Global patient outcomes after elective surgery: Prospective cohort study in 27 low, middle and high income countries

Running title: Global patient outcomes after elective surgery

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Abstract

Introduction

As global initiatives increase patient access to surgical treatments, there remains a need to understand the adverse effects of surgery, and define appropriate levels of perioperative care at a global level.

Methods

Prospective international seven-day cohort study of outcomes following elective adult in-patient surgery. The primary outcome was in-hospital complications. Secondary outcomes were death following a complication (failure to rescue), and death in hospital. Process measures were admission to critical care immediately after surgery, or to treat a complication, and duration of hospital stay. A single definition of critical care was used for all countries.

Results

474 hospitals in 19 high, 7 middle and one low income country were included in the primary analysis. The dataset included 44814 patients with a median hospital stay of 4 (2-7) days. 7508 patients (16.8%) developed ≥1 postoperative complications, and 207 died (0.5%). The overall mortality amongst patients who developed complications was (2.8%). Mortality following complications ranged from 2.4% for pulmonary embolism to 43.9% for cardiac arrest. 4360 (9.7%) patients were admitted to a critical care unit as routine immediately after surgery, of whom 2198 (50.4%) developed a complication with 105 (2.4%) deaths. 1233 patients (16.4%) were admitted to a critical care unit to treat complications with 119 (9.7%) deaths. Despite lower baseline risk, outcomes were similar in low and middle, when compared to high income countries.

Conclusions

Poor patient outcomes are common after in-patient surgery. Global initiatives to increase access to surgical treatments should also address the need for safe perioperative care.

Introduction

Currently, 310 million patients undergo surgery worldwide each year, with more procedures taking place in high income countries.[1, 2] Findings from epidemiological studies suggest that 4.8 billion people are unable to access safe surgical treatments,[3] and that at least 143 million additional procedures are required each year, primarily in low and middle income countries.[4, 5] However, as healthcare systems develop to improve access to surgical treatments, the number of patients who suffer postoperative complications will also increase.[3, 4]

Postoperative complications increase treatment costs,[6] and reduce both life expectancy and quality of life at a societal level.[7, 8] Nonetheless, our global understanding of outcomes after surgery remains limited. Estimates from high income countries suggest postoperative complications occur in up to 20% of patients,[9, 10] and short-term mortality may vary from 1 to 4%.[11-18] While effective perioperative care is considered essential to the safe provision of surgical treatments,[8] the optimal level of such care has not been defined. Admission to a critical care unit is often considered necessary to prevent, or treat, life threatening complications. However, this standard of patient care is very expensive, and there is little or no evidence to confirm the critical care resource provision needed for a safe surgical service.

As we seek to ensure the global availability of surgical treatments to all patients, we need to understand how often patients develop complications after surgery, the severity of harm which results, and how hospital systems should be configured to safely respond. We performed the International Surgical Outcomes Study (ISOS) to evaluate the incidence and risk factors for complications and death after in-patient elective surgery at a global level, and to describe current standards of postoperative care.

Methods

Project organisation

ISOS was a seven-day international cohort study. Regulatory requirements differed between countries with some requiring research ethics approval and some requiring only data governance approval. In the UK, the study was approved by the Yorkshire & Humber Research Ethics Committee (Reference: 13/YH/0371). The inclusion criteria were all adult patients (age ≥18 years) undergoing elective surgery with a planned overnight stay in hospital. Each participating country selected a single data collection week between April and August 2014. Patients undergoing emergency surgery, day-case surgery or radiological procedures were excluded. Patient data included only that recorded as part of routine care. In some countries, patient consent was sought to allow the collection of supplementary data for pre-specified sub-studies. In each country, we approached individuals to act as national co-ordinators using contacts in national and international specialist societies in surgery and anaesthesia. Individual participating hospitals were then identified through a global online recruitment campaign led by the study management group, and through the direct approach of the national co-ordinators. Nominations for participation were then confirmed as appropriate through discussion with national co-ordinators. The study website provided all study documentation and guidance on study procedures (www.isos.org.uk/documents). ISOS was registered prospectively with an international trial registry (ISRCTN51817007).

Data collection

Data describing perioperative care facilities were collected for each hospital at the beginning of the study. Data describing consecutive patients were collected until hospital discharge on paper case record forms (Supplementary file). Complications were assessed according to predefined criteria and graded as mild, moderate or severe.[19] Data were censored at 30 days following surgery for patients who remained in hospital. Data were anonymised before entry onto a secure internet based electronic case record form designed specifically for ISOS, which incorporated automated checks for plausibility, consistency and completeness.

Outcome measures

The primary outcome measure was in-hospital postoperative complications. Secondary outcomes were death following a postoperative complication (failure to rescue), and in-hospital mortality. Process measures were admission directly to critical care after surgery, admission to critical care for treatment of a postoperative complication, and duration of hospital stay. A single prospective definition of critical care was used for all countries (a facility routinely capable of admitting patients who require invasive ventilation overnight).

Statistical analysis

We aimed to recruit as many hospitals and countries as possible, and asked investigators in those hospitals to enrol all eligible patients. No formal sample size calculation was performed. Only hospitals returning valid data describing 20 or more patients, and countries with ten or more participating hospitals were included in the primary analysis.

Association between surgical procedure category and patient outcomes

We assessed the association between surgical procedure category and complications or mortality both before and after adjustment for potential confounding factors. The unadjusted analysis was performed using a logistic regression model with the surgical procedure category included as a fixed factor. The adjusted analysis was performed using a three-level mixed-effects logistic regression model. Patients were entered at the first level, hospitals at the second and countries at the third level. This model accounted for correlation between patients in the same hospital or country. The following variables were included as fixed factors in the model: age, current smoker, American Society of Anesthesiologists physical status (ASA) score, severity of surgery, surgical procedure category and presence of ischaemic heart disease, heart failure, diabetes mellitus, chronic obstructive pulmonary disease/asthma, cirrhosis, stroke, and other co-morbid diseases. Factors were selected for biological plausibility, scientific rationale and a low rate of missing data. We used restricted cubic splines to account for a potential non-linear association between age and outcome.[20] To assess the effect of predefined exclusions on our findings, we repeated our analyses for all patients in the database. For both the unadjusted and adjusted analyses, Hosmer-Lemeshow

goodness-of-fit statistics were used to test model calibration, and multi-collinearity was assessed using the variance inflation factor. The ability of the model to discriminate cases from non-cases was assessed using the area under the receiver operating characteristic curve (AUROC). Data are presented as mean (SD) and median (IQR) for continuous data, number (%) for binary data, or as odds ratios (OR) with 95% confidence intervals. Analyses were performed using Stata 14 (StataCorp, USA).

Results

Data describing 44814 patients were collected in 474 hospitals in the following countries and regions: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, France, Germany, Greece, Hong Kong, Indonesia, Italy, Malaysia, Netherlands, New Zealand, Nigeria, Portugal, Romania, Russia, South Africa, Spain, Sweden, Switzerland, Uganda, United Kingdom, and the United States of America (Figure 1). Fewer than ten hospitals participated in India, Iraq and Mexico, and in accordance with the prospective statistical analysis plan, patients recruited in these countries were excluded from the primary analysis (Figure 2). Seven countries were classed middle income and one as low income, with 134 participating hospitals between them.[21] Hospitals had a median of 550 (329-850) ward beds and 21 (10-38) critical care beds. The median critical care capacity (ratio of critical care beds to total hospital beds) was 4 (2-6) %. 310 hospitals (66%) were affiliated to a university. 77% of hospitals provided only government funded healthcare, 3% only privately funded healthcare, whilst 21% of hospitals were funded by both sources. Baseline patient data are presented in table 1.

Data validation

There was high concordance in a random 1% data sample selected for duplicate entry (95% for categorical variables, 92% for continuous variables), with very high concordance for clinical outcomes (99.7%). Investigators were granted immediate access to their uncleaned data once this was locked following entry, and were encouraged to review this for accuracy and completeness. All national co-ordinators confirmed the face validity of the baseline and crude outcome data for their countries. Only a small proportion of patients (451/44814 [1%]), were missing data for at least one of the factors included in the model. Due to the low proportion of missing data, we performed a complete case analysis, where patients with missing data were excluded from the analysis (Supplementary table 1). Hosmer-Lemeshow goodness-of-fit statistics indicated that the models were well calibrated, with a good match between observed and expected outcomes. The discrimination of the model was good with an AUROC of 0·80 (95% CI 0·80 - 0·81). Residuals showed that the assumptions for regression analyses were met. All variables had a variance inflation factor of less than five.

Clinical outcomes

A total of 7508 (16.8%) patients developed complications in hospital, and 207 died before hospital discharge (0.5%), indicating an overall mortality amongst patients who developed complications (failure to rescue) of (2.8%). 5254 (11.7%) patients developed a single postoperative complication whilst a further 2254 (5.0%) patients developed two or more complications. The breakdown of complications is presented in table 2. Infectious complications were the most frequent, in particular superficial surgical site infections. 2925 patients developed an unspecified complication ('other' category). There were significant variations in complications and mortality across surgical procedure categories and countries (Figure 3, Supplementary tables 2 and 3). Outcomes for patients according to planned admission to critical care immediately after surgery are presented in Table 3. 1233 patients (16.4%) were admitted to a critical care unit to treat complications of whom 119 (9.7%) died. 58 (28.0%) patients who died were not admitted to critical care at any stage during their admission, either immediately after surgery or for treatment of a complication. The clinical outcomes for all patients included in the database are presented in Supplementary table 4.

Process measures

The median stay in a post-anaesthetic care unit was 1 (0-2) hours. 4360 (9.7%) patients were admitted to a critical care unit as routine immediately after surgery. The median length of time spent in critical care for those with a planned admission directly after surgery was 1 (1-3) days. Of these patients, 2198 (50.4%) developed a complication with 105 (2.4%) deaths. 1233 (4.9%) patients were admitted to a critical care unit to treat complications of whom 119 (9.7%) died. The median length of time spent in critical care for patients admitted to treat a complication was 3 (1-6) days. The median overall hospital stay was 4 (2-7) days, increasing to 8 (5-14) days amongst those patients who developed complications.

Outcomes in low, middle and high income countries

Patient outcomes and process measures according to low and middle, or high income country status are presented in Table 4. One country in the low and middle income group, which returned a large patient sample, experienced much lower complication rates than other

participating nations. Patients in low and middle income countries tended to be younger with lower ASA scores. Crude complication rates were lower, but mortality rates overall, and for patients developing complications, were similar to those in high income countries, suggesting care for patients who develop complications may be less effective. There was a much lower rate of planned admission to critical care immediately after surgery in low and middle income countries.

Discussion

This international prospective cohort study has provided detailed outcome data on a population of more than 44,000 consecutive patients undergoing elective in-patient surgery in 27 low, middle and high income countries worldwide. The principal finding was that one in six patients experienced a complication before hospital discharge, and one in thirty-five patients who experienced a complication subsequently died without leaving hospital. The mortality amongst patients who developed complications (failure to rescue) of 2.8% indicates the continued need for a more effective treatment response for patients who develop postoperative complications. Despite lower baseline risk, crude patient outcomes were broadly similar in low and middle, compared to high income countries.

There are few large datasets of complication rates after surgery, and none we are aware of which provide data at an international level, although the findings of a recent study of almost 11,000 patients undergoing emergency abdominal surgery in 58 low, middle and high income countries indicate a high mortality following such procedures.[22] Comparisons between country level datasets should be cautious because of international differences in patterns of surgical disease and genomics, as well as in healthcare systems. A variable degree of selection bias is also likely to result in important differences between reports which are few in number. Whilst overall complication rates in the current data were slightly lower than those previously reported in the USA,[9, 23] this may simply be due to differences in patient risk factors and the surgical procedures included. In particular, ISOS only included patients undergoing elective surgery. Previous mortality estimates for unselected patient populations undergoing in-patient surgery vary between 1 and 4%.[15-18] A recent study of postoperative mortality in Europe suggested an in-hospital mortality of 3% for elective in-patient surgery,[11] similar to the overall mortality rates in reports from the USA.[9, 16, 23]

These data provide detailed insights into patterns of critical care admission after surgery. This is an expensive resource, and rates of admission in low and middle income countries appear to be much lower than high-income countries. The value of routine admission of high-risk patients to a critical care unit after surgery remains uncertain and allocation of this this

resource appears inconsistent. For example, admission to critical care after cardiac surgery is routine in most countries, whilst high-risk patients undergoing non-cardiac surgery may not be provided with this level of care despite a much higher mortality rate.[12-14] The findings of two recent healthcare registry studies in the UK suggest that provision of critical care may improve survival for surgical patients, although the effect may be subtle.[24, 25] Meanwhile, a study of Medicare registry data in the US failed to identify any benefit of critical care admission.[26, 27] Comparison of failure to rescue (rate of death after postoperative complications) between hospitals and healthcare systems may help us to understand the impact of postoperative critical care on patient outcomes. Whilst it seems unlikely that we could ever reduce the mortality from postoperative complications to zero, failure to rescue has provided a useful metric of the quality of postoperative care for surgical patients in high income countries.[9, 28-31] We could argue that, in a well-resourced system, very few patients should die after elective surgery without being admitted to a critical care unit. The current data confirm there is an important rate of failure to rescue at a global level, which is placed in context by the rates of use of critical care facilities. Global strategies to improve access to surgical treatments should take account of the increased demand for perioperative care services, in particular critical care, for those patients who develop complications.[3, 4] However, whilst the surgical population is very large, few countries have any reliable system to monitor the volume of activity and clinical outcomes. Understanding of the safety and effectiveness of surgical treatments is therefore limited and the need remains for robust audit and public reporting of outcomes after all surgery worldwide.[8] Data driven improvement in quality of perioperative care may be possible even in resource limited environments.[32]

The strengths of this study include the large number of consecutive patients enrolled worldwide. Importantly, critical care beds were classified according to a standard definition in all participating hospitals. We also distinguished between planned admission to critical care immediately after surgery as a part of routine postoperative management, and unplanned admission to critical care to treat a life threatening complication. By developing a very simple data set consisting primarily of categorical variables, we were able to minimise the amount of missing data. Patient-level variables were selected on the basis that they were objective,

routinely collected for clinical reasons, could be transcribed with a high level of accuracy, a low rate of missing data, and would be relevant to a risk adjustment model which included a wide variety of surgical procedures. The online data entry system was designed specifically for ISOS, and included a variety of internal error checks, whilst avoiding the redundant functionality of generic software designed for complex trials. The study also has a number of weaknesses. Despite the large sample size, we cannot consider this study as representative of current practice in all countries. ISOS was a pragmatic study and only a small proportion of hospitals took part in a small number of countries. Whilst we are pleased to have recruited hospitals in 30 countries, only 27 of these reached the predefined number of participating hospitals. We discussed participation with potential investigators in a number of countries who did not feel they had adequate resources to take part. This affected the participation of low, middle and high income countries. Many patients were enrolled in university hospitals whilst smaller, low volume centres are under-represented. This effect was greater in the low and middle income countries which took part. The risk adjustment methods used may not fully account for high mortality rates in hospitals specialising in more complex surgery. After risk adjustment, there were differences in postoperative outcomes between countries, but there are likely to be differences in casemix which are not fully represented in our baseline data.[1, 2] We note that crude complication and mortality rates were lower in one high volume country, reducing the overall event rate. Given the pragmatic nature of this study, it was only possible to follow patients until hospital discharge. In countries where the availability of hospital beds is more limited, early hospital discharge of patients may have resulted in a lower measured complication rate. Although we planned to enrol every eligible patient undergoing surgery during the study period, we cannot be sure of the exact proportion of eligible patients included. Despite these limitations, assuming the volume of surgery during the cohort week is typical of the participating hospitals, these centres perform over 3 million in-patient surgical procedures each year, approximately 1% of the estimated volume of surgery taking place worldwide.[1, 2]

Conclusions

The findings of this international cohort study indicate that a large number of patients develop complications after elective in-patient surgery. Global strategies to improve access to surgical treatments should take account of the increased demand placed on perioperative care services.

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Role of the funding source

This was an investigator initiated study funded by Nestle Health Sciences through an unrestricted research grant, by a National Institute for Health Research Professorship held by RP, and sponsored by Queen Mary University of London. ISOS investigators were entirely responsible for study design, conduct and data analysis. Members of the writing committee had full data access and were solely responsible for data interpretation, drafting and revision of the manuscript, and the decision to submit for publication. Nestle Health Sciences had no data access and no role in study design, conduct, analysis, or in drafting this report.

Contributors

RP conceived the study and designed this together with all members of the writing committee and steering committees. Patient recruitment and data collection were performed by the members of the ISOS study group (see supplementary file). TA and BK performed the data analysis with input from all members of the writing committee. The manuscript was drafted by RP and revised following critical review by all members of the writing committee and steering committees. The ISOS investigators would like to thank our patient representative, Naomi Pritchard, for her guidance and support throughout this project.

Data sharing

The authors are happy to consider data sharing requests from bona fide researchers. Enquiries should be addressed to the chief investigator at: admin@isos.org.uk.

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Figure & table legends

Figure 1. Countries participating in the International Surgical Outcomes Study

Blue: countries included in primary analysis. Green: countries with fewer than ten participating hospitals included in secondary analysis.

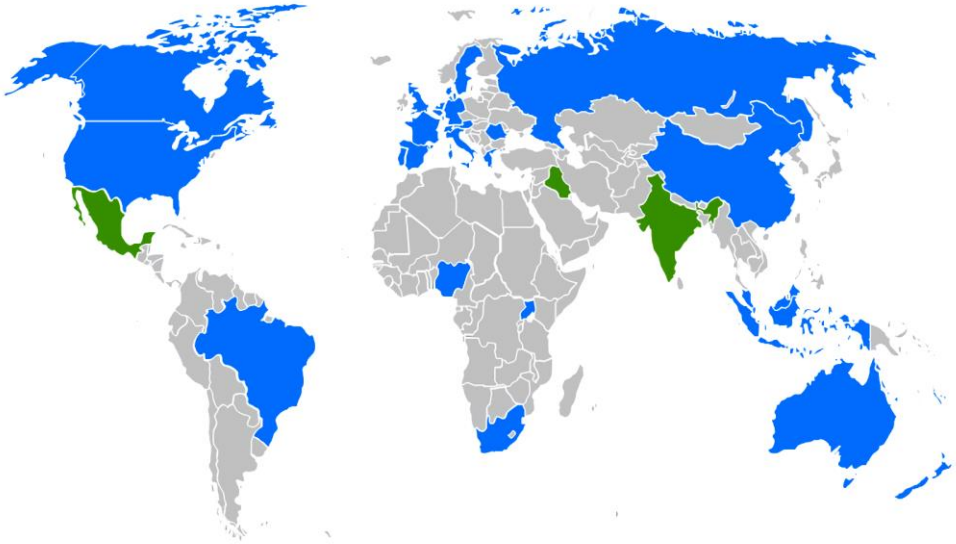

Figure 2. Patients, hospital and countries excluded from study.

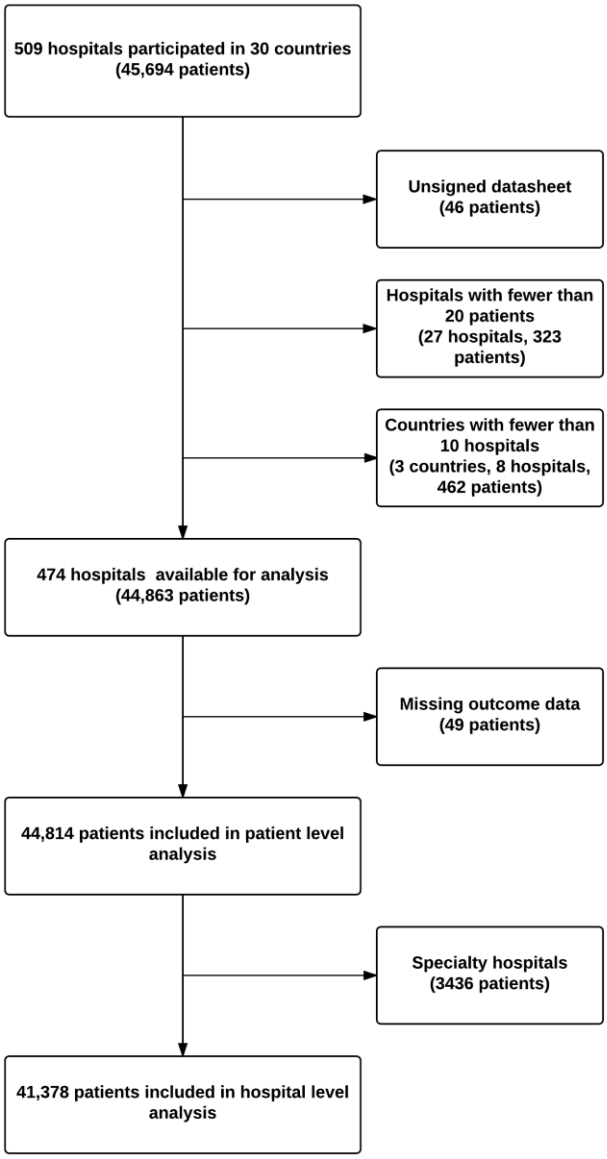

Figure 3. Adjusted risk (odds ratio) of complications with 95% confidence intervals, and in-hospital mortality in different surgical procedure categories.

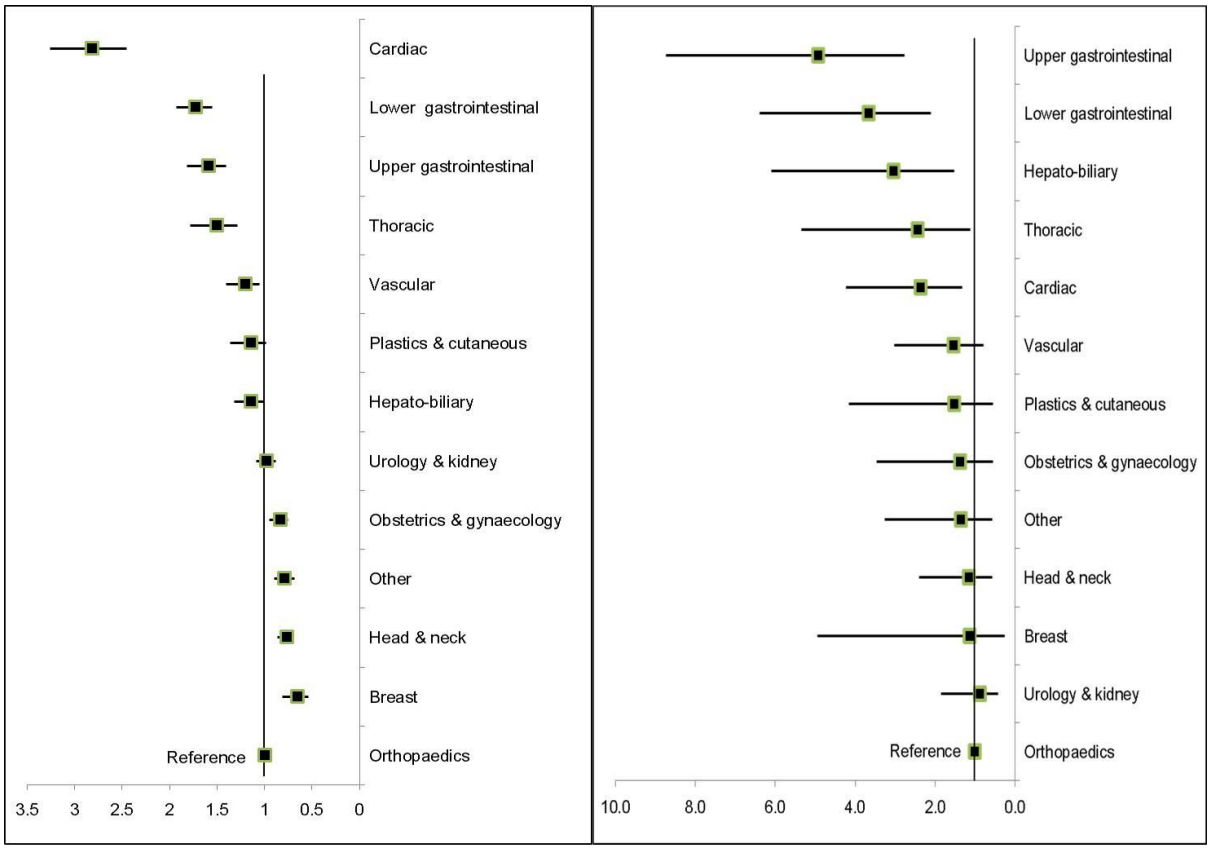

Table 1. Baseline patient characteristics.

All data presented as n (%). ASA, American Society of Anesthesiologists physical status score; COPD, chronic obstructive pulmonary disease.

	All patients n = 44814	Patients with complications n = 7508	Patients with no complications n = 37306	Patients who died n = 207	Patients who survived n = 44607
Age in years (mean SD)	55.3 (17.1)	61.8 (16.0)	54.1 (17.0)	69.1 (13.3)	55.3 (17.1)
Age in years (median range)	57 (18-102)	64 (18-100)	55 (18-102)	73 (28-93)	57 (18-102)
Male	20458 (45.7%)	3968 (19.4%)	16490 (80.6%)	121 (0.6%)	20337 (99.4%)
Smoker	7913 (17.8%)	1305 (16.5%)	6608 (83.5%)	47 (0.6%)	7866 (99.4%)
ASA score					
I	11227 (25.1%)	848 (7.6%)	10379 (92.5%)	1 (0.1%)	11226 (99.9%)
II	22265 (49.8%)	3005 (13.5%)	19260 (86.5%)	38 (0.2%)	22227 (99.8%)
III	10193 (22.8%)	3090 (30.3%)	7103 (69.7%)	115 (1.1%)	10078 (98.9%)
IV	1038 (2.3%)	554 (53.4%)	484 (46.6%)	53 (5.1%)	985 (94.9%)
Severity of surgery					
Minor	8411 (18.8%)	672 (8.0%)	7739 (92.0%)	14 (0.2%)	8397 (99.8%)
Intermediate	20203 (45.1%)	2494 (12.3%)	17709 (87.7%)	56 (0.3%)	20147 (99.7%)
Major	16175 (36.1%)	4336 (26.8%)	11839 (73.2%)	137 (0.9%)	16038 (99.1%)
Surgical procedure					

Orthopaedic	9459 (21.1%)	1556 (16.5%)	7893 (83.5%)	25 (0.3%)	9434 (99.7%)
Breast	1538 (3.4%)	128 (8.3%)	1410 (91.7%)	2 (0.1%)	1536 (99.9%)
Obstetrics & gynaecology	5674 (12.7%)	554 (9.8%)	5120 (90.2%)	6 (0.1%)	5668 (99.9%)
Urology & kidney	4871 (10.9%)	720 (14.8%)	4151 (85.2%)	10 (0.2%)	4861 (99.8%)
Upper gastro-intestinal	1986 (4.4%)	485 (24.4%)	1501 (75.6%)	29 (1.5%)	1957 (98.5%)
Lower gastro-intestinal	3073 (6.9%)	748 (24.3%)	2325 (75.7%)	32 (1.0%)	3041 (99.0%)
Hepato-biliary	2282 (5.1%)	366 (16.0%)	1916 (83%)	14 (0.6%)	2268 (99.4%)
Vascular	1599 (3.6%)	410 (25.6%)	1189 (74.4%)	15 (0.9%)	1584 (99.0%)
Head & neck	6510 (14.5%)	674 (10.4%)	5836 (89.6%)	12 (0.2%)	6498 (99.8%)
Plastics & cutaneous	1670 (3.7%)	244 (14.6%)	1426 (85.4%)	5 (0.3%)	1665 (99.7%)
Cardiac	1716 (3.8%)	979 (57.0%)	737 (43.0%)	40 (2.3%)	1676 (97.7%)
Thoracic	1157 (2.6%)	305 (26.4%)	852 (73.6%)	10 (0.9%)	1147 (99.1%)
Other	3270 (7.3%)	328 (10.0%)	2942 (90.0%)	7 (0.2%)	3263 (99.8%)
Co-morbid disease					
Ischaemic heart disease	4588 (10.3%)	1525 (33.2%)	3063 (66.8%)	67 (1.5%)	4521 (98.5%)
Heart failure	1882 (4.2%)	775 (41.2%)	1107 (58.8%)	49 (2.6%)	1833 (97.4%)
Diabetes mellitus	5171 (11.6%)	1319 (25.5%)	3852 (74.5%)	58 (1.1%)	5113 (98.9%)
Cirrhosis	342 (0.8%)	113 (33.0%)	229 (67.0%)	10 (2.9%)	332 (97.1%)
Metastatic cancer	1706 (3.8%)	508 (29.8%)	1198 (70.2%)	36 (2.1%)	1670 (97.9%)
Stroke	1492 (3.3%)	451 (30.2%)	1041 (69.8%)	38 (2.6%)	1454 (97.4%)

COPD / asthma	4094 (9.2%)	1012 (24.7%)	3082 (75.3%)	40 (1.0%)	4054 (99.0%)
Other	18607 (41.6%)	4134 (22.2%)	14464 (77.8%)	134 (0.7%)	18473 (99.3%)
Other measures					
Laparoscopic surgery	7087 (15.8%)	905 (12.8%)	6182 (87.2%)	16 (0.2%)	7071 (99.8%)
Cancer surgery	9006 (20.3%)	2005 (22.2%)	7001 (77.7%)	70 (0.8%)	8936 (99.2%)

Table 2. Postoperative complications and mortality for 44814 patients undergoing elective surgery.

Data presented as n (%). ARDS, acute respiratory distress syndrome; N/A, category not applicable for this complication. Some patients may have developed more than one complication, and consequently in some cases the denominator is the number complications whilst in the left most column the denominator is the number of patients. The cell at the bottom of the far right column represents the number of deaths divided by the number of patients with at least one complication.

		Severity of complications			Mortality for patients who developed complications
	n=44814	Mild	Moderate	Severe	n = 207
Infectious complications					
Superficial surgical site	1320 (2.9)	681/1320 (51.6)	517/1320 (39.2)	122/1320 (9.2)	17/1320 (1.3)
Deep surgical site	566 (1.3)	120/566 (21.2)	250/566 (44.2)	196/566 (34.6)	28/566 (4.9)
Body cavity	340 (0.8)	97/340 (28.5)	136/340 (40.0)	107/340 (31.5)	24/340 (7.0)
Pneumonia	708 (1.6)	240/708 (33.9)	325/708 (45.9)	143/708 (20.2)	55/708 (7.8)
Urinary tract	681 (1.5)	294/681 (43.2)	333/681 (48.9)	54/681 (7.9)	13/681 (1.9)
Bloodstream	417 (0.9)	140/417 (33.6)	162/417 (38.8)	115/417 (27.6)	48/417 (11.5)
Total infectious complications	4032	1572/4032 (39.0)	1723/4032 (42.7)	737/4032 (18.3)	104/4032 (2.6)
Cardiovascular complications					
Myocardial infarction	139 (0.3)	45/139 (32.4)	43/139 (30.9)	51/139 (36.7)	26/139 (18.7)
Arrhythmia	1222 (2.7)	468/1222 (38.3)	568/1222 (46.5)	186/1222 (15.2)	74/1222 (6.1)
Pulmonary oedema	330 (0.7)	127/330 (38.4)	141/330 (42.8)	62/330 (18.8)	34/330 (10.3)
Pulmonary embolism	78 (0.2)	17/78 (21.8)	33/78 (42.3)	28/78 (35.9)	5/78 (6.4)

Stroke	111 (0.2)	31/111 (27.9)	28/111 (25.2)	52/111 (46.9)	18/111 (16.2)
Cardiac arrest	153 (0.3)	N/A	N/A	153/153 (100.0)	91/153 (59.5)
Total cardiovascular complications	2033	688/2033 (33.8)	813/2033 (40.0)	532/2033 (26.2)	141/2033 (6.9)
Other complications					
Gastro-intestinal bleed	201 (0.4)	95/201 (47.3)	66/201 (32.8)	40/201 (19.9)	24/201 (11.9)
Acute kidney injury	778 (1.7)	423/778 (54.4)	203/778 (26.1)	152/778 (19.5)	76/778 (9.8)
Post-operative bleed	1362 (3.0)	N/A	1147/1362 (84.2)	215/1362 (15.8)	55/1362 (4.0)
ARDS	142 (0.3)	46/142 (32.4)	41/142 (28.9)	55/142 (38.7)	34/142 (23.9)
Anastomotic leak	208 (0.5)	52/208 (25.0)	62/208 (29.8)	94/208 (45.2)	21/208 (10.1)
All others	2934 (6.5)	1342/2925 (45.9)	1200/2925 (41.0)	392/2925 (13.4)	83/2925 (2.8)
Total other complications	5625	1958/5625 (34.8)	2719/5625 (48.3)	948/5625 (16.9)	158/5625 (2.8)
Total number of complications	**11690**	**4218/11690 (36.1)**	**5255/11690 (45.0)**	**2217/11690 (19.0)**	**207/7508 (2.8)**

Table 3. Outcomes for patients according to planned admission to critical care immediately after surgery.

Data presented as n (%).

	All patients	Patients admitted to critical care immediately after surgery	Patients not admitted to critical care immediately after surgery
	n=44814	**n=4360**	**n=39935**
Mortality	207/44814 (0.5%)	105/4360 (2.4%)	99/39935 (0.2%)
Complication(s)	7508/44814 (16.8%)	2198/4360 (50.4%)	5270/39935 (13.2%)
Critical care admission to treat complication(s)	1233/7508 (16.4%)	857/2198 (39.0%)	365/5270 (6.9%)
Death following a complication (Failure to rescue)	207/7508 (2.8%)	105/2198 (4.8%)	99/5270 (1.9%)

Table 4. Hospital resources, process measures and patient outcomes in low, middle and high income countries. **ASA, American Society of Anesthesiologists physical status score; Data presented as mean (SD), median (IQR), or n (%).**

	Low and middle income countries (n=8)	High income Countries (n=19)
Number of hospitals	126	348
Number of patients	15806	29008
Hospital characteristics		
Total beds per hospital	825 (412 - 1318)	570 (361 - 835)
Critical care beds per hospital	25 (12 - 45)	20 (11 - 37)
Critical care capacity per hospital	2.8% (1.5% - 4.8%)	3.6% (2.4% - 5.9%)
Patient characteristics		
Age	50.8 (16.0)	57.8 (17.2)
ASA I & II	13766 (87.2%)	19726 (68.2%)
ASA III & IV	2029 (12.8%)	9202 (31.8%)
Co-morbid disease (any)	6488 (41.2)	19590 (67.6)
Metastatic cancer	297 (1.9)	1409 (4.9)
Process measures		
Post-anaesthetic care unit stay (hours)	1 (0 - 1)	1 (1 - 2)
Length of hospital stay (days)	5 (3 - 8)	3 (1 - 6)
Planned critical care admission	1051/15299 (6.9%)	3309/28996 (11.4%)
Critical care to treat complication(s)	317/15806 (2.0%)	916/28905 (3.2%)
Patient outcomes		
Complication(s)	1760/15806 (11.1%)	5748/29008 (19.8%)
Mortality	58/15806 (0.4%)	149/29008 (0.5%)
Mortality following complications	58/1760 (3.3%)	149/5748 (2.6%)

Global patient outcomes after elective surgery: Prospective cohort study in 27 low, middle and high income countries

Supplementary file

International Surgical Outcomes Study (ISOS) group*

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Paper case record form (CRF) for International Surgical Outcomes Study

Patient name: ..... Date of birth: dd/mm/yyyy

International Surgical Outcomes Study Case Record Form v2.3

For use with Outcomes definitions guide

Age ☐☐☐ years Gender ☐ M ☐ F Current smoker ☐ Y ☐ N

ASA ☐ I ☐ II ☐ III ☐ IV Black ethnicity (eGFR) ☐ Y ☐ N

Chronic Disease (*tick all that apply*):

- ☐ Coronary Artery Disease
- ☐ Heart Failure
- ☐ Diabetes Mellitus
- ☐ Cirrhosis
- ☐ Metastatic cancer
- ☐ Stroke
- ☐ COPD / Asthma
- ☐ Other

Most recent blood results (no more than 28 days before surgery):

Haemoglobin ☐☐☐.☐ g/L Leucocytes ☐☐.☐ x10^9/L

Sodium ☐☐☐ mmol/L Creatinine ☐☐☐.☐ µmol/L

Anaesthesia induction time & date: H H m m D D 0 M 2 0 1 4

Anaesthetic technique (*tick all that apply*)

☐ General ☐ Spinal ☐ Epidural ☐ Sedation / Local

Surgical procedure category (*single best answer*):

- ☐ Orthopaedic
- ☐ Breast
- ☐ Obstetrics & Gynaecology
- ☐ Urology & Kidney
- ☐ Upper gastro-intestinal
- ☐ Lower gastro-intestinal
- ☐ Hepato-biliary
- ☐ Vascular
- ☐ Head and neck
- ☐ Plastics / Cutaneous
- ☐ Cardiac
- ☐ Thoracic (lung & other)
- ☐ Thoracic (gut)
- ☐ Other

Severity of surgery ☐ Minor ☐ Intermediate ☐ Major

Laparoscopic surgery	☐ Y	☐ N
Cancer surgery	☐ Y	☐ N
Surgical checklist used (eg WHO checklist)	☐ Y	☐ N
Critical care immediately after surgery	☐ Y	☐ N

Data entry staff use only

ISOS patient Identifier: ☐☐☐ ☐☐☐☐☐☐☐

Patient name: ..... Date of birth: dd/mm/yyyy

Outcome after surgery

Infection				
Superficial surgical site	Mild ☐	Moderate ☐	Severe ☐	None ☐
Deep surgical site	Mild ☐	Moderate ☐	Severe ☐	None ☐
Body cavity	Mild ☐	Moderate ☐	Severe ☐	None ☐
Pneumonia	Mild ☐	Moderate ☐	Severe ☐	None ☐
Urinary tract	Mild ☐	Moderate ☐	Severe ☐	None ☐
Bloodstream	Mild ☐	Moderate ☐	Severe ☐	None ☐
Cardiovascular				
Myocardial infarction	Mild ☐	Moderate ☐	Severe ☐	None ☐
Arrhythmia	Mild ☐	Moderate ☐	Severe ☐	None ☐
Pulmonary oedema	Mild ☐	Moderate ☐	Severe ☐	None ☐
Pulmonary embolism	Mild ☐	Moderate ☐	Severe ☐	None ☐
Stroke	Mild ☐	Moderate ☐	Severe ☐	None ☐
Cardiac arrest			Severe ☐	None ☐
Other				
Gastro-intestinal bleed	Mild ☐	Moderate ☐	Severe ☐	None ☐
Acute kidney injury	Mild ☐	Moderate ☐	Severe ☐	None ☐
Post-operative bleed		Moderate ☐	Severe ☐	None ☐
ARDS	Mild ☐	Moderate ☐	Severe ☐	None ☐
Anastomotic leak	Mild ☐	Moderate ☐	Severe ☐	None ☐
Other	Mild ☐	Moderate ☐	Severe ☐	None ☐

Treatment for post-operative complications:

Drug therapy, blood transfusion or parenteral nutrition	☐ Y	☐ N
Surgical or radiological procedure	☐ Y	☐ N
Critical care admission	☐ Y	☐ N

Hours in Post-Anaesthetic Care Unit after surgery h h

Days in critical care after surgery d d

Days in hospital after surgery d d

Status at 30 days after surgery ☐ Alive ☐ Dead

Data entry staff use only

ISOS patient Identifier: ☐☐☐ ☐☐☐☐☐☐☐

Supplementary table 1. Missing data in primary analysis cohort.

Data presented as n (%).

Variable	All patients (n = 44814)
Age	15 (<1)
Smoker	249 (1)
ASA score	91 (<1)
Severity of surgery	25 (<1)
Surgical procedure	9 (<1)
Ischaemic heart disease	107 (<1)
Heart failure	107 (<1)
Diabetes mellitus	102 (<1)
Cirrhosis	107 (<1)
Stroke	107 (<1)
COPD / asthma	107 (<1)
Other	107 (<1)
Patients missing at least one variable	451 (1)

Supplementary table 2. Complications after surgery.

Output of the three level hierarchical generalised mixed modelling (mixed effect logistic regression). Patients were entered in the first level, hospitals in second level and countries in the third level. Population average was used as a reference for the countries. Country was added as a random effect in the model. Odds ratios and 95% confidence intervals (CI) for each country were produced by using the random effects estimates of each country. ASA, American Society of Anesthesiologists physical status score; COPD, chronic obstructive pulmonary disease.

	Complications n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-value
Age mean (SD)	61.8 (16.0)	---	---	---
Age spline 1	---	1.01 (1.00 - 1.02)	1.00 (0.99 - 1.01)	0.63
Age spline 2	---	1.08 (1.04 - 1.12)	1.04 (0.99 - 1.08)	0.09
Age spline 3	---	0.77 (0.65 - 0.91)	0.88 (0.73 - 1.06)	0.18
Age spline 4	---	1.35 (0.99 - 1.83)	1.25 (0.89 - 1.76)	0.20
Current smoker	1305 (17.5)	0.98 (0.92 - 1.04)	1.02 (0.95 - 1.1)	0.57
ASA score				
I	848 (11.3)	Reference	---	---
II	3005 (40.1)	1.91 (1.76 - 2.07)	1.38 (1.25 - 1.52)	<0.01
III	3090 (41.2)	5.32 (4.91 - 5.78)	2.39 (2.13 - 2.68)	<0.01
IV	554 (7.4)	14.01 (12.17 - 16.12)	4.30 (3.55 - 5.21)	<0.01
Severity of surgery				
Minor	672 (8.9)	Reference	---	---
Intermediate	2494 (33.2)	1.62 (1.48 - 1.77)	1.76 (1.59 - 1.94)	<0.01
Major	4336 (57.8)	4.22 (3.87 - 4.60)	4.12 (3.71 - 4.56)	<0.01
Surgical procedure				
Orthopaedics	1556 (20.9)	Reference	---	---
Breast	128 (1.7)	0.46 (0.38 - 0.55)	0.66 (0.54 - 0.81)	<0.01
Obstetrics & gynaecology	554 (7.4)	0.55 (0.49 - 0.60)	0.84 (0.75 - 0.95)	<0.01
Urology & kidney	720 (9.6)	0.87 (0.79 - 0.96)	0.98 (0.88 - 1.09)	0.67
Upper gastro-intestinal	485 (6.5)	1.63 (1.45 - 1.83)	1.59 (1.4 - 1.82)	<0.01
Lower gastro-intestinal	748 (10.0)	1.62 (1.47 - 1.79)	1.73 (1.55 - 1.93)	<0.01
Hepato-biliary	366 (4.9)	0.96 (0.85 - 1.09)	1.15 (1 - 1.32)	0.06
Vascular	410 (5.5)	1.74 (1.53 - 1.97)	1.21 (1.05 - 1.4)	0.01
Head & neck	674 (9.0)	0.58 (0.53 - 0.64)	0.77 (0.69 - 0.86)	<0.01
Plastics & cutaneous	244 (3.2)	0.86 (0.75 - 1.00)	1.15 (0.98 - 1.36)	0.09
Cardiac	979 (13.0)	6.70 (6.00 - 7.47)	2.82 (2.45 - 3.26)	<0.01
Thoracic	305 (4.1)	1.80 (1.57 - 2.08)	1.51 (1.28 - 1.78)	<0.01

Other	328 (4.4)	0.56 (0.50 - 0.64)	0.79 (0.68 - 0.9)	<0.01
Co-morbidity				
Coronary artery disease	1525 (20.3)	2.85 (2.66 - 3.01)	1.03 (0.94 - 1.12)	0.59
Heart failure	775 (10.3)	3.76 (3.42 - 4.13)	1.24 (1.10 - 1.40)	<0.01
Diabetes mellitus	1319 (17.6)	1.85 (1.73 - 1.98)	1.10 (1.02 - 1.20)	0.02
Cirrhosis	113 (1.5)	2.47 (1.97 - 3.10)	1.47 (1.12 - 1.91)	0.01
Stroke	451 (6.0)	2.22 (1.98 - 2.49)	1.13 (0.99 - 1.29)	0.07
COPD/Asthma	1012 (13.5)	1.73 (1.60 - 1.86)	1.12 (1.03 - 1.23)	0.01
Other	4134 (55.2)	1.94 (1.85 - 2.04)	1.19 (1.12 - 1.27)	<0.01
Country				
AA	176 (19.9)	1.12 (0.95 - 1.32)	0.90 (0.66 - 1.23)	-
Z	102 (19.3)	1.08 (0.87 - 1.33)	1.02 (0.72 - 1.43)	-
Y	310 (31.4)	2.07 (1.81 - 2.36)	1.38 (1.01 - 1.90)	-
X	129 (13.3)	0.69 (0.58 - 0.83)	0.98 (0.72 - 1.34)	-
W	321 (21.5)	1.24 (1.09 - 1.40)	0.83 (0.62 - 1.10)	-
V	1060 (9.6)	0.48 (0.45 - 0.52)	0.69 (0.56 - 0.86)	-
U	223 (19.7)	1.11 (0.96 - 1.28)	1.08 (0.81 - 1.44)	-
T	174 (17.8)	0.98 (0.83 - 1.15)	1.12 (0.83 - 1.50)	-
S	529 (20.2)	1.14 (1.03 - 1.26)	1.18 (0.89 - 1.57)	-
R	360 (20.6)	1.17 (1.04 - 1.32)	1.11 (0.88 - 1.42)	-
Q	192 (16.9)	0.92 (0.79 - 1.07)	0.90 (0.67 - 1.22)	-
P	70 (16.2)	0.88 (0.68 - 1.12)	1.09 (0.78 - 1.51)	-
O	141 (19.2)	1.07 (0.90 - 1.28)	1.02 (0.73 - 1.42)	-
N	79 (12.4)	0.64 (0.51 - 0.81)	1.10 (0.79 - 1.52)	-
M	298 (19.2)	1.07 (0.94 - 1.22)	1.01 (0.75 - 1.37)	-
L	265 (19.7)	1.11 (0.97 - 1.27)	1.11 (0.84 - 1.46)	-
K	37 (16.0)	0.86 (0.61 - 1.21)	1.10 (0.78 - 1.55)	-
J	168 (22.0)	1.27 (1.08 - 1.51)	1.10 (0.80- 1.50)	-
I	304 (16.3)	0.88 (0.78 - 1.00)	0.94 (0.73 - 1.22)	-
H	125 (19.1)	1.07 (0.88 - 1.29)	0.94 (0.68 - 1.32)	-
G	39 (7.8)	0.38 (0.28 - 0.52)	0.85 (0.61 - 1.19)	-
F	266 (20.4)	1.16 (1.01 - 1.33)	1.07 (0.79 - 1.45)	-
E	163 (23.7)	1.40 (1.18 - 1.66)	1.13 (0.82 - 1.56)	-
D	180 (15.4)	0.82 (0.70 - 0.96)	0.92 (0.68 - 1.24)	-
C	589 (26.4)	1.62 (1.47 - 1.79)	1.03 (0.77 - 1.38)	-
B	42 (23.0)	1.35 (0.96 - 1.88)	1.22 (0.86 - 1.72)	-
A	1166 (16.6)	0.9 (0.84 - 0.96)	0.83 (0.72 - 0.96)	-

Supplementary table 3. Mortality after surgery.

Output of the three level hierarchical generalised mixed modelling (mixed effect logistic regression). Patients were entered in the first level, hospitals in second level and countries in the third level. Population average was used as a reference for countries. Country was added as a random effect in the model, Odds ratios and 95% confidence intervals (CI) for each country were produced by using the random effects estimates for each country. ASA, American Society of Anesthesiologists physical status score; COPD, chronic obstructive pulmonary disease.

	In-hospital mortality n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-value
Age mean (SD)	69.1 (13.3)	---	---	---
Age spline 1	---	1.15 (1.00 - 1.33)	1.12 (0.97 - 1.30)	0.12
Age spline 2	---	0.83 (0.56 - 1.24)	0.79 (0.53 - 1.18)	0.25
Age spline 3	---	1.57 (0.36 - 6.86)	1.94 (0.43 - 8.68)	0.39
Age spline 4	---	0.91 (0.11 - 7.61)	0.75 (0.08 - 6.67)	0.80
Current smoker	121 (58.5)	1.37 (0.99 - 1.90)	1.57 (1.09 - 2.25)	0.02
ASA score				
I	1 (0.5)	Reference		
II	38 (18.4)	19.19 (2.63 - 139.8)	9.23 (1.24 - 68.50)	0.03
III	115 (55.6)	128.10 (17.89 - 917.32)	32.79 (4.41 - 243.84)	<0.01
IV	53 (25.6)	604.04 (83.45 - 4372.45)	111.98 (14.56 - 861.14)	<0.01
Severity of surgery				
Minor	14 (6.8)	Reference	---	---
Intermediate	56 (27.1)	1.67 (0.93 - 3.00)	1.44 (0.78 - 2.66)	0.24
Major	137 (66.2)	5.12 (2.95 - 8.89)	3.01 (1.65 - 5.47)	<0.01
Surgical procedure				
Orthopaedic	25 (12.1)	Reference	---	---
Breast	2 (1.0)	0.49 (0.12 - 2.08)	1.14 (0.26 - 4.95)	0.86
Obstetrics & gynaecology	6 (2.9)	0.40 (0.16 - 0.97)	1.38 (0.55 - 3.47)	0.50
Urology & kidney	10 (4.8)	0.78 (0.37 - 1.62)	0.87 (0.41 - 1.84)	0.71
Upper gastro-intestinal	29 (14.0)	5.59 (3.27 - 9.57)	4.92 (2.77 - 8.74)	<0.01
Lower gastro-intestinal	32 (15.5)	3.97 (2.35 - 6.71)	3.66 (2.10 - 6.39)	<0.01
Hepato-biliary	14 (6.8)	2.33 (1.21 - 4.49)	3.04 (1.52 - 6.10)	<0.01
Vascular	15 (7.2)	3.57 (1.88 - 6.79)	1.54 (0.78 - 3.02)	0.21
Head & neck	12 (5.8)	0.70 (0.35 - 1.39)	1.16 (0.57 - 2.39)	0.68
Plastics & cutaneous	5 (2.4)	1.13 (0.43 - 2.96)	1.51 (0.55 - 4.16)	0.42
Cardiac	40 (19.3)	9.01 (5.45 - 14.88)	2.36 (1.32 - 4.23)	<0.01
Thoracic	10 (4.8)	3.29 (1.58 - 6.87)	2.43 (1.11 - 5.35)	0.03

Other	7 (3.4)	0.81 (0.35 - 1.87)	1.36 (0.57 - 3.26)	0.49
Co-morbidities				
Coronary artery disease	67 (32.4)	4.23 (3.16 - 5.67)	0.99 (0.70 - 1.41)	0.97
Congestive heart failure	49 (23.7)	7.22 (5.22 - 9.98)	1.41 (0.96 - 2.07)	0.08
Diabetes mellitus	58 (28.0)	3.00 (2.21 - 4.07)	1.24 (0.89 - 1.73)	0.20
Cirrhosis	10 (4.8)	6.75 (3.55 - 12.86)	2.61 (1.27 - 5.33)	0.01
Stroke	38 (18.4)	6.66 (4.66 - 9.50)	2.58 (1.74 - 3.82)	<0.01
COPD/Asthma	40 (19.3)	2.39 (1.69 - 3.38)	1.14 (0.79 - 1.67)	0.48
Other	134 (64.7)	2.59 (1.94 - 3.44)	1.30 (0.95 - 1.78)	0.11
Country				
AA	2 (0.2)	0.46 (0.12 - 1.78)	0.57 (0.25 - 1.29)	-
Z	7 (1.3)	2.74 (1.30 - 5.77)	1.76 (0.81 - 3.85)	-
Y	4 (0.4)	0.83 (0.32 - 2.18)	0.82 (0.37 - 1.83)	-
X	17 (1.7)	3.63 (2.20 - 6.01)	3.95 (2.12 - 7.36)	-
W	6 (0.4)	0.83 (0.37 - 1.83)	0.57 (0.29 - 1.12)	-
V	12 (0.1)	0.22 (0.12 - 0.40)	0.64 (0.37 - 1.11)	-
U	7 (0.6)	1.27 (0.60 - 2.67)	1.29 (0.63 - 2.65)	-
T	6 (0.6)	1.26 (0.57 - 2.79)	1.43 (0.68 - 3.02)	-
S	11 (0.4)	0.86 (0.47 - 1.57)	0.93 (0.5 - 1.75)	-
R	15 (0.9)	1.77 (1.04 - 3.00)	1.29 (0.74 - 2.26)	-
Q	3 (0.3)	0.54 (0.18 - 1.64)	0.75 (0.34 - 1.68)	-
P	1 (0.2)	0.47 (0.07 - 3.17)	1.10 (0.38 - 3.13)	-
O	5 (0.7)	1.40 (0.59 - 3.34)	1.19 (0.53 - 2.68)	-
N	2 (0.3)	0.64 (0.17 - 2.49)	1.48 (0.53 - 4.13)	-
M	4 (0.3)	0.53 (0.20 - 1.38)	0.76 (0.35 - 1.62)	-
L	2 (0.1)	0.30 (0.08 - 1.17)	0.58 (0.26 - 1.33)	-
K	2 (0.9)	1.78 (0.46 - 6.91)	1.67 (0.57 - 4.92)	-
J	5 (0.7)	1.35 (0.56 - 3.21)	1.12 (0.52 - 2.43)	-
I	20 (1.1)	2.22 (1.39 - 3.55)	1.65 (0.98 - 2.78)	-
H	5 (0.8)	1.57 (0.66 - 3.76)	1.17 (0.52 - 2.61)	-
G	3 (0.6)	1.23 (0.40 - 3.72)	1.78 (0.67 - 4.73)	-
F	14 (1.1)	2.22 (1.29 - 3.83)	1.79 (0.97 - 3.29)	-
E	2 (0.3)	0.59 (0.15 - 2.29)	0.91 (0.37 - 2.24)	-
D	4 (0.3)	0.70 (0.27 - 1.84)	0.95 (0.43 - 2.09)	-
C	24 (1.1)	2.22 (1.44 - 3.44)	0.94 (0.55 - 1.60)	-
B	1 (0.5)	1.12 (0.17 - 7.52)	1.38 (0.44 - 4.36)	-
A	23 (0.3)	0.67 (0.43 - 1.04)	0.87 (0.58 - 1.31)	-

Supplementary table 4. Complications and mortality after surgery including all patients entered onto the International Surgical Outcomes Study database. **Data presented as n (%). ARDS, acute respiratory distress syndrome; N/A, category not applicable for this complication. Some patients may have developed more than one complication, and consequently in some cases the denominator is the number complications whilst in the left most column the denominator is the number of patients. The cell at the bottom of the far right column represents the number of deaths divided by the number of patients with at least one complication.**

		Severity of complications			Mortality for patients who developed complications
	n = 45,599	Mild	Moderate	Severe	n = 212
Infectious complications					
Superficial surgical site	1366 (3.0)	711/1366 (52.0)	527/1366 (38.6)	128/1366 (9.4)	19/1366 (1.4)
Deep surgical site	585 (1.28)	127/585 (21.7)	256/585 (43.8)	202/585 (34.5)	29/585 (5.0)
Body cavity	348 (0.8)	99/348 (28.4)	138/348 (39.7)	111/348 (31.9)	26/348 (7.5)
Pneumonia	732 (1.6)	246/732 (33.6)	335/732 (45.8)	151/732 (20.6)	57/732 (7.8)
Urinary tract	696 (1.5)	299/696 (43.0)	342/696 (49.1)	55/696 (7.9)	13/696 (1.9)
Bloodstream	432 (0.9)	143/432 (33.1)	169/432 (39.1)	120/432 (27.8)	50/432 (11.6)
Total infectious complications	4159	1625/4159 (39.1)	1767/4159 (42.5)	767/4159 (18.4)	110/4159 (2.6)
Cardiovascular complications					
Myocardial infarction	145 (0.3)	48/145 (33.1)	45/145 (31.0)	52/145 (35.9)	26/145 (17.9)
Arrhythmia	1238 (2.7)	477/1238 (38.5)	571/1238 (46.1)	190/1238 (15.3)	76/1238 (6.1)
Pulmonary oedema	337 (0.7)	131/337 (38.9)	142/337 (42.1)	64/337 (19.0)	33/337 (9.8)
Pulmonary embolism	83 (0.2)	17/83 (20.5)	36/83 (43.4)	30/83 (36.1)	6/83 (7.2)

Stroke	117 (0.3)	33/117 (28.2)	30/117 (25.6)	54/117 (46.2)	18/117 (15.4)
Cardiac arrest	160 (0.4)	N/A	N/A	160/160 (100)	94/160 (58.8)
Total cardiovascular complications	2080	706/2080 (33.9)	824/2080 (39.7)	550/2080 (26.4)	147/2080 (7.1)
Other complications					
Gastro-intestinal bleed	206 (0.5)	98/206 (47.6)	68/206 (33.0)	40/206 (19.4)	25/206 (12.1)
Acute kidney injury	798 (1.8)	433/798 (54.3)	209/798 (26.2)	156/798 (19.5)	80/798 (10.0)
Post-operative bleed	1377 (3.0)	N/A	1162/1377 (84.4)	215/1377 (15.6)	54/1377 (3.9)
ARDS	147 (0.3)	50/147 (34.0)	41/147 (27.9)	56/147 (38.1)	34/147 (23.1)
Anastomotic leak	212 (0.5)	52/212 (24.5)	64/212 (30.2)	96/212 (45.3)	21/212 (9.9)
All others	2978 (6.5)	1371/2978 (46.0)	1221/2978 (41.0)	386/2978 (13.0)	85/2978 (2.9)
Total other complications	5718	2004/5718 (35.0)	2765/5718 (48.4)	949/5718 (16.6)	163/5718 (2.9)
Total number of complications	**11957**	**4335/11957 (36.3)**	**5356/11957 (44.8)**	**2266/11957 (18.9)**	**212/7673 (2.8)**

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North Manchester General Hospital

Mohammed Absar*, Joanne Allsop, Zoe Drinkwater, Tracey Hodgkiss, Kirsty Smith

North Tyneside General

Jamie Brown*, Sara Pick

Northampton General Hospital

Farhad Alexander-Sefre, Lorraine Campey, Lucy Dudgeon, Kathryn Hall*, Rachael Hitchcock, Lynne James, Kate Smith, Ulrika Winstone

Northern General Hospital

Norfaizan Ahmad, Kris Bauchmuller, Jonathan Harrison, Holly Jeffery, Duncan Miller, Angela Pinder, Sailaja Pothuneedi, Jonathan Rosser, Sumayer Sanghera*, Diane Swift, Rachel Walker

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Queen Victoria Hospital

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