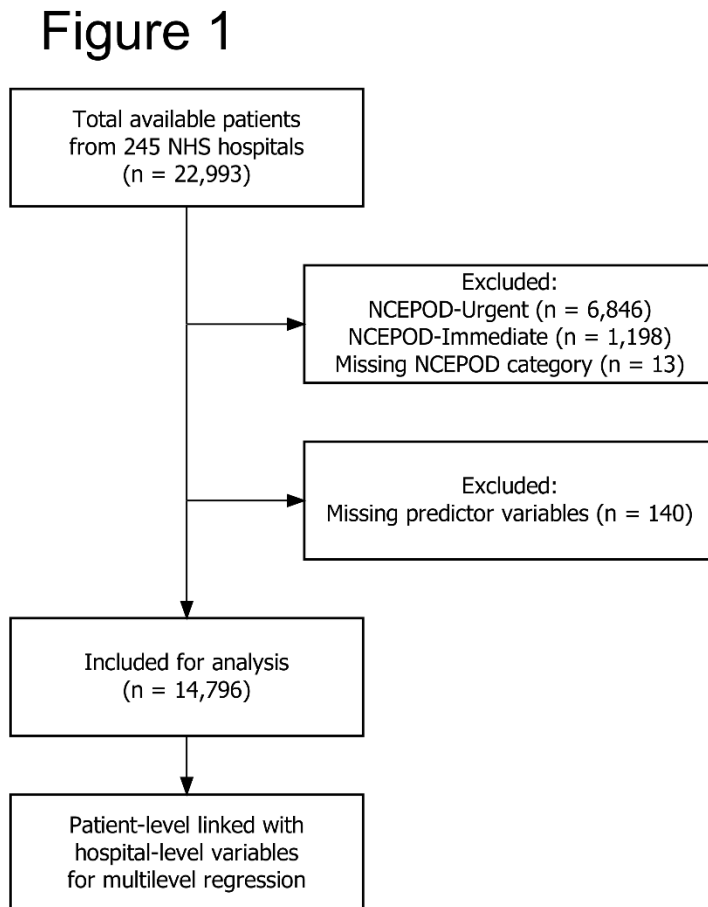


Figure 1: Flow diagram of patients included and excluded from analysis.

Figure 2

Figure 2

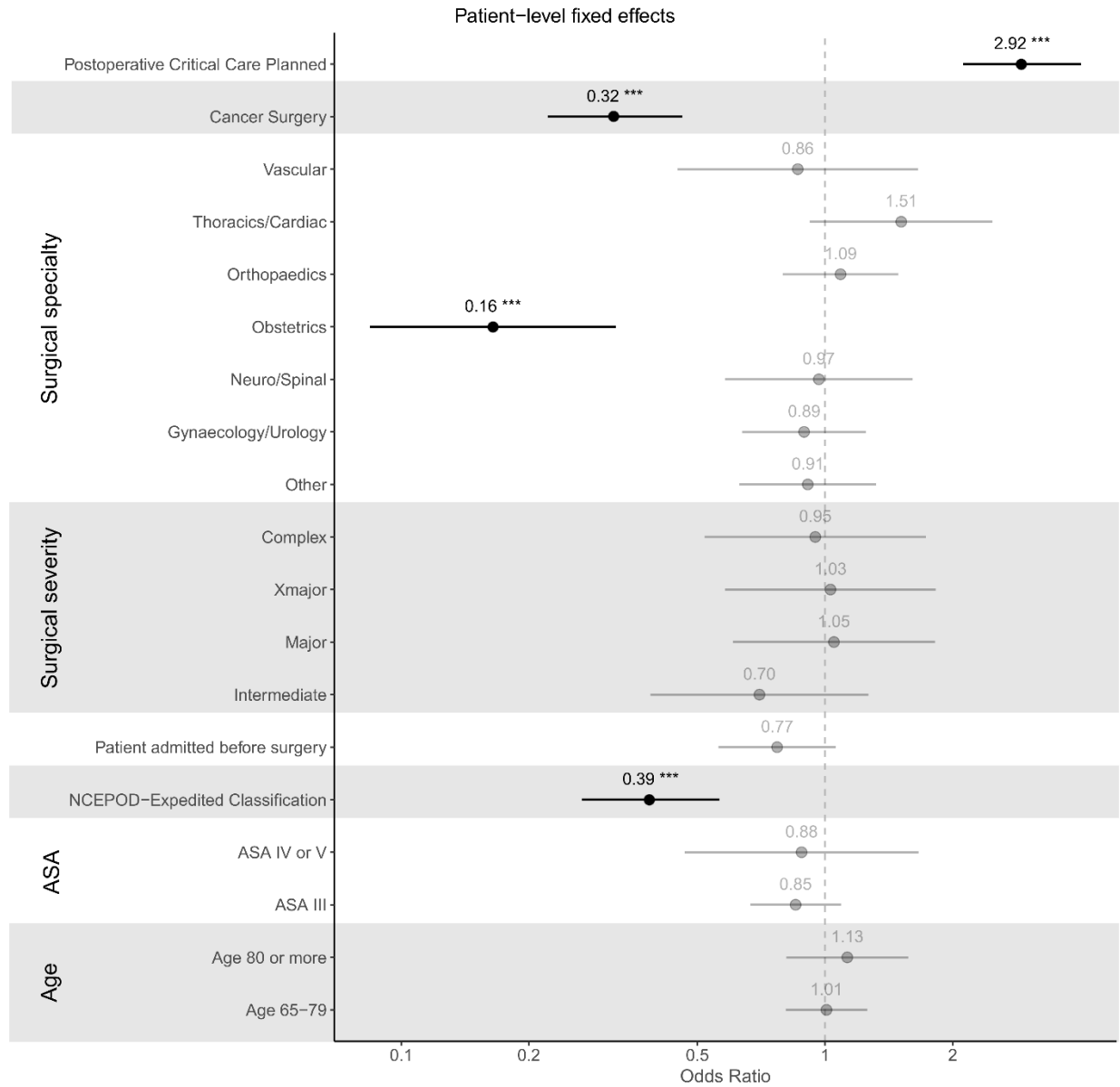
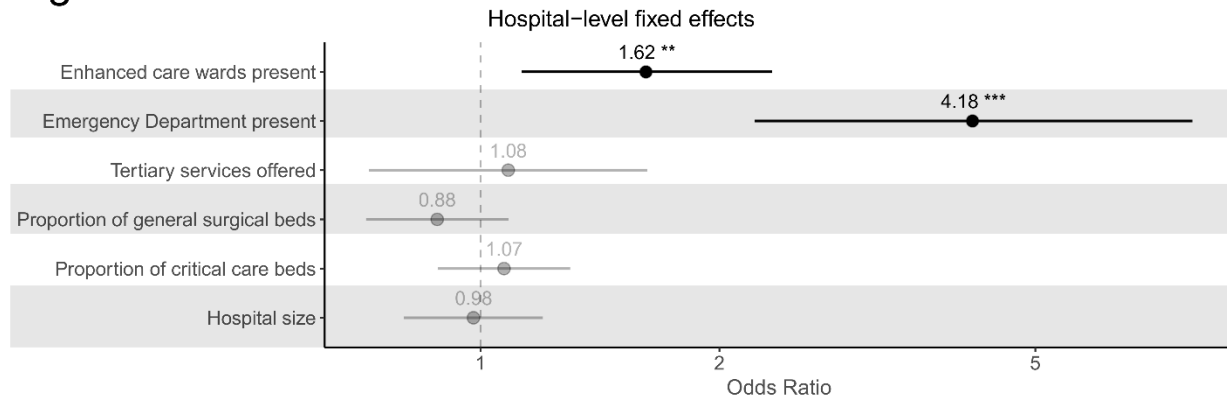


Figure 2: Patient-level fixed effects associated with the likelihood of experiencing a previous cancellation. Significant effects are highlighted in black, and insignificant effects have been de-emphasised for clarity of interpretation. * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

Figure 3

Figure 3



*Figure 3: Hospital-level fixed effects associated with the likelihood of experiencing a previous cancellation. Significant effects are highlighted in black, and insignificant effects have been de-emphasised for clarity of interpretation. * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$*

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