Effects of Night Surgery on Postoperative Mortality and Morbidity

A Multicentre Cohort Study

Supplement 1

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1 Data sources

Several data management systems were used to compile the final database: Perioperative data (anaesthesia record data, monitored patient parameters) were retrieved from the Anaesthesia Information Management System (AIMS). Clinical variables (electronic health record data including International Classification of Diseases 9thand 10th revision [ICD-9/10] diagnostic codes) were obtained through the Research Patient Data Registry (RPDR). The financial tracking database, Enterprise Performance Systems Inc. (EPSi), was used to obtain information regarding hospital admission and discharge. Demographics and discharge disposition data were available in a Research Patient Data Registry (RPDR) and Enterprise Performance Systems Inc. (EPSi) and allowed extraction of mortality data.

The Anaesthesia Information Management System (AIMS) as well as the Perioperative Information Management System (PIMS) were utilised for patient data. Anaesthesia-related data were collected from AIMS and surgical data, such as the surgical specialty and duration of the procedure were provided by PIMS. Current Procedural Terminology (CPT) codes to define work relative value units were obtained from the Center for Clinical Computing (CCC) anaesthesia billing database.

International Classification of Diseases (ICD) codes regarding comorbidities and encounter dates were collected from the Admission Discharge Transfer (ADT) and Casemix databases. Data on mortality were retrieved from the Miscellaneous (MISC) database. Data were de-identified and subsequently combined across institutions.

2 Categorisation of confounding variables

Confounding variables of the primary model were included according to the linearity assumption. Variables demonstrating non-linear associations with the primary outcome were categorised into quintiles (age, duration of surgery, work relative value units, date of surgery, vasopressor equivalent dose, and SpO_2/FiO_2-ratio) or clinically relevant groups (BMI, ASA

status, Charlson Comorbidity Index, intraoperative hypotension (defined as mean arterial pressure < 55 mmHg), and packed red blood cell (PRBC) units transfused.

3 Multiple Imputation

For the primary analysis, we imputed missing data by utilising multiple imputation. We conducted five imputations of five iterations each. The variable with the highest number of missing values prior to imputation was BMI (36,937 missing values), followed by SpO2/FiO2 ratio (19,498 missing values), and admission type (4,224 missing values). The variables anaesthesia and surgical provider which were included into the multivariable-adjusted mixed effects model were not imputed. Cases with missing data for the random effects were excluded before imputation.

4 Potential causes of 30-day mortality

We additionally analysed the following postoperative complication data that have been validated by our team in previous studies. Details on the definition of complications are provided below. We made comparisons between patients undergoing day versus night surgery: Acute kidney injury (AKI), major adverse cardiac events (MACE), stroke after surgery, and reintubation. There were significantly increased risks of AKI, MACE, acute heart failure, and reintubation among patients who underwent night surgery (eTable 10.a).

We then assessed whether these major postoperative adverse events associated with night surgery occurred more often among patients who died within 30 days after surgery (eTable 10.b). Particularly acute kidney failure (24.3% vs. 3.4%), major adverse cardiac events (13.1% vs 1.9%), and reintubation (16.9% vs. 0.6%) occurred much more frequently in patients who died within 30 days, and occurred more frequently after night surgeries. Both renal and cardiac complications have also been shown to be associated with higher transfusion rates,[1-4] as well as higher frequency of anaesthesia handovers.[5] Information on the data sources and variable creation of the postoperative complication data is given below.

4.1 Postoperative acute kidney injury

Institution A

Postoperative AKI was identified according to the following protocol: the most recent creatinine lab values prior to surgery, within a 30-day window, and creatinine values within 48 hours after surgery were extracted and the differences between creatinine values were calculated. Patients with an increase of 0.3 mg/dl or 50% or more from baseline in the first 48 hours after surgery were considered to AKI, according to the Kidney Disease Improving Global Outcomes (KDIGO) Guidelines.[6 7] Cases without creatinine values but with an ICD-9 diagnostic code of AKI (eTable 16) within seven days of surgery, but not thirty days prior, were also considered to have this outcome. Finally, cases without data on serum creatinine or AKI administrative codes following surgery were considered free of this outcome on the premise that there was no clinically meaningful concern for kidney injury in such patients. Our definition of AKI was validated by chart review and studies have been published previously using this definition.[8]

Institution B

Postoperative AKI was identified according to the following protocol: the creatinine lab values prior to surgery, within a 6-month window, and creatinine values within 48 hours after surgery were extracted and the difference between creatinine values was calculated. Those patients with an increase of 0.3 mg/dl or 50% or more from baseline in the first 48 hours after surgery were considered to AKI, according to the Kidney Disease Improving Global Outcomes (KDIGO) Guidelines.[6 7] Cases without creatinine values but with an ICD-9/10 diagnostic code of AKI within seven days of surgery, but not thirty days prior, were also considered to have this outcome (eTable16). Finally, cases without data on serum creatinine or AKI administrative codes following surgery were considered free of this outcome on the premise that there was no clinically meaningful concern for kidney injury in such patients.

4.2 Postoperative major adverse cardiovascular events (MACE)

Postoperative major adverse cardiovascular events were identified using ICD-9/10 diagnostic codes at both institutions, including myocardial infarction, cardiac arrest, and acute heart failure within 30 days after surgery, but not seven days prior to surgery. Cases without the described diagnostic codes were considered free of this outcome on the premise that there was no clinically meaningful concern for major adverse cardiovascular events in such patients.

4.3 Postoperative stroke

Postoperative stroke was identified using ICD-9/10 diagnostic codes at both institutions, including stroke within thirty days after surgery, but not seven days prior to surgery. Cases without the described diagnostic codes were considered free of this outcome on the premise that there was no clinically meaningful concern for stroke in such patients.

4.4 Postoperative reintubation

Institution A

Postoperative reintubation was identified using CPT codes of intubation events (CPT 31500, CPT 94002) within 7 days after the day of surgery.

Institution B

Postoperative reintubation was identified using data from the respiratory therapist database, while any ventilated patient in the hospital was recorded by this database. This variable definition has been used in previous studies and is therefore highly-validated.[9]

5 Mediation analysis

5.1 Potential impact of provider variability on the association between night surgery and transfusion rate

We tested whether variability across individual providers had an impact on the association between night surgery and the mediator transfusion rate. Therefore, we used a mixed-effects logistic regression analysis having individual anaesthesiologists as random effects and adding anaesthesia provider-related variables to the primary confounder model to account for the individual provider's experience level:

- overall number of anaesthesia cases (median number 423 [IQR 296 to 563]),
- number of anaesthesia cases per trimester (median number 54 [IQR 32 to 75])
- number of anaesthesia cases up to index surgery at the respective hospital (median number 189 [IQR 81 to 339])
- and the anaesthesia provider type (residents, certified registered nurse anaesthetists (CRNA), or attendings).

To designate the primary anaesthesia provider responsible for each case, we used the following definitions: The primary anaesthesia provider was the resident in resident plus attending-cases and the CRNA in CRNA plus attending-cases. In cases where two attendings delivered anaesthesia care, the primary provider was the attending who stayed the longest. If more than two providers were responsible for a case, the primary provider was the one who stayed longest, and if different provider types stayed equally long, the resident or CRNA was defined as primary provider. For this analysis, only providers who performed both day and night surgeries during the study period were included.

Similarly, we repeated this sensitivity analysis having individual surgeons as random effects and including indicators of the individual surgeon's experience level in the primary confounder model:

- overall number of surgeries (median number 1,130 [IQR 526 to 1,932])
- number of surgeries per trimester (median number 47 [IQR 27 to 69])
- and number of surgeries up to the index surgery (median number 427 [IQR 142 to 946])

Further important transfusion-associated factors such as estimated intraoperative blood loss and preoperative mild and moderate to severe anaemia within 30 days prior to surgery, respectively, were also added to the primary confounder model to analyse the association between transfusion rate and night surgery.

Results

The observation of a higher risk of blood transfusion associated with night surgery remained robust when accounting for a potential variability in transfusion practice across individual anaesthesia providers (OR_{adj} 1.19, 95% CI 1.10 to 1.30, p=0.005; n=128,691) and across individual surgeons (OR_{adj} 1.35, 95% CI 1.21 to 1.51, p<0.001, n=162,907).

5.2 Case delay as potential mediator

To evaluate the role of case delay as potential mediator in the association between night surgery and 30-day mortality, we used path mediation analysis in a subgroup of sufficient data for case delays. Case delay was defined as difference between scheduled and actual start time in minutes in a subgroup with available data. First, we tested the hypothesis that case delays were higher during night cases than day cases. We used a multivariable-adjusted linear regression model on the association between night surgery and case delays that included all confounding variables of the primary analysis. Second, we used adjusted logistic regression analyses to examine whether case delay was associated with 30-day

mortality, indicating potential effect mediation. Conditional on an association between the mediator and 30-day mortality, we performed adjusted formal mediation analysis. We estimated odds ratios of the indirect (mediated) effect of case delay, and the total (unmediated) effect of night surgery on mortality, using bootstrapping with 1,000 replications. Percentage mediation by the mediators was calculated using the following equation: [ln (indirect effect)/ln (total effect)] x 100.

Results

Data on case delay was available for 159,666 cases. The case delay time was longer in patients who underwent night surgery compared with day surgery (78 [SD 150] vs. 17 [SD 50] minutes, p<0.001). Night surgery was significantly associated with an increased case delay in adjusted linear regression analysis (Coef. 54.86, 95 % CI 53.35 to 56.37, p<0.001). Case delay was significantly associated with an increased risk of 30-day mortality (OR_{adj} 1.001, 95% CI 1.000 to 1.001, p=0.001). Case delay was found to not mediate the effect of night surgery on mortality (p=0.548).

6 Sensitivity analyses

6.1 Robustness of the primary analysis to analytic approach

To account for potential bias originating from systematic differences between patients operated during the day versus night, we tested the robustness of the association between night surgery and 30-day mortality and morbidity in several analytic approaches. We performed propensity score-matched analysis based on the probability of 30-day mortality conditional on all confounding variables included in the primary model. Night versus day cases were matched on a 1:1 basis using a calliper of 0.1 without replacement. To determine the impact of provider variability on the association between night surgery and 30-day mortality, we used a multivariable-adjusted mixed-effects logistic regression model that included individual anaesthesia and surgical providers as random effects (eTable 2).

Results

Propensity score matching and multivariable-adjusted mixed-effects logistic regression analysis confirmed our primary finding (OR_{adj} 1.21, 95% CI 1.06 to 1.39, p=0.005, n=41,414; OR_{adj} 1.34, 95% CI 1.18 to 1.52, n=289,480 cases with anaesthesia provider and surgical provider data available).

6.2 Potential modification of the primary analysis by a one-year diagnosis of cancer

We tested whether the association between night surgery and 30-day mortality was modified by a recent diagnosis of cancer, including the interaction term "night surgery * one-year diagnosis of cancer" in the multivariable-adjusted logistic regression model. We included both types of solid and non-solid cancer, which were defined by ICD-9/10 diagnostic codes (eTable 11).[10]

Results

The primary association between 30-day mortality and night surgery was not modified by a recent diagnosis of cancer (p-for-interaction=0.2). Using linear combinations of the association between night surgery and 30-day mortality, and the interaction term, we confirmed the association of night surgery and 30-day mortality in subgroups of patients with or without a diagnosis of cancer (without cancer: OR_{adj}1.26, 95% CI 1.06 to 1.49, p=0.007; with cancer: OR_{adj}1.46, 95% CI 1.24 to 1.71, p<0.001).

6.3 Subgroup analyses

In subgroup analyses, we assessed whether the association between night surgery and 30-day mortality varied by patient population to ensure that the impact of night surgery on mortality was not driven by a narrow patient population. First, we excluded patients with an ASA status of more than 3 to further address that the effect may be driven by a more severe condition of patients undergoing night surgery. In addition, we performed analyses within

subgroups based on age (quartiles), work RVUs (quartiles), hospital networks (institution A versus B), cases managed by different anaesthesia provider types (residents, CRNAs, attendings), among general surgery patients and finally, in a subgroup including only the 50 most frequently performed surgeries (≥1,000 cases within our cohort; CPT codes are provided in eTable 13), to have a more generalisable sample.

Results

Results remained robust across subgroup analyses after excluding patients with an ASA status of more than 3 (OR_{adj} 1.43, 95% CI 1.13 to 1.79, p=0.003), in patients undergoing one of the 50 most frequently performed surgeries (OR_{adj} 1.44, 95% CI 1.07 to 1.92, p=0.015, n= 119,796), and across subgroups by age, surgical complexity, hospital networks, and the provider type that performed primary anaesthesia care (eTable 14). Among 54,615 patients undergoing general surgery, we found a 1.86 times higher adjusted odds ratio for 30-day mortality associated with night surgery (95% CI 1.31 to 2.65, p=0.001).

6.4 Sample size justification in a subgroup of emergency patients

As described in the main manuscript, we examined the effect of night surgery in a subgroup of patients undergoing emergency surgery. Characteristics of emergency patients were compared between night and day surgeries (eTable 8). In order to ensure sufficient power for this subgroup analysis, we performed a power analysis based on the observed rates of night surgery and mortality within that cohort, assuming a two-sided alpha level of 0.05. In this subgroup, we achieved a power of 80 % to detect a clinically significant difference of 27 % between the groups.

6.5 Effect of specific time windows

Based on a recent study that investigated the effect of operation time on postoperative mortality and morbidity among non-emergency patients,[11] we performed analyses in specific time windows in this subgroup. 30-day mortality and morbidity were categorised by the time surgery started (eTable 12).

Results

The risk of 30-day mortality was significantly higher for surgery start times between 3:00 and 10:59 pm than baseline risk during routine operating hours (7:00 to 11:59 am) (eFigure 2a). Similarly, the risk of 30-day morbidity increased when surgeries started between 4:00 pm and 6:59 am compared with baseline risk (eFigure 2b).

6.6 Effect of weekend surgery

To address that the effect of night surgery on mortality may partly be due to logistic processes and staffing, we investigated the effect of weekend surgery on mortality in the full cohort as well as in a subgroup of patients undergoing day surgery.

Results

In this analysis, exposure to weekend surgery was not associated with 30-day mortality in the full cohort (p=0.867) and in a subgroup of 283,260 patients undergoing day surgery (p=0.766).

6.7 Analysis by year of surgery

We used a Poisson regression analysis correlating the number of patients who underwent night surgery with the respective year of surgery, while accounting for the logarithm of the total number of patients who underwent surgery during that year. To further examine

whether the effect changed over the study period, we included an interaction term between night surgery and the year of surgery in the primary model.

Results

In the Poisson regression analysis, we found an incidence rate ratio of 1.01 (95% CI 1.01 to 1.02, p<0.001) per year. The analysis was performed in the years 2006 to 2017. Year of surgery did not modify the effect of night surgery on 30-day mortality (p-for-interaction=0.415).

6.8 Mortality starting three months after surgery

We compared mortality risk after excluding the first three months after surgery from the logistic regression analysis.

Results

Evaluation of mortality starting three months after surgery revealed no difference in mortality between patients undergoing day and night surgery (OR_{adj} 0.98, 95% CI 0.91 to 1.05, p=0.501).

6.9 Additional confounding variables

We added several confounding variables individually to the association between night surgery and 30-day mortality to evaluate the robustness of the effect with respect to variables not included in the primary analysis (eTable 15).

6.10 Varying definitions of night surgery

We applied varying definitions of night surgery (5 pm to 9 pm and 9 pm to 6:59 am) to test the robustness of the effect on 30-day mortality varying by exposure classification.

Night surgery was associated with a higher risk of 30-day mortality across varying definitions of the exposure variable (5 pm to 9 pm: OR_{adj} 1.33 95% CI 1.17 to 1.51 p<0.001; 9 pm to 6:59 am: OR_{adj} 1.32 95% CI 1.09 to 1.60, p=0.005).

7 Supplemental tables

eTable 1. Definition of the secondary outcome

The definition of the secondary outcome 30-day morbidity was based on the International Classification of Diseases, Ninth and Tenth Revision (ICD-9 and ICD-10 codes).

Types of complications	**ICD-10 diagnostic and procedure codes**	**ICD-9 diagnostic and procedure codes**
Atrial fibrillation or flutter	I4800 I4801 I481 I483 I484 I4890 I4891	427.31 427.32
Acute renal failure	N170 N171 N172 N178 N179	583.6 583.7 584.5 584.6 584.7 584.8 584.9
Bleeding	T810 R58	998.1 459.0 99.07 99.03

Cardiac arrest or life-threatening incident	R092 I460 I461 I469	799.1 V12.53 427.5
Coma	R4020 R4029	780.01
Deep venous thrombosis	I801 I802 I803 I808 I809	410.11 451.11 451.19 451.2 451.89 451.9
Major disruption of wound	T813	998.30

Myocardial infarction & associated complications	I210	410
	I211	429.5
	I212	429.6
	I213	429.71
	I214	429.79
	I2140	
	I2141	
	I2142	
	I2149	
	I219	
	I220	
	I221	
	I228	
	I229	
	I230	
	I231	
	I232	
	I233	
	I234	
	I235	
	I236	
	I2380	
	I2381	
	I2382	
	I2388	
	I2389	

New-onset haemodialysis	3E1M39Z	38.95 39.27 39.95 54.98 **Additional CPT codes:** 90935 90937 90945 90947 90966 90970 90999
Pneumonia	J120 J121 J122 J123 J128 J129 J13 J14 J150 J151 J152 J153 J154	480 481 482 483 484 485 486 507 507.1 507.8 517.1

	J155 J156 J157 J158 J159 J160 J168 J170 J171 J172 J173 J178 J180 J181 J182 J188 J189 J690 J691 J698	
Pulmonary embolism	I260 I269	415

Sepsis	A410	38.10
	A411	38.11
	A412	38.12
	A413	38.19
	A414	38.3
	A4150	38.40
	A4151	38.41
	A4152	38.42
	A4158	38.43
	A4159	38.49
	A4180	995.91
	A4188	
	A419	
Shock	R570	785.5
	R571	
	R572	
	R578	
	R579	
Stroke		362.31
	H341	362.34
	I630	430
	I631	431
	I632	433.91
	I634	434.01
	I635	434.11
	I636	434.91
		435

	I638	435.2
	I639	435.9
	I64	437.7
	I610	V17.1
	I611	
	I612	
	I613	
	I614	
	I615	
	I616	
	I618	
	I619	
	I600	
	I601	
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	I607	
	I608	
	I609	
	G450	
	G451	
	G452	
	G453	

	G454 G458 G459	
Ventilator use for 48 hours or more	V46.11	Z99.11
Additional cardiac complications	I97.0 I97.11 I97.130 I97.190	429.4
Functional digestive disorders	K91.1 K91.0 K91.89	564.2 564.3 564.4
Haemorrhage, haematoma or inflammation complicating a procedure not elsewhere classified	D78.01 D78.02 D78.21 D78.22 D78.31 D78.32 D78.33 E36.01 E36.02 E89.821 E89.820 E89.810 E89.811	998.1 998.11 998.12 998.13 998.5 998.51 998.59

	E89.822 E89.823 G97.31 G97.32 G97.51 G97.52 G97.61 G97.62 G97.63 G97.64 H59.111 H59.112 H59.113 H59.119 H59.121 H59.122 H59.123 H59.129 H59.311 H59.312 H59.313 H59.319 H59.321 H59.322 H59.323 H59.329	

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	H95.42	
	I97.410	
	I97.411	

	I97.418	
	I97.42	
	I97.610	
	I97.611	
	I97.618	
	I97.620	
	I97.621	
	I97.622	
	I97.630	
	I97.631	
	I97.638	
	I97.640	
	I97.641	
	I97.648	
	J95.61	
	J95.62	
	J95.830	
	J95.831	
	J95.860	
	J95.861	
	J95.863	
	K91.61	
	K91.62	
	K91.840	
	K91.841	
	K91.870	

	K91.871 K91.872 K91.873 L76.01 L76.02 L76.31 L76.32 L76.33 L76.34 L76.21 L76.22 M96.810 M96.811 M96.830 M96.840 M96.841 M99.842 M99.843 M96.831 N99.61 N99.62 N99.820 N99.821 N99.840 N99.841 T88.8XXA	

	K68.11	
Hypotension	I95.3 I95.2 I95.81	458.21 458.29
Infection of tracheostomy	J95.02	519.01
Infection of gastrostomy	K94.22	536.41
Infection of oesophagostomy	K94.32	530.86
Intestinal complications	K91.850 K91.858 K62.5	569.6 569.71 569.79 579.3
Other cardiac, urinary, respiratory or digestive complications not elsewhere specified	I97.710 I97.790 I97.88 I97.89 J95.851 J95.859 J95.88 J95.89 N99.89 T87.40	997.1 997.3 997.31 997.39 997.4 997.5 997.62
Other infection due to medical care not elsewhere classified	T80.219A	999.3

eTable 2. Confounding variables

The primary confounder model included a large number of variables (fixed effects). As sensitivity analysis, we used mixed-effects logistic regression by including the random effects of 1,478 anaesthesia and 1,190 surgical providers in the model.

Fixed effects		**Random effects**
Patient-related characteristics		**Individual provider**
Age [y], quintiles Sex BMI [kg/m^2], categorical ASA physical status, categorical CCI, categorical History of chronic obstructive pulmonary disease, binary History of chronic heart failure, binary History of coronary artery disease, binary History of malignant disease, binary Stroke 1 year prior to surgery, binary Home oxygen therapy		Anaesthesia provider Surgeon
Procedure-related characteristics		
Duration of surgery [min], quintiles Date of surgery, quintiles Surgery type, categorical Surgical setting, categorical Emergency surgery, binary Work RVUs, quintiles Hospital network (institution A versus B)	+	
Anaesthesia-related characteristics		
Intraoperative hypotensive minutes [MAP <55 mmHg], quintiles Units of packed red blood cells (0, 1, 2, ≥3 units) Intraoperative dose of vasopressors [mg], quintiles SpO2/FiO2 ratio, quintiles Handover of anaesthesia care, binary		

Abbreviations: ASA, American Society of Anaesthesiologists Physical Status Classification System; BMI, body mass index; CCI, Charlson Comorbidity Index; MAP, mean arterial pressure; RVUs, relative value units.

eTable 3. Comorbidities within one year prior to surgery among patients undergoing day surgery versus night surgery in the primary imputed cohort

Patient comorbidities, n (%)	Day surgery n = 322,327	Night surgery n = 27,908	Standardised difference
Coronary artery disease	33,938 (10.5%)	3,724 (13.3%)	-0.087
Myocardial infarction	13,732 (4.3%)	1,657 (5.9%)	-0.076
Heart failure	20,662 (6.4%)	2,960 (10.6%)	-0.151
Ischemic stroke	5,585 (1.73%)	816 (2.92%)	-0.079
Cerebrovascular disease	21,195 (6.6%)	2,702 (9.7%)	-0.114
Peripheral vascular disease	25,549 (7.9%)	3,173 (11.4%)	-0.117
Diabetes mellitus with chronic complications	14,306 (4.4%)	1,789 (6.4%)	-0.087
Diabetes mellitus without chronic complications	46,742 (14.5%)	4,739 (17.0%)	-0.068
Renal disease	22,454 (7.0%)	3,016 (10.8%)	-0.135
Moderate to severe liver disease	3,076 (1.0%)	666 (2.4%)	-0.112
Chronic obstructive pulmonary disease	56,249 (17.5%)	5,081 (18.2%)	-0.020
Malignant disease (with or without metastasis)	92,546 (28.7%)	5,644 (20.2%)	0.198
Peptic ulcer disease	3,864 (1.2%)	649 (2.3%)	-0.086
Dementia	2,181 (0.7%)	384 (1.4%)	-0.069
Hemiplegia	5,515 (1.7%)	1,012 (3.6%)	-0.119
HIV infection	2,855 (0.9%)	299 (1.1%)	-0.019

CCI, median (IQR)	1 (0, 3)	1 (0, 3)	-0.071
Home oxygen therapy	2,287 (0.7%)	260 (0.9%)	-0.025

eTable 4. Surgical services among patients undergoing day surgery versus night surgery in the primary imputed cohort

The surgical service was included as a categorical variable in the primary confounder model with a standardised difference of 0.168 between patients undergoing day versus night surgery. Characteristics and distribution of variables by day versus night surgery are presented for cases with observed data.

Surgical service, n (%)	**Day surgery** **n = 322,327**	**Night surgery** **n = 27,908**
Non-operating room anaesthesia	5,952 (1.9%)	276 (1.0%)
Burn surgery	1,942 (0.6%)	65 (0.2%)
Acute care surgery	8,606 (2.7%)	3,819 (13.7%)
General surgery	54,667 (17.0%)	5,092 (18.3%)
Gynaecology	31,607 (9.8%)	2,040 (7.3%)
Neurosurgery	21,177 (6.6%)	2,521 (9.0%)
Oral/Maxillofacial surgery/Otolaryngology	3,488 (1.1%)	90 (0.3%)
Orthopedic surgery	76,262 (23.7%)	5,492 (19.7%)
Other	3,800 (1.2%)	416 (1.5%)
Plastic surgery	8,963 (2.8%)	525 (1.9%)
Radiology	730 (0.2%)	92 (0.3%)
Surgical oncology	21,354 (6.6%)	1,424 (5.1%)
Thoracic surgery	1,413 (0.4%)	147 (0.5%)
Transplant surgery	14,674 (4.6%)	391 (1.4%)
Urology	21,412 (6.6%)	1,467 (5.3%)

Vascular surgery	6,161 (1.9%)	1,089 (3.9%)

eTable 5. Characteristics and distribution of variables by day versus night surgery in the complete-case cohort

Patient characteristics	**Day surgery n = 283,185**	**Night surgery n = 20,707**
Sex, male, n (%)	123,530 (43.6%)	10,270 (49.6%)
Age (years), mean ± SD	53.98 ± 16.38	51.96 ± 18.65
BMI (kg/m^2), mean ± SD	28.36 ± 6.86	27.79 ± 6.89
ASA status, median (IQR)	2 (2, 3)	2 (2, 3)
ASA ≥ 3, n (%)	90,415 (31.9%)	8,676 (41.9%)
Admission type, n (%)		
Ambulatory	107,409 (37.9%)	3,002 (14.5%)
Same day admission	133,359 (47.1%)	9,753 (47.1%)
Inpatient	42,417 (15.0%)	7,952 (38.4%)
Comorbidities within 1 year prior to surgery, n (%)		
Coronary artery disease	28,579 (10.1%)	2,505 (12.1%)
Myocardial infarction	11,202 (4.0%)	1,099 (5.3%)
Heart failure	16,894 (6.0%)	2,018 (9.7%)
Ischemic stroke	4,719 (1.7%)	531 (2.6%)
Cerebrovascular disease	18,124 (6.4%)	1,854 (9.0%)
Peripheral vascular disease	21,012 (7.4%)	2,210 (10.7%)
Diabetes mellitus with chronic complications	11,465 (4.0%)	1,228 (5.9%)
Diabetes mellitus without chronic complications	39,427 (13.9%)	3,270 (15.8%)
Renal disease	18,671 (6.6%)	2,117 (10.2%)

Moderate to severe liver disease	2,460 (0.9%)	441 (2.1%)
Chronic obstructive pulmonary disease	48,581 (17.2%)	3,644 (17.6%)
Malignant disease (with or without metastasis)	84,716 (29.9%)	4,485 (21.7%)
Peptic ulcer disease	3,279 (1.2%)	446 (2.2%)
Dementia	1,699 (0.6%)	246 (1.2%)
Hemiplegia	4,657 (1.6%)	688 (3.3%)
HIV infection	2,382 (0.8%)	222 (1.1%)
CCI, median (IQR)	1 (0, 3)	1 (0, 3)
Home oxygen therapy	1,803 (0.6%)	168 (0.8%)
Intraoperative data		
Duration of surgery (min), median (IQR)	133.00 (86.00, 207.00)	113.00 (80.00, 164.00)
Handover of anaesthesia care, n (%)	24,949 (8.8%)	4,686 (22.6%)
Intraoperative hypotensive minutes of MAP <55mmHg, median (IQR)	0.00 (0.00, 2.00)	0.00 (0.00, 1.00)
Emergency surgery, n (%)	6,404 (2.3%)	7,162 (34.6%)
Work RVUs, median (IQR)	13.18 (7.38, 19.91)	10.62 (7.08, 17.63)
Packed red blood cell units transfused intraoperatively, n (%)		
0 units	275,303 (97.2%)	19,558 (94.5%)
1 unit	3,433 (1.2%)	469 (2.3%)
2 units	2,852 (1.0%)	373 (1.8%)
≥ 3 units	1,597 (0.6%)	307 (1.5%)
Total intraoperative vasopressor dose, norepinephrine equivalent (mg), median (IQR)	0.01 (0.00, 0.11)	0.00 (0.00, 0.11)
Median SpO_2/FiO_2 ratio, median (IQR)	183.33 (161.29, 220.22)	178.57 (152.31, 206.56)

Surgical service, n (%)		
Non-operating room anaesthesia	5,549 (2.0%)	244 (1.2%)
Burn surgery	1,754 (0.6%)	59 (0.3%)
Acute care surgery	7,365 (2.6%)	3,069 (14.8%)
General surgery	50,982 (18.0%)	3,633 (17.5%)
Gynaecology	29,245 (10.3%)	1,742 (8.4%)
Neurosurgery	19,338 (6.8%)	1,806 (8.7%)
Oral/Maxillofacial surgery/Otolaryngology	3,085 (1.1%)	83 (0.4%)
Orthopedic surgery	63,206 (22.3%)	3,936 (19.0%)
Other	3,067 (1.1%)	318 (1.5%)
Plastic surgery	7,808 (2.8%)	354 (1.7%)
Radiology	643 (0.2%)	77 (0.4%)
Surgical oncology	18,478 (6.5%)	1,005 (4.9%)
Thoracic surgery	1,297 (0.5%)	145 (0.7%)
Transplant surgery	13,893 (4.9%)	355 (1.7%)
Urology	18,007 (6.4%)	991 (4.8%)
Vascular surgery	4,909 (1.7%)	757 (3.7%)
Hospital network (institution A vs. B), n (%)	148,703 (52.5%)	11,329 (54.7%)
30-day mortality	1,769 (0.6%)	465 (2.3%)
30-day morbidity	22,919 (8.1%)	2,723 (13.2%)

Abbreviations: ASA, American Society of Anesthesiologists Physical Status Classification System; BMI, body mass index; CCI, Charlson Comorbidity Index; IQR, interquartile range; MAP, mean arterial pressure; SD, standard deviation, RVUs, relative value units.

eTable 6. Characteristics and distribution of variables by patients who underwent ambulatory/same-day surgery versus inpatient surgery

Normally distributed continuous variables were expressed as mean (± SD), non-normally distributed variables as median (IQR), and categorical variables as frequency (percentages).

Patient characteristics	Ambulatory/same-day surgery n = 253,523	Inpatient surgery n = 50,369
Night surgery, n (%)	12,755 (5.0%)	7,952 (15.8%)
Sex, male, n (%)	108,163 (42.7%)	25,637 (50.9%)
Age (years), mean ± SD	53.06 ± 16.09	57.80 ± 18.21
BMI (kg/m^2), mean ± SD	28.42 ± 6.81	27.82 ± 7.12
ASA ≥ 3, n (%)	69,447 (27.4%)	29,644 (58.9%)
Comorbidities within 1 year prior to surgery, n (%)		
Coronary artery disease	21,766 (8.6%)	9,318 (18.5%)
Myocardial infarction	8,132 (3.2%)	4,169 (8.3%)
Heart failure	10,770 (4.2%)	8,142 (16.2%)
Ischemic stroke	2,714 (1.1%)	2,536 (5.0%)
Cerebrovascular disease	12,372 (4.9%)	7,606 (15.1%)
Peripheral vascular disease	14,597 (5.8%)	8,625 (17.1%)
Diabetes mellitus with chronic complications	8,159 (3.2%)	4,534 (9.0%)
Diabetes mellitus without chronic complications	31,924 (12.6%)	10,773 (21.4%)
Renal disease	13,125 (5.2%)	7,663 (15.2%)
Moderate to severe liver disease	1,625 (0.6%)	1,276 (2.5%)
Chronic obstructive pulmonary disease	41,008 (16.2%)	11,217 (22.3%)
Malignant disease (with or without metastasis)	76,379 (30.1%)	13,881 (27.6%)
Peptic ulcer disease	2,404 (0.9%)	1,321 (2.6%)
Dementia	920 (0.4%)	1,025 (2.0%)
Hemiplegia	2,651 (1.0%)	2,694 (5.3%)
HIV infection	1,956 (0.8%)	648 (1.3%)
CCI, median (IQR)	1 (0, 2)	2 (0, 5)
Home oxygen therapy	1,307 (0.5%)	664 (1.3%)
Intraoperative data		
Duration of surgery (min), median (IQR)	131 (85, 205)	133 (89, 202)
Handover of anaesthesia care, n (%)	9,936 (8.6%)	3,665 (12.8%)
Intraoperative hypotensive minutes of MAP	0.00 (0.00, 2.00)	1.00 (0.00, 3.00)

<55mmHg, median (IQR)		
Emergency surgery, n (%)	7,723 (3.0%)	5,843 (11.6%)
Work RVUs, median (IQR)	12.80 (7.38, 19.61)	13.22 (7.38, 19.66)
Packed red blood cell units transfused intraoperatively, n (%)		
0 units	249,233 (98.3%)	45,628 (90.6%)
1 unit	1,733 (0.7%)	2,169 (4.3%)
2 units	1,573 (0.6%)	1,652 (3.3%)
≥ 3 units	984 (0.4%)	920 (1.8%)
Total intraoperative vasopressor dose, norepinephrine equivalent (mg), median (IQR)	0.00 (0.00, 0.08)	0.04 (0.00, 0.25)
Median SpO_2/FiO_2 ratio, median (IQR)	183.33 (161.90, 220.00)	180.33 (151.15, 217.07)
Surgical service, n (%)		
Non-operating room anaesthesia	4,740 (1.9%)	1,053 (2.1%)
Burn surgery	667 (0.3%)	1,146 (2.3%)
Emergency surgical service	5,148 (2.0%)	5,286 (10.5%)
General surgery	49,163 (19.4%)	5,452 (10.8%)
Gynaecology	29,526 (11.6%)	1,461 (2.9%)
Neurosurgery	15,232 (6.0%)	5,912 (11.7%)
Oral/Maxillofacial surgery	2,866 (1.1%)	302 (0.6%)
Orthopedic surgery	53,605 (21.1%)	13,537 (26.9%)
Other	2,122 (0.8%)	1,263 (2.5%)
Otolaryngology	7,638 (3.0%)	524 (1.0%)
Paediatric surgery	544 (0.2%)	176 (0.3%)
Plastic surgery	17,783 (7.0%)	1,700 (3.4%)
Radiology	858 (0.3%)	584 (1.2%)
Surgical oncology	13,633 (5.4%)	615 (1.2%)
Thoracic surgery	15,469 (6.1%)	3,529 (7.0%)
Transplant surgery	4,407 (1.7%)	1,259 (2.5%)
Urology	23,586 (9.3%)	2,083 (4.1%)
Vascular surgery	6,536 (2.6%)	4,487 (8.9%)
Hospital network (institution A vs. B), n (%)	115,196 (45.4%)	28,664 (56.9%)
Study outcomes, n (%)		
30-day mortality	632 (0.3%)	1,602 (3.2%)

30-day morbidity	21,612 (8.5%)	4,030 (8.0%)

eTable 7. Characteristics and distribution of variables by day versus night surgery in a sub cohort of patients undergoing ambulatory/same-day surgery.

Normally distributed continuous variables were expressed as mean (± SD), non-normally distributed variables as median (IQR), and categorical variables as frequency (percentages).

Patient characteristics	**Day surgery n = 240,768**	**Night surgery n = 12,755**
Sex, male, n (%)	10,1917 (42.33%)	6,246 (48.97%)
Age (years), mean ± SD	52.24 ± 15.95	49.72 ± 18.17
BMI (kg/m^2), mean ± SD	28.45 ± 6.81	27.86 ± 6.71
ASA ≥ 3, n (%)	65,419 (27.17%)	4,028 (31.58%)
Admission type, n (%)		
Ambulatory	107,409 (44.6%)	3,002 (23.5%)
Same day admission	133,359 (55.4%)	9,753 (76.5%)
Comorbidities within 1 year prior to surgery, n (%)		
Coronary artery disease	20,614 (8.6%)	1,152 (9.0%)
Myocardial infarction	7,645 (3.2%)	487 (3.8%)
Heart failure	10,009 (4.2%)	761 (6.0%)
Ischemic stroke	2,549 (1.1%)	165 (1.3%)
Cerebrovascular disease	11,631 (4.8%)	741 (5.8%)
Peripheral vascular disease	13,644 (5.7%)	953 (7.5%)
Diabetes mellitus with chronic complications	7,634 (3.2%)	525 (4.1%)
Diabetes mellitus without chronic complications	30,270 (12.6%)	1,654 (13.0%)
Renal disease	12,195 (5.1%)	930 (7.3%)

Moderate to severe liver disease	1,435 (0.6%)	190 (1.5%)
Chronic obstructive pulmonary disease	39,078 (16.2%)	1,930 (15.1%)
Malignant disease (with or without metastasis)	19,589 (8.1%)	841 (6.6%)
Peptic ulcer disease	2,183 (0.9%)	221 (1.7%)
Dementia	828 (0.3%)	92 (0.7%)
Hemiplegia	2,390 (1.0%)	261 (2.1%)
HIV infection	1,821 (0.8%)	135 (1.1%)
CCI median, (IQR)	1 (0, 2)	1 (0, 2)
Home oxygen therapy	1,231 (0.5%)	76 (0.6%)
Intraoperative data		
Duration of surgery (min), median (IQR)	133.00 (85.00, 207.00)	110.00 (78.00, 159.00)
Handover of anaesthesia care, n (%)	19,911 (8.3%)	2,953 (23.2%)
Intraoperative hypotensive minutes of MAP <55mmHg, median (IQR)	0.00 (0.00, 2.00)	0.00 (0.00, 2.00)
Emergency surgery, n (%)	2,966 (1.2%)	4,757 (37.3%)
Work RVUs, median (IQR)	13.18 (7.38, 19.94)	10.47 (7.07, 16.47)
Packed red blood cell units transfused intraoperatively, n (%)		
0 units	236,926 (98.4%)	12,307 (96.5%)
1 unit	1,556 (0.6%)	177 (1.4%)
2 units	1,426 (0.6%)	147 (1.1%)
≥ 3 units	860 (0.4%)	124 (1.0%)
Total intraoperative vasopressor dose, norepinephrine equivalent (mg), median (IQR)	0.00 (0.00, 0.08)	0.00 (0.00, 0.08
Median SpO_2/FiO_2 ratio, median (IQR)	183.49 (161.30, 220.45)	180.00 (156.35, 208.33)

Surgical service, n (%)		
Non-operating room anaesthesia	4,600 (1.9%)	140 (1.1%)
Burn surgery	650 (0.3%)	17 (0.1%)
Acute care surgery	1,371 (0.6%)	785 (6.2%)
General surgery	46,817 (19.4%)	2,346 (18.4%)
Gynaecology	28,116 (11.7%)	1410 (11.1%)
Neurosurgery	14,378 (6.0%)	854 (6.7%)
Oral/Maxillofacial surgery/Otolaryngology	3,716 (1.5%)	66 (0.5%)
Orthopedic surgery	51,105 (21.2%)	2,500 (19.6%)
Other	10,940 (4.5%)	1,440 (11.3%)
Plastic surgery	17,105 (7.1%)	678 (5.3%)
Radiology	805 (0.3%)	53 (0.4%)
Surgical oncology	13,361 (5.6%)	272 (2.1%)
Thoracic surgery	14,976 (6.2%)	493 (3.9%)
Transplant surgery	3,951 (1.6%)	456 (3.6%)
Urology	22,737 (9.4%)	849 (6.7%)
Vascular surgery	6140 (2.6%)	396 (3.1%)
Hospital network (institution A vs. B), n (%)	109,621 (45.5%)	5,575 (43.7%)
Study outcomes, n (%)		
30-day mortality	497 (0.2%)	135 (1.1%)
30-day morbidity	19,535 (8.1%)	2,077 (16.3%)

Abbreviations: ASA, American Society of Anesthesiologists Physical Status Classification System; BMI, body mass index; CCI, Charlson Comorbidity Index; IQR, interquartile range; MAP, mean arterial pressure; SD, standard deviation, RVUs, relative value units.

eTable 8. Characteristics and distribution of variables among emergency cases

Normally distributed continuous variables were expressed as mean (± SD), non-normally distributed variables as median (IQR), and categorical variables as frequency (percentages).

Patient characteristics	**Day surgery n = 6,404**	**Night surgery n = 7,162**
Sex, male, n (%)	3,217 (50.2%)	3,676 (51.3%)
Age (years), mean ± SD	52.82 ± 20.07	49.32 ± 19.79
BMI (kg/m^2), mean ± SD	27.59 ± 6.81	27.41 ± 6.78
ASA ≥ 3, n (%)	3,024 (47.2%)	2,808 (39.2%)
Admission type, n (%)		
Ambulatory	440 (6.9%)	531 (7.4%)
Same day admission	2,526 (39.4%)	4,226 (59.0%)
Inpatient	3,438 (53.7%)	2,405 (33.6%)
Comorbidities within 1 year prior to surgery, n (%)		
Coronary artery disease	914 (14.3%)	798 (11.1%)
Myocardial infarction	399 (6.2%)	363 (5.1%)
Heart failure	734 (11.5%)	686 (9.6%)
Ischemic stroke	223 (3.5%)	143 (2.0%)
Cerebrovascular disease	764 (11.9%)	587 (8.2%)
Peripheral vascular disease	820 (12.8%)	764 (10.7%)
Diabetes mellitus with chronic complications	368 (5.7%)	335 (4.7%)
Diabetes mellitus without chronic complications	1,064 (16.6%)	998 (13.9%)
Renal disease	731 (11.4%)	628 (8.8%)
Moderate to severe liver disease	172 (2.7%)	205 (2.9%)
Chronic obstructive pulmonary disease	1,148 (17.9%)	1,162 (16.2%)
Malignant disease (with or without metastasis)	1,118 (17.5%)	1,040 (14.5%)
Peptic ulcer disease	172 (2.7%)	202 (2.8%)
Dementia	115 (1.8%)	84 (1.2%)
Hemiplegia	245 (3.8%)	214 (3.0%)
HIV infection	64 (1.0%)	74 (1.0%)
CCI median, (IQR)	1 (0, 3)	1 (0, 3)

Home oxygen therapy	70 (1.1%)	67 (1.0%)
Intraoperative data		
Duration of surgery (min), median (IQR)	124.00 (87.00, 184.00)	112.00 (83.00, 163.00)
Handover of anaesthesia care, n (%)	879 (13.7%)	1,162 (16.2)
Intraoperative hypotensive minutes of MAP <55mmHg, median (IQR)	1.00 (0.00, 3.00)	1.00 (0.00, 3.00)
Work RVUs, median (IQR)	12.15 (8.07, 18.46)	10.62 (8.78, 17.82)
Packed red blood cell units transfused intraoperatively, n (%)		
0 units	5,707 (89.1%)	6,565 (91.7%)
1 unit	299 (4.7%)	186 (2.6%)
2 units	240 (3.8%)	200 (2.8%)
≥ 3 units	158 (2.4%)	211 (2.9%)
Total intraoperative vasopressor dose, norepinephrine equivalent (mg), median (IQR)	0.02 (0.00, 0.21)	0.01 (0.00, 0.14)
Median SpO_2/FiO_2 ratio, median (IQR)	178.57 (149.25, 208.33)	178.57 (153.08, 202.02)
Surgical service, n (%)		
Non-operating room anaesthesia	43 (0.7%)	19 (0.3%)
Burn surgery	29 (0.5%)	8 (0.1%)
Acute care surgery	1,002 (15.6%)	1,632 (22.8%)
General surgery	1,093 (17.1%)	1,621 (22.6%)
Gynaecology	442 (6.9%)	642 (9.0%)
Neurosurgery	560 (8.7%)	490 (6.8%)
Oral/Maxillofacial surgery/Otolaryngology	46 (0.7%)	21 (0.3%)
Orthopedic surgery	1,465 (22.9%)	997 (13.9%)
Other	98 (1.5%)	85 (1.2%)
Plastic surgery	98 (1.5%)	167 (2.3%)
Radiology	32 (0.5%)	36 (0.5%)
Surgical oncology	160 (2.5%)	237 (3.3%)
Thoracic surgery	60 (0.9%)	25 (0.3%)
Transplant surgery	55 (0.9%)	82 (1.1%)
Urology	190 (3.0%)	128 (1.8%)
Vascular surgery	221 (3.5%)	280 (3.9%)

Hospital network (institution A vs. B), n (%)	131,544 (47.5%)	6,554 (48.4%)
Study outcomes, n (%)		
30-day mortality	226 (3.5 %)	219 (3.1%)
30-day morbidity	691 (10.8%)	863 (12.0%)

Abbreviations: ASA, American Society of Anaesthesiologists Physical Status Classification System

eTable 9. Characteristics and distribution of variables after propensity score matching

Normally distributed continuous variables were expressed as mean (± SD), non-normally distributed variables as median (IQR), and categorical variables as frequency (percentages).

PSM cohort n = 14,414	**Day surgeries n = 7,207**	**Night surgeries n = 7,207**
Sex, male, n (%)	10,477 (50.6%)	10,270 (49.6%)
Age (years), mean ± SD	53.17 ± 18.27	51.96 ± 18.65
BMI (kg/m^2), mean ± SD	27.88 ± 7.01	27.79 ± 6.89
ASA ≥ 3, n (%)	9,415 (45.5%)	8,676 (41.9%)
Admission type, n (%)		
Ambulatory	3,079 (14.9%)	3,002 (14.5%)
Same day admission	7,587 (36.6%)	9,753 (47.1%)
Inpatient	10,041 (48.5%)	7,952 (38.4%)
Comorbidities within one year prior to surgery n (%)		
Coronary artery disease	2706 (13.1%)	2505 (12.1%)
Myocardial infarction	1,200 (5.8%)	1,099 (5.3%)
Heart failure	2,173 (10.5%)	2,018 (9.7%)
Ischemic stroke	608 (2.9%)	531 (2.6%)
Cerebrovascular disease	2,000 (9.7%)	1,854 (9.0%)
Peripheral vascular disease	2,240 (10.8%)	2,210 (10.7%)
Diabetes mellitus with chronic complications	1,297 (6.3%)	1,228 (5.9%)
Diabetes mellitus without chronic complications	3,528 (17.0%)	3,270 (15.8%)
Renal disease	2,252 (10.9%)	2,117 (10.2%)
Moderate to severe liver disease	419 (2.0%)	441 (2.1%)
Chronic obstructive pulmonary disease	3,664 (17.7%)	3,644 (17.6%)
Malignant disease (with or without metastasis)	4,657 (22.5%)	4,583 (22.1%)
Peptic ulcer disease	451 (2.2%)	446 (2.2%)
Dementia	299 (1.4%)	246 (1.2%)
Hemiplegia	693 (3.3%)	688 (3.3%)
HIV infection	274 (1.3%)	222 (1.1%)
CCI, median (IQR)	1.00 (0.00, 3.00)	1.00 (0.00, 3.00)
Home oxygen therapy	166 (0.8%)	168 (0.8%)
Intraoperative data		
Duration of surgery (min), median (IQR), median (IQR)	117.00 (78.00, 177.00)	113.00 (80.00, 164.00)
Handover of anaesthesia care, n (%)	2,318 (23.7%)	2,168 (23.2%)
Intraoperative hypotensive minutes of MAP <55mmHg, median (IQR)	0.00 (0.00, 2.00)	0.00 (0.00, 2.00)
Emergency surgery, n (%)	6,323 (30.5%)	7,162 (34.6%)
Work RVUs, median (IQR)	11.43 (6.48, 18.00)	10.62 (7.08, 17.63)

Packed red blood cell units transfused intraoperatively, n (%)		
0 units	19,377 (93.6%)	19,558 (94.5%)
1 unit	579 (2.8%)	469 (2.3%)
2 units	462 (2.2%)	373 (1.8%)
≥ 3 units	289 (1.4%)	307 (1.5%)
Total intraoperative vasopressor dose, norepinephrine equivalent (mg), median (IQR)	0.01 (0.00, 0.14)	0.01 (0.00, 0.11)
Median SpO_2/FiO_2 ratio, median (IQR)	178.57 (151.52, 210.53)	178.57 (152.31, 206.56)
Surgical service, n (%)		
Non-operating room anaesthesia	403 (1.9%)	244 (1.2%)
Burn surgery	337 (1.6%)	59 (0.3%)
Emergency surgical service	1,935 (9.3%)	3,069 (14.8%)
General surgery	3,544 (17.1%)	3,633 (17.5%)
Gynaecology	1,563 (7.5%)	1,742 (8.4%)
Neurosurgery	1,591 (7.7%)	1,806 (8.7%)
Oral/Maxillofacial surgery	140 (0.7%)	83 (0.4%)
Orthopedic surgery	5,112 (24.7%)	3,936 (19.0%)
Other	328 (1.6%)	318 (1.5%)
Otolaryngology	399 (1.9%)	354 (1.7%)
Paediatric surgery	71 (0.3%)	77 (0.4%)
Plastic surgery	869 (4.2%)	1,005 (4.9%)
Radiology	160 (0.8%)	145 (0.7%)
Surgical oncology	416 (2.0%)	355 (1.7%)
Thoracic surgery	1,099 (5.3%)	991 (4.8%)
Transplant surgery	470 (2.3%)	757 (3.7%)
Urology	1,288 (6.2%)	1,217 (5.9%)
Vascular surgery	982 (4.7%)	916 (4.4%)
Hospital network (institution A vs. B), n (%)	9,787 (47.3%)	9,378 (45.3%)

eTable 10.a Association between major postoperative adverse events and night surgery compared with day surgery

Major postoperative adverse events	Day surgery (n = 283,185)	Night surgery (n = 20,707)	Unadjusted analysis			Adjusted analysis		
			Adjusted risk difference (95% CI)	Odds ratio (95% CI)	p-value	Adjusted risk difference (95% CI)	Odds ratio (95% CI)	p-value
Acute kidney injury	9,372 (3.31%)	1,406 (6.79%)	3.48% (3.13 to 3.83%)	2.13 (2.01–2.26)	<0.001	0.24% (0.16 to 0.31%)	1.29 (1.20 to 1.39)	<0.001
Stroke	1,694 (0.60%)	211 (1.02%)	0.42% (0.28 to 0.56%)	1.71 (1.48–1.98)	<0.001	0.00% (–0.01 to 0.01%)	1.04 (0.86 to 1.26)	0.665

Major adverse cardiac events (MACE)	5,382 (1.90%)	678 (3.27%)	1.37% (1.13 to 1.62%)	1.75 (1.61–1.89)	<0.001	0.08% (0.03 to 0.12%)	1.22 (1.10 to 1.36)	<0.001
Myocardial infarction	881 (0.31%)	129 (0.62%)	0.31% (0.20 to 0.42%)	2.01 (1.67–2.42)	<0.001	0.01% (–0.01 to 0.02%)	1.14 (0.93 to 1.42)	0.204
Cardiac arrest	255 (0.09%)	43 (0.21%)	0.12% (0.05 to 0.18%)	2.31 (1.67–3.19)	<0.001	0.01% (–0.01 to 0.02%)	1.21 (0.83 to 1.76)	0.328
Acute heart failure	4,545 (1.60%)	564 (2.72%)	1.12% (0.89 to 1.35%)	1.72 (1.57–1.88)	<0.001	0.06% (0.03 to 0.10%)	1.27 (1.13 to 1.43)	<0.001
Reintubation*	1,738 (0.62%)	291 (1.49%)	0.87% (0.69 to 1.04%)	2.41 (2.12–2.73)	<0.001	0.05% (0.02 to 0.07%)	1.35 (1.17 to 1.56)	<0.001
*Reintubation in a subgroup of available data (n=297,778)								

eTable 10.b Postoperative complications stratified by patients who died within 30 days versus patients who survived

Postoperative complications	**Deceased within 30 days n = 2,234**	**Survived within 30 days n = 301,658**	**p-value**
Acute kidney injury	542 (24.26%)	10,236 (3.39%)	<0.001
Major adverse cardiac events (MACE)	292 (13.07%)	5,768 (1.91%)	<0.001
Cardiac arrest	107 (4.79%)	191 (0.06%)	<0.001
Acute heart failure	162 (7.25%)	4,497 (1.64%)	<0.001
Reintubation *	293 (16.92%)	1,736 (0.59%)	<0.001

* *Reintubation in a subgroup of available data (n = 297,778)*

eTable 11. ICD-9 and ICD-10 codes to define a recent history of solid/non-solid cancer

A one-year history of solid/non-solid cancer was based on the International Classification of Diseases, Ninth and Tenth Revision (ICD-9 and ICD-10 codes).[10]

Variable	ICD-9 code	ICD-10 code	Description
Solid cancer	140.X	C00.X	Malignant neoplasm of lip
	141.X	C01.X, C02.X	Malignant neoplasm of tongue
	142.X	C07.X, C08.X	Malignant neoplasm of major salivary glands
	143.X	C03.X	Malignant neoplasm of gum
	144.X	C04.X	Malignant neoplasm of floor of mouth
	145.X	C05.X, C06.X, C09.X, C14.X	Malignant neoplasm of other and unspecified parts of mouth
	146.X	C10.X	Malignant neoplasm of oropharynx
	147.X	C11.X	Malignant neoplasm of nasopharynx
	148.X	C12.X, C13.X	Malignant neoplasm of hypopharynx
	149.X	C14.X	Malignant neoplasm of other and ill-defined sites within the lip
	150.X	C15.X	Malignant neoplasm of oesophagus
	151.X	C16.X	Malignant neoplasm of stomach
	152.X	C17.X	Malignant neoplasm of small intestine, including duodenum
	153.X	C18.X	Malignant neoplasm of colon

154.X	C19.X, C20.X, C21.X	Malignant neoplasm of rectum, rectosigmoid junction, and anus
155.X	C22.X	Malignant neoplasm of liver and intrahepatic bile ducts
156.X	C23.X, C24.X	Malignant neoplasm of gallbladder and extrahepatic bile ducts
157.X	C25.X	Malignant neoplasm of pancreas
158.X	C48.X	Malignant neoplasm of retroperitoneum and peritoneum
159.X	C26.X	Malignant neoplasm of other and ill-defined sites within the digestive organs and peritoneum
160.X	C30.X, C31.X	Malignant neoplasm of nasal cavities, middle ear, and accessory sinuses
161.X	C32.X	Malignant neoplasm of larynx
162.X	C33.X, C34.X	Malignant neoplasm of trachea, bronchus, and lung
163.X	C38.X	Malignant neoplasm of pleura
164.X	C37.X, C38.X	Malignant neoplasm of thymus, heart, and mediastinum
165.X	C39.X	Malignant neoplasm of other and ill-defined sites within the respiratory system and intrathoracic organs
170.X	C40.X, C41.X	Malignant neoplasm of bone and articular cartilage

171.X	C45.X, C49.X	Malignant neoplasm of connective and other soft tissue
172.X	C43.X	Malignant melanoma of skin
173.X	C44.X	Other malignant neoplasm of skin
174.X	C50.X	Malignant neoplasm of female breast
175.X	C50.X	Malignant neoplasm of male breast
176.X	C46.X	Kaposi's sarcoma
179.X	C55.X	Malignant neoplasm of uterus, part unspecified
180.X	C53.X	Malignant neoplasm of cervix uteri
181.X	C58.X	Malignant neoplasm of placenta
182.X	C54.X	Malignant neoplasm of body of uterus
183.X	C56.X	Malignant neoplasm of ovary and other uterine adnexa
184.X	C51.X, C52.X, C57.X	Malignant neoplasm of other and unspecified female genital organs
185.X	C61.X	Malignant neoplasm of prostate
186.X	C62.X	Malignant neoplasm of testis
187.X	C60.X, C63.X	Malignant neoplasm of penis and other male genital organs
188.X	C67.X	Malignant neoplasm of bladder
189.X	C64.X, C65.X, C66.X, C68.X	Malignant neoplasm of kidney and other and unspecified urinary organs
190.X	C69.X	Malignant neoplasm of eye

	191.X	C71.X	Malignant neoplasm of brain
	192.X	C47.X, C70.X, C72.X	Malignant neoplasm of other and unspecified parts of nervous system
	193.X	C73.X	Malignant neoplasm of thyroid gland
	194.X	C74.X, C75.X	Malignant neoplasm of other endocrine glands and related structures
Definitions of solid cancer primary sites			
Lung	162.2, 162.3, 162.4, 162.5, 162.8, 162.9	C34.X	Malignant neoplasm of bronchus and lung
Breast	174.X 233.0	C50	Malignant neoplasm of breast
Colorectal	153.X	C18.X	Malignant neoplasm of colon
	154.0, 154.1, 154.2, 154.3, 154.8	C20	Malignant neoplasm of rectum
Prostate	185, 233.4	C61	Malignant neoplasm of prostate

Pancreatic	157.X	C25.X	Malignant neoplasm of pancreas
Brain	191.X	C71.X	Malignant neoplasm of brain
Hepatobiliary	155.X	C22.X	Malignant neoplasm of liver and intrahepatic bile ducts
	156.X	C23	Malignant neoplasm of gallbladder
Cervical	180.X	C53.X	Malignant neoplasm of cervix uteri
Ovarian	183.0	C56.X	Malignant neoplasm of ovary
Kidney	189.0	C64.0	Malignant neoplasm of kidney, except renal pelvis
Thyroid	193.X	C73	Malignant neoplasm of thyroid gland
Oesophageal	150.X	C15.X	Malignant neoplasm of esophagus
Stomach	151.X	C16.0	Malignant neoplasm of stomach
Bladder	188.X	C67.X	Malignant neoplasm of bladder
Uterus	182.X	C54.X	Malignant neoplasm of corpus uteri
	179.X	C55.X	Malignant neoplasm of uterus, part unspecified
Malignant Melanoma	172.X	C43.X	Malignant melanoma of skin
Lip and oral cavity	140.X	C00.X	Malignant neoplasm of lip
	141.X	C01.X	Malignant neoplasm of base of tongue
		C02.X	Malignant neoplasm of other and unspecified parts of tongue
	143.X	C03.X	Malignant neoplasm of gum

	144.X	C04.X	Malignant neoplasm of floor of mouth
	145.X	C05.X	Malignant neoplasm of palate
	149.X	C06.X	Malignant neoplasm of other and unspecified parts of mouth
Metastatic cancer	196.X.	C77.X	Secondary and unspecified malignant neoplasm of lymph nodes
	197.X	C78.XX	Secondary malignant neoplasm of respiratory and digestive organs
	198.X	C79.XX	Secondary malignant neoplasm of other and unspecified sites
	199.X	C80.0	Disseminated malignant neoplasm, unspecified

Non-solid types of cancer	200.X		Lymphosarcoma and reticulosarcoma
	201.X	C81.X	Hodgkin's disease
	202.X	C82.X, C83.X, C84.X, C85X, C86.X, C96.X C88.X, C90.X	Other malignant neoplasms of lymphoid and histiocytic tissue
	203.X	C91.X	Multiple myeloma and immunoproliferative neoplasms
	204.X	C92.X	Lymphoid leukaemia
	205.X	C93.X	Myeloid leukaemia
	206.X	C94.X	Monocytic leukaemia

	207.X	C95.X	Other specified leukaemia
	208.X		Leukaemia of unspecified cell type

eTable 12. Results of 30-day mortality and morbidity categorised by the time surgery started

30-day mortality				
Operation time	**OR_{adj} (95% CI)**	**p-value**	**Total n**	**n of positive outcome**
7:00-11:59 AM	Baseline	Baseline	165,922	804
12 PM	1.13 (0.95-1.35)	0.178	27,140	182
1 PM	1.10 (0.92-1.31)	0.288	29,802	188
2 PM	1.13 (0.95-1.34)	0.176	26,402	211
3 PM	1.25 (1.04-1.49)	0.015	20,687	217
4 PM	1.32 (1.08-1.62)	0.007	13,214	166
5-6 PM	1.45 (1.19-1.78)	<0.001	9,553	194
7-8 PM	1.50 (1.13-1.99)	0.005	4,543	113
9-10 PM	1.91 (1.31-2.80)	0.001	2,688	67
11 PM - 6:59 AM	1.21 (0.70-2.09)	0.488	3,941	92
30-day morbidity				
Operation time	**OR_{adj} (95% CI)**	**p-value**	**Total n**	**n of positive outcome**
7:00-11:59 AM	Baseline	Baseline	165,922	13,681
12 PM	0.98 (0.93-1.04)	0.339	27,140	2,097
1 PM	0.97 (0.92-1.02)	0.170	29,802	2,274
2 PM	0.99 (0.94-1.05)	0.627	26,402	2,061
3 PM	1.06 (0.99-1.12)	0.073	20,687	1,676
4 PM	1.11 (1.03-1.19)	0.008	13,214	1,126
5-6 PM	1.35 (1.24-1.47)	<0.001	9,553	1,041
7-8 PM	1.65 (1.47-1.86)	<0.001	4,543	654
9-10 PM	1.92 (1.64-2.25)	<0.001	2,688	443
11 PM - 6:59 AM	1.54 (1.29-1.84)	<0.001	3,941	589

eTable 13. Subgroup analysis of the 50 most frequently performed procedures

Defined by primary surgery Current Procedural Terminology (CPT) codes. A total of 108,338 participants were included in this subgroup analysis.

CPT code description[12 13]	CPT	Frequency	Percent
Laparoscopy, surgical; cholecystectomy	47562	8,545	7.89
Arthroscopy, knee, surgical; with meniscectomy (medial OR lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed	29881	4,841	4.47
Laparoscopy, surgical; with removal of adnexal structures (partial or total oophorectomy and/or salpingectomy)	58661	4,547	4.2
Arthroplasty, knee, condyle and plateau; medial AND lateral compartments with or without patella resurfacing (total knee arthroplasty)	27447	3,992	3.68
Arthroplasty, acetabular and proximal femoral prosthetic replacement (total hip arthroplasty), with or without autograft or allograft	27130	3,684	3.4
Thyroidectomy, total or complete	60240	3,645	3.36
Hysteroscopy, surgical; with sampling (biopsy) of endometrium and/or polypectomy, with or without D & C	58558	3,460	3.19
Laparoscopy, surgical, appendectomy	44970	3,333	3.08
Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc; 1 interspace, lumbar	63030	2,974	2.75
Arthrodesis, posterior or posterolateral technique, single level; lumbar (with lateral transverse technique, when performed)	22612	2,873	2.65
Thromboendarterectomy, including patch graft, if performed;	35301	2,776	2.56

carotid, vertebral, subclavian, by neck incision			
Repair initial inguinal hernia, age 5 years or older; reducible	49505	2,669	2.46
Laparoscopy, surgical, with total hysterectomy, for uterus 250 g or less; with removal of tube(s) and/or ovary(s)	58571	2,657	2.45
Arthroscopy, shoulder, surgical; with rotator cuff repair	29827	2,626	2.42
Total abdominal hysterectomy (corpus and cervix), with or without removal of tube(s), with or without removal of ovary(s)	58150	2,589	2.39
Reduction mammaplasty	19318	2,555	2.36
Parathyroidectomy or exploration of parathyroid(s)	60500	2,490	2.3
Laparoscopy, surgical prostatectomy, retropubic radical, including nerve sparing, includes robotic assistance, when performed	55866	2,435	2.25
Biopsy or excision of lymph node(s); open, deep axillary node(s)	38525	2,123	1.96
Removal of implant; deep (e.g., buried wire, pin, screw, metal band, nail, rod or plate)	20680	2,099	1.94
Craniectomy, trephination, bone flap craniotomy; for excision of brain tumour, supratentorial, except meningioma	61510	2,088	1.93
Laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [eg, spinal or lateral recess stenosis]), single vertebral segment; lumbar	63047	2,059	1.9
Bronchoscopy, rigid or flexible, including fluoroscopic guidance, when performed; with transbronchial needle aspiration biopsy(s), trachea, main stem and/or lobar bronchus(i)	31629	1,995	1.84
Cystourethroscopy, with ureteroscopy and/or pyeloscopy; with lithotripsy (ureteral catheterization is included)	52353	1,938	1.79

Repair initial incisional or ventral hernia; reducible	49560	1,888	1.74
Gastric restrictive procedure, with gastric bypass for morbid obesity; with short limb (150 cm or less) Roux-en-Y gastroenterostomy	43644	1,684	1.55
Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); cervical below C2	22554	1,669	1.54
Arthroscopically aided anterior cruciate ligament repair/augmentation or reconstruction	29888	1,616	1.49
Laparoscopy, surgical, gastric restrictive procedure; longitudinal gastrectomy (ie, sleeve gastrectomy)	43775	1,592	1.47
Laparoscopy, surgical; repair initial inguinal hernia	49650	1,486	1.37
Mediastinoscopy - expired code	39400	1,430	1.32
Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); lumbar	22558	1,419	1.31
Laparoscopy, surgical; colectomy, partial, with anastomosis	44204	1,403	1.3
Arthroplasty, glenohumeral joint; total shoulder (glenoid and proximal humeral replacement (e.g., total shoulder))	23472	1,400	1.29
Revision of reconstructed breast	19380	1,382	1.28
Repair umbilical hernia, age 5 years or older; reducible	49585	1,194	1.1
Pancreatectomy, proximal subtotal with total duodenectomy, partial gastrectomy, choledochoenterostomy and gastrojejunostomy (Whipple-type procedure); with pancreatojejunostomy	48150	1,183	1.09
Enterectomy, resection of small intestine; single resection and anastomosis	44120	1,177	1.09
Nasal/sinus endoscopy, surgical; with biopsy, polypectomy or	31237	1,176	1.09

debridement (separate procedure)			
Treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture; with intramedullary implant, with or without interlocking screws and/or cerclage	27245	1,109	1.02
Arthroscopy, knee, surgical; with meniscectomy (medial AND lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed	29880	1,088	1
Total thyroid lobectomy, unilateral; with or without isthmusectomy	60220	1,087	1
Thyroidectomy, including substernal thyroid; cervical approach	60271	1,082	1
Mastectomy, partial	19302	1,076	0.99
Septoplasty or submucous resection, with or without cartilage scoring, contouring or replacement with graft	30520	1,067	0.98
Colectomy, partial; with anastomosis	44140	1,059	0.98
Thoracoscopy, surgical; with lobectomy (single lobe)	32663	1,036	0.96
Renal allotransplantation, implantation of graft; without recipient nephrectomy	50360	1,018	0.94
Cystourethroscopy, with insertion of indwelling ureteral stent (e.g., Gibbons or double-J type)	52332	1,014	0.94
Cholecystectomy	47600	1,010	0.93

eTable 14. Results of additional subgroup analyses

Sensitivity analyses evaluating the robustness of the primary analysis within additional subgroups.

Subgroup analysis by:	**OR_{adj}, p-value**	**Sample size**
Age (quartiles)	1.86 p=0.03 1.44 p=0.028 1.37 p=0.014 1.31 p=0.001	77,179 73,344 73,783 72,242
Work RVUs (quartiles)	1.37 p=0.003 1.41 p=0.029 1.46 p=0.003 1.32 p=0.024	76,508 74,991 68,957 74,975
Hospital network (institution A versus B)	1.52 p<0.001 1.22 p=0.013	143,860 159,957
Anaesthesia provider type (residents, certified registered nurse anaesthetist, or attendings)	1.33 p<0.001 1.47 p=0.018 1.41 p=0.017	178,283 85,517 39,686

eTable 15. Results after adjusting for additional confounding variables

Additional confounding variables were separately added to the logistic regression model.

Additional confounding variable	OR_{adj} [95% CI], p-value	Sample size*
Weekend surgery	1.36 [1.20-1.53], p<0.001	Full cohort
Procedural severity score[14]	1.37 [1.19-1.56], p<0.001	240,855
Community hospital status	1.36 [1.20-1.53], p<0.001	Full cohort
Intraoperative opioid dose	1.37 [1.21-1.54], p<0.001	Full cohort
Score for Prediction of Postoperative Respiratory Complications > 6[15]	1.36 [1.20-1.53], p<0.001	Full cohort
NMBA dose (measured as multiples of NMBA dose needed to reduce twitch height by 95 %)	1.36 [1.20-1.53], p<0.001	303,887
Age-adjusted minimum alveolar concentration of volatiles and nitrous oxide[16]	1.35 [1.19-1.52], p<0.001	Full cohort
Federal insurance status	1.35 [1.20-1.53], p<0.001	303,671
*The number of patients per analysis was determined by the data that were available for the additional confounding variable.		

eTable 16. ICD-9 and ICD-10 codes to define potential causes of death (validated postoperative complications).

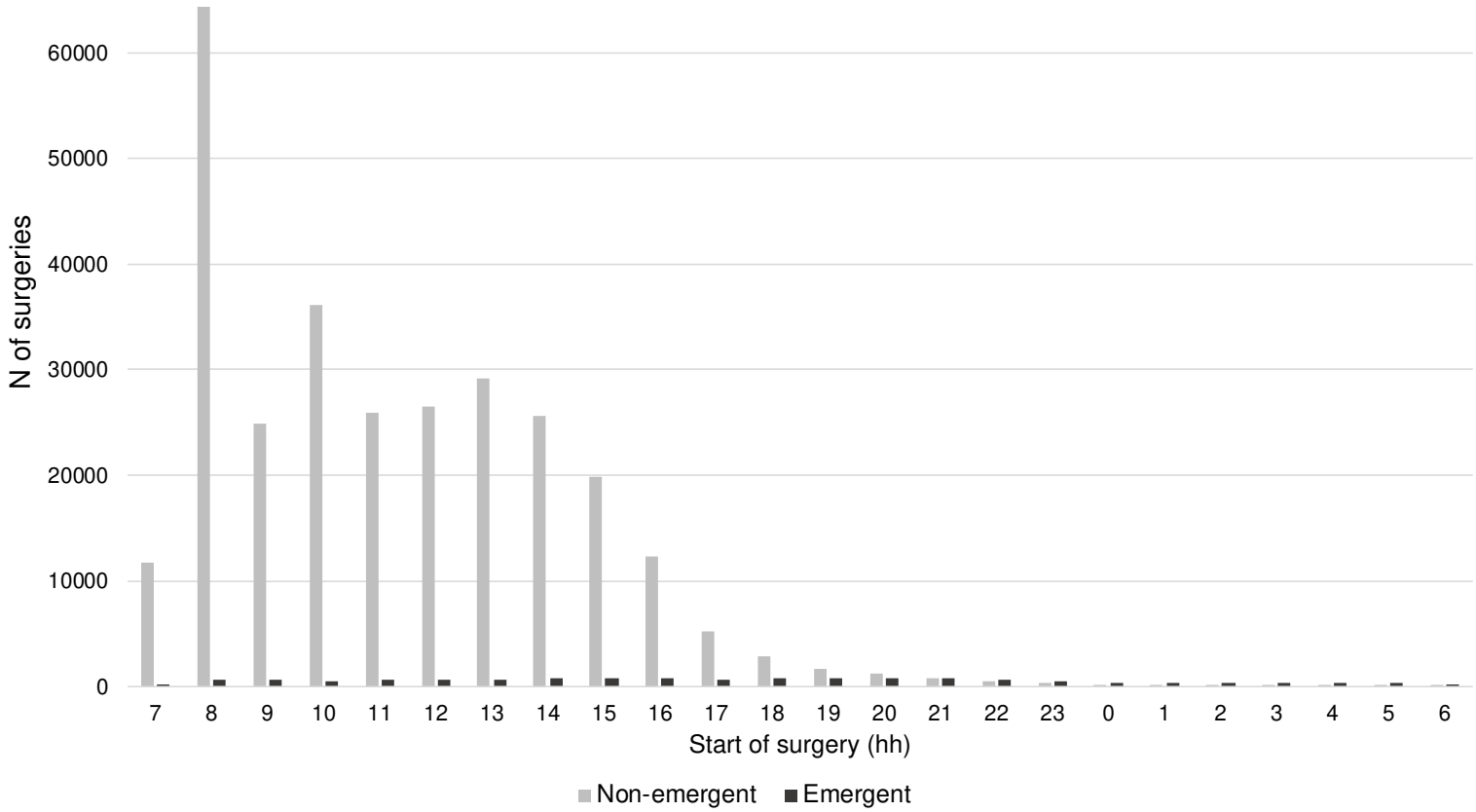
Types of complications	**ICD-9 and ICD-10 diagnostic and procedure codes**
Acute renal failure	584.5 Acute kidney failure with lesion of tubular necrosis 584.6 Acute kidney failure with lesion of renal cortical necrosis 584.7 Acute kidney failure with lesion of renal medullary [papillary] necrosis 584.8 Acute kidney failure with other specified pathological lesion in Kidney N17.0 Acute kidney failure with tubular necrosis N17.1 Acute kidney failure with acute cortical necrosis N17.2 Acute kidney failure with medullary necrosis N17.8 Other acute kidney failure N17.9 Acute kidney failure, unspecified
Myocardial infarction	410 Acute myocardial infarction I21 Acute myocardial infarction I22 Subsequent ST elevation (STEMI) and non-ST elevation (NSTEM) myocardial infarction
Cardiac arrest	427.5 Cardiac arrest I46 Cardiac arrest

Acute heart failure	428.0 Congestive heart failure, unspecified 428.1 Left heart failure 428.20 Systolic heart failure, unspecified 428.21 Acute systolic heart failure 428.23 Acute on chronic systolic heart failure 428.30 Diastolic heart failure, unspecified 428.31 Acute diastolic heart failure 428.33 Acute on chronic diastolic heart failure 428.40 Combined systolic and diastolic heart failure, unspecified 428.41 Acute combined systolic and diastolic heart failure 428.43 Acute on chronic combined systolic and diastolic heart failure 428.9 Heart failure, unspecified I50.1 Left ventricular failure, unspecified I50.20 Unspecified systolic (congestive) heart failure I50.21 Acute systolic (congestive) heart failure I50.23 Acute on chronic systolic (congestive) heart failure I50.30 Unspecified diastolic (congestive) heart failure I50.31 Acute diastolic (congestive) heart failure I50.33 Acute on chronic diastolic (congestive) heart failure I50.40 Unspecified combined systolic (congestive) and diastolic (congestive) heart failure I50.41 Acute combined systolic (congestive) and diastolic (congestive) heart failure

	I50.43 Acute on chronic combined systolic (congestive) and diastolic (congestive) heart failure I50.9 Heart failure, unspecified
Stroke	433.01 Occlusion and stenosis of basilar artery with cerebral infarction 433.11 Occlusion and stenosis of carotid artery with cerebral infarction 433.21 Occlusion and stenosis of vertebral artery with cerebral infarction 433.31 Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction 433.81 Occlusion and stenosis of other specified precerebral artery with cerebral infarction 433.91 Occlusion and stenosis of unspecified precerebral artery with cerebral infarction 434.01 Cerebral thrombosis with cerebral infarction 434.11 Cerebral embolism with cerebral infarction 434.91 Cerebral artery occlusion, unspecified with cerebral infarction 437.1 Other generalized ischemic cerebrovascular disease 437.9 Unspecified cerebrovascular disease I63 Cerebral infarction I67.81 Acute cerebrovascular insufficiency I67.89 Other cerebrovascular disease I67.9 Cerebrovascular disease, unspecified

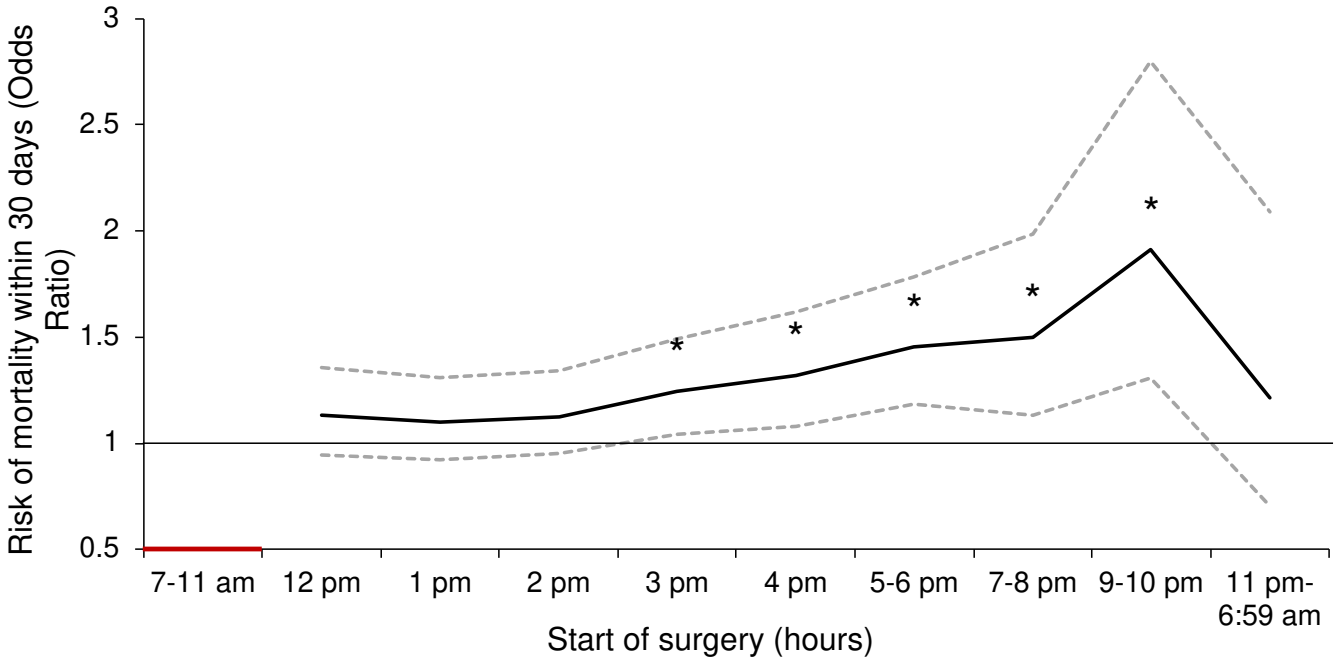
8 Supplemental figures

eFigure 1. Distribution of emergency and non-emergency cases throughout the day

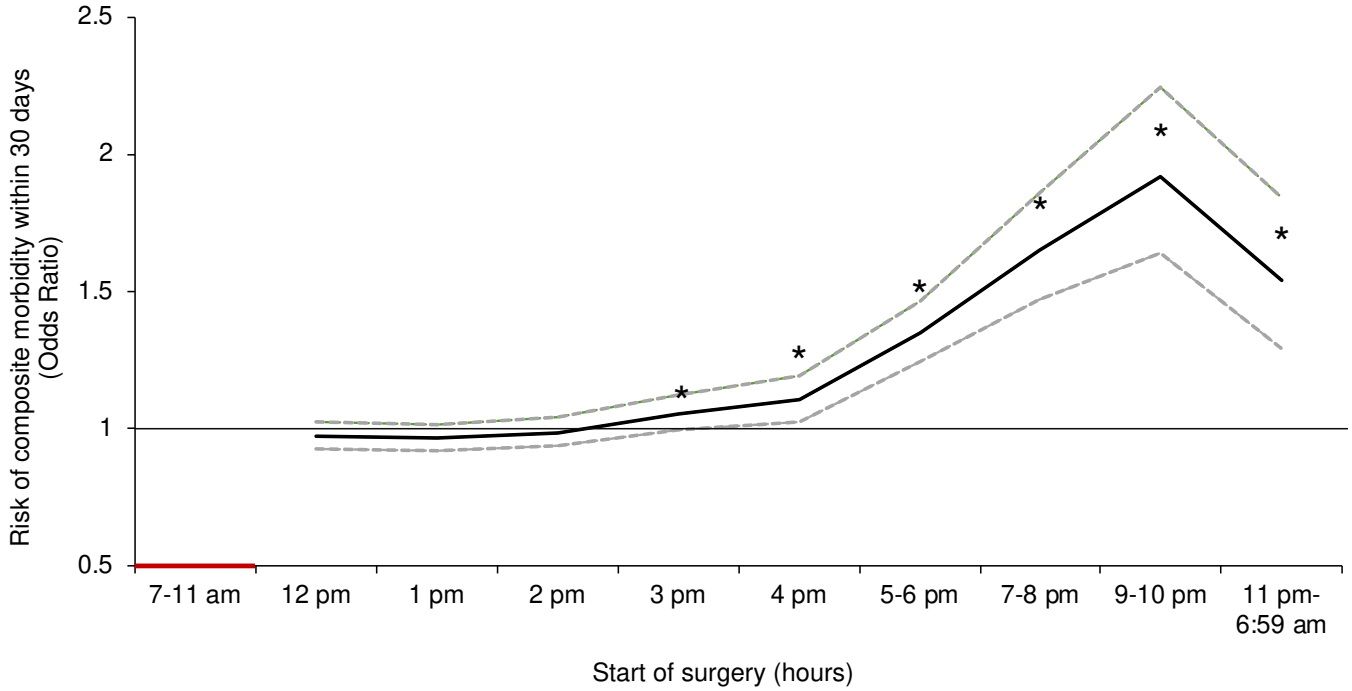


eFigure 2a. Adjusted odds ratios for mortality within 30 days of non-emergency surgery

Odds of 30-day mortality and morbidity after surgery started 3:00-10:59 pm and 3:00pm-6:59 am, respectively, were significantly higher ($p<0.05$) than after baseline risk morning hours from 07:00 to 11:59 h. The figure demonstrates adjusted odds ratios (—) and 95% confidence intervals (···) compared with baseline risk morning hours (_).

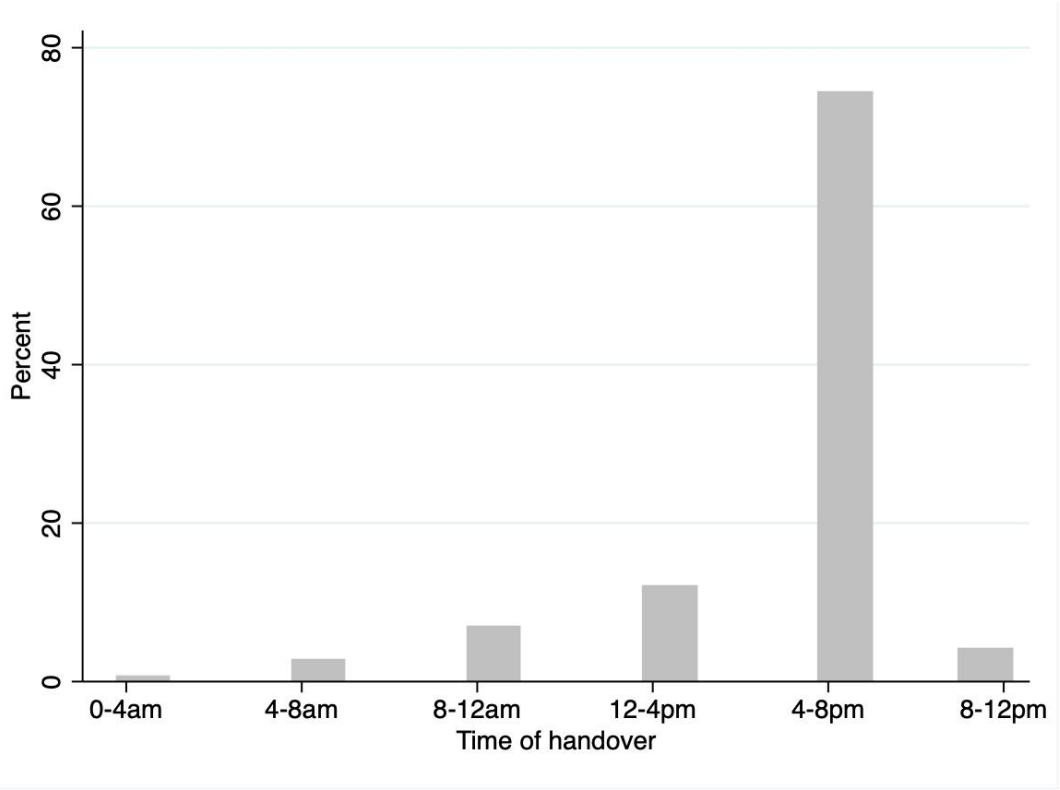


eFigure 2b. Adjusted odds ratios for 30-day morbidity within 30 days of non-emergency surgery



eFigure 3. Proportion of handovers between anaesthesiologists throughout the day

The percentage of handovers between anaesthesiologists occurring between 5 pm and 7 pm is 57 %. Overall, 65 % versus 35 % of handovers occurred during the night and day surgery periods, respectively. Patients undergoing night surgery were also disproportionately affected by multiple handovers (0.36 % of patients during day versus 0.99 % during night surgeries).



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