**Use of failure to rescue to identify international variation in postoperative care in low, middle and high income countries:**

**Analysis of data from a seven day cohort study of elective surgery**

***Running title: International evaluation of Failure to Rescue***

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**Keywords:** Postoperative care/methods; Postoperative care/statistics & numerical data; Surgical Procedures, Operative/mortality; Postoperative care/methods

**Main text:** 3271 words  **Summary:** 249 words

**Abstract**

**Introduction**

The incidence and impact of postoperative complications are poorly described in the literature. Failure to rescue, the rate of death following complications, is an important quality measure for perioperative care but has not been investigated across multiple healthcare systems.

**Methods**

Planned analysis of data collected during an international seven-day cohort study of adults undergoing elective in-patient surgery. Hospitals were ranked in quintiles according to surgical procedural volume (Q1 lowest to Q5 highest). For each quintile, we assessed in-hospital complications rates, mortality, and failure to rescue. We repeated this analysis ranking hospitals by risk-adjusted complication rates (Q1 lowest to Q5 highest).

**Results**

44814 patients from 474 hospitals in 27 low, middle and high income countries were available for analysis. 7508 (16.8%) developed ≥1 postoperative complications, with 207 deaths in hospital (0.5%), giving an overall failure to rescue rate of 2.8%. When hospitals were ranked in quintiles by procedural volume, we identified a three-fold variation in mortality (Q1: 0.6% vs Q5: 0.2%), and a two-fold variation in failure to rescue (Q1: 3.6% vs Q5: 1.7%). Ranking hospitals in quintiles by risk adjusted complication rate further confirmed the presence of important variations in failure to rescue, indicating differences between hospitals in the risk of death amongst patients after they develop complications.

**Conclusions**

Comparison of failure to rescue rates across healthcare systems suggests the presence of preventable post-operative deaths. Using such metrics, developing nations may benefit from the data driven approach to quality improvement which has proved effective in high income countries.

**Introduction**
Global epidemiological studies suggest that 4.8 billion people are unable to access safe surgical treatments,[1](#_ENREF_1) and that at least 143 million additional procedures are required each year, primarily in low and middle income countries.[2](#_ENREF_2), [3](#_ENREF_3) However, as healthcare systems develop to improve access to surgical treatments, the number of patients who suffer postoperative complications will also increase.[1](#_ENREF_1), [2](#_ENREF_2) Postoperative complications occur frequently and can lead to death or reduce the clinical effectiveness of surgical treatments, as well as increasing costs.[4](#_ENREF_4), [5](#_ENREF_5) Recent commentaries have emphasised that any attempts to extend healthcare coverage must not occur at the expense of extending safe patient care.[6](#_ENREF_6)

In developed countries, estimates of short-term mortality after surgery vary from 1 to 4%,[7-11](#_ENREF_7) and effective perioperative care is considered essential to the safe provision of surgical treatments. Numerous studies have described important variations in survival following surgery.[10](#_ENREF_10), [12-14](#_ENREF_12) The underlying reasons for these observations are complex, but variations in clinical outcomes after surgery are increasingly used to identify differences in quality of patient care which may affect survival. Failure to rescue, defined as the hospital rate of death following a complication, is a metric which has been widely used to identify differences in the quality of perioperative care between hospitals within healthcare systems.[14-18](#_ENREF_14) Important determinants of the quality of patient care reflected by variations in failure to rescue rates include hospital activity volume, nurse : patient ratios, and training of nursing and medical staff.[19-21](#_ENREF_19) However, there has been no international comparison of the incidence of failure to rescue, and there is no reported evidence of the use of this metric in low, and middle income countries. Inclusion of failure to rescue data in clinical audits of perioperative care may provide developing nations with an objective measure of quality, allowing hospitals to identify problem areas and share best practice.

We performed a prospective analysis of data collected during the International Surgical Outcomes Study (ISOS) which describe patient outcomes following elective surgery in 27 countries.[22](#_ENREF_22) Our aim was to investigate failure to rescue as a metric of healthcare quality across different healthcare systems, and to establish its utility in improving safety for patients undergoing surgery in low and middle income countries, as well as high income countries.

**Methods**

*Project organisation*

ISOS was a seven-day international cohort study.[22](#_ENREF_22) 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. Only hospitals returning valid data describing 20 or more patients, and countries with ten or more participating hospitals were included in the analysis. ISOS was registered prospectively with an international trial registry (ISRCTN51817007). 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. Complications were assessed according to predefined criteria and graded as mild, moderate or severe.[23](#_ENREF_23) Data were censored at 30 days following surgery for patients who remained in hospital. A single prospective definition of critical care was used for all countries (a facility routinely capable of admitting patients who require invasive ventilation overnight).

*Outcome measures*

The primary outcome measure was failure to rescue, defined as the proportion of those patients who developed a postoperative complication who subsequently died within 30 days of surgery. The online data entry system required investigators to enter data describing the complications experienced by all patients who died. Thus our dataset did not include patients who died without developing a complication. Secondary outcomes were in-hospital rates of complications, and mortality within 30 days of surgery.

*Failure to rescue analyses*

For the primary analysis, we ranked the hospitals into five quintiles according to the volume of surgical procedures performed during the study week. Hospitals with the lowest procedural volume were placed in quintile 1, and hospitals with the highest procedural volume were placed in quintile 5. We calculated the mortality, failure to rescue, and complication rates for each individual hospital, and then took the average across all the hospitals in each quintile to provide the quintile specific outcome rates. The rate of critical care admission to treat a complication was calculated as the number of patients admitted to critical care to treat a complication divided by the total number of patients developing complications in that hospital. For the secondary analysis, we used a previously described method to group hospitals into quintiles based on their risk adjusted complication rate.[15](#_ENREF_15) The risk adjusted complication rate for each hospital was calculated using a multivariable logistic regression model in which the independent variables were age (splines), gender, current smoker, American Society of Anesthesiologists (ASA) physical status 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 (see below) and the dependent variable was postoperative complications. Risk adjusted rates of complications were calculated from the predicted probabilities generated by this model, and then used to rank hospitals into quintiles containing approximately equal numbers of patients. To assess how the outcomes differed across quintiles, we then repeated the same method used in the primary analysis. Data are presented as n (%), mean (SD) or median (IQR). Odds ratios are presented with 95% confidence intervals. All analyses were performed using STATA 13 (StataCorp, USA).

*Sensitivity analyses*

We have included some additional analyses not included in the original analysis plan. We tested the statistical significance of patterns of patient outcomes across quintiles using the chi-square test for trend. We repeated the primary analysis ranking hospitals in quintiles by procedural volume but excluding minor complications. We have included data describing failure to rescue rates according critical care admission in each quintile, and patterns of failure to rescue in low or middle, and high income countries.

**Results**

Hospitals in 27 countries and regions participated in ISOS: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, France, Germany, Greece, Hong Kong, India, Indonesia, Iraq, Italy, Malaysia, Mexico, The Netherlands, New Zealand, Nigeria, Portugal, Romania, Russia, South Africa, Spain, Sweden, Switzerland, Uganda, United Kingdom, and the United States of America. 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. Data describing 44814 patients from 474 hospitals were included in the analysis. Eight countries were classed as low or middle income countries, with 134 participating hospitals. Hospitals had a median of 550 ward beds (329-850) and 21 critical care beds (10-38). The median ratio of critical care beds to ward beds was 0·04 (0·02-0·06). 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.

*Clinical outcomes*

A total of 7508 (16.8%) patients developed complications in hospital, and 207 died before hospital discharge (0.5%) giving an overall failure to rescue rate of 2.8%. 5254 (11.7%) patients developed a single postoperative complication and a further 2254 (5.0%) patients developed two or more complications. No patients died without a recorded complication. Patient outcomes are presented according to baseline risk factors in Table 1. The median overall hospital stay was 4 (2-7) days, increasing to 8 (5-14) days amongst those patients who developed complications. 4360 patients (9.7%) were admitted directly to critical care after surgery with a mean length of critical care stay of 0.3 (1.7) days. 1233 patients (2.8%) were admitted to critical care to treat a postoperative complication, or experienced an extended critical care stay for this reason. Outcomes for patients according to planned admission to critical care immediately after surgery are presented in Table 2.

*Failure to rescue analysis*

Table 3 describes hospital factors, process measures, crude patient outcomes, and risk-adjusted patient outcomes for the five quintiles ranked by hospital procedural volume. Complication rates varied from 19.4% to 11.1%, mortality varied almost three fold between quintile 1 to quintile 5 (0.6% in quintile 2 vs 0.2% in quintile 5), and Failure to Rescue varied two-fold across the quintiles (3.6% in Q1 vs 1.7% in Q5). The risk adjusted complication rate did not vary much across quintiles but the risk adjusted mortality rate varied two fold (1.6% in quintile 4 vs 3.2% in quintile 1). The output of the multivariable logistic regression model used to calculate the risk adjusted complication rate for each hospital is presented in Supplementary table 1. When hospitals were ranked in quintiles by risk adjusted complication rate, there was a five-fold variation in crude complication rates between hospital quintiles from 5.5% in Q1 to 28.2% in Q5 (Figure 2). However, the pattern of mortality across quintiles was very different, with much less variation but failure to rescue rates varied more than two fold from 1.9% in Q1 and Q5 to 4.2% in Q3.

*Sensitivity analyses*

The results of the sensitivity analyses did not alter our overall findings. The trend across quintiles was significant for all patient outcomes (p<0.05, chi-square test for trend). The effect of removing minor complications from the primary analysis is presented in Supplementary figure 1. Patterns of failure to rescue across the quintiles for planned admission to critical care and critical care admission to treat a complication are presented in Supplementary table 2. Data describing failure to rescue rates in low or middle, and high income countries are presented in Supplementary table 3.

**Discussion**

This is the first large scale study to investigate failure to rescue following elective surgery in order to provide a global comparison of hospitals in different countries and healthcare systems. We identified important variations between hospitals in death following postoperative complications (failure to rescue) at an international level. Across the whole cohort, one in thirty-five patients who experienced a complication subsequently died without leaving hospital, equivalent to a failure to rescue rate of 2.8%. However, when ranked either by hospital procedure volume or by risk adjusted complication rate, we identified very different patterns of complication rates and mortality, and more than two-fold variation in failure to rescue rates between the best and worst performing hospitals. Hospitals with the highest complication rates did not have the highest failure to rescue rates. These observations suggest differences in the capability of individual hospitals to identify and escalate the care of patients who develop complications after surgery. Failure to rescue appears to be an effective metric for identifying the presence of preventable post-operative deaths when comparing healthcare systems at an international level. The use of failure to rescue alongside similar metrics, may facilitate a data driven approach to quality improvement in low and middle income countries.

The failure to rescue metric does not define poor care, instead it is an indicator of where poor care may exist. To be useful, the metric must be applied at hospital level across large populations where risk adjustment is more difficult. Interpretation must be cautious, as with mortality and other outcomes which are routinely used to compare the performance of healthcare systems. Failure to rescue has been used as an outcome measure for various patient groups, including upper gastrointestinal, gynaecological, liver, colorectal, and aortic surgery,[24-28](#_ENREF_24) as well as emergency surgery.[29](#_ENREF_29) Traditionally, the prevention of post-operative complications has been the primary focus of efforts to reduce mortality after surgery. However, with the advent of large projects designed to improve the quality of perioperative care, we have identified the management of complications as an important opportunity to prevent postoperative deaths. The importance of monitoring the quality of care is emphasised by increasing expectations of both patients and regulatory bodies, with growing emphasis on quality of care metrics, rather than clinical outcomes alone. Overall hospital mortality has limitations as a measure of the quality of patient care, because it does not discriminate between preventable and non-preventable deaths. Failure to rescue is considered a robust measure of healthcare quality because the mortality rate for patients who develop complications more closely reflects the quality of hospital systems for escalating the care of patients experiencing life threatening physiological deterioration. An effective hospital system will ensure prompt identification of a patient who develops a complication, and commence appropriate treatment, including resuscitation, in order to prevent their death.[14](#_ENREF_14) Hospitals with the greatest complication rates do not necessarily have the greatest mortality, indicating the role perioperative care may play in avoiding preventable deaths. Because the metric primarily reflects patient care once complications have developed, it is less sensitive to differences in casemix and the problems associated with inadequate risk adjustment.[14](#_ENREF_14) However, comparisons between hospitals using failure to rescue do rely on accurate monitoring of postoperative complications, and consistent coding between different hospitals.[30](#_ENREF_30) Anecdotally, the term ‘failure to rescue’ has led to reluctance amongst some clinicians to accept this metric because of the perception of implicit criticism. Nonetheless, this measure is now recognised as an important marker of the quality of care for surgical patients, and has been used in particular to assess the effect of nurse staffing levels.[20](#_ENREF_20) Studies of failure to rescue rates have identified substantial variations between hospitals within countries and/or specific sub-groups of surgical patients.[15-18](#_ENREF_15) The current data now confirm relevance of failure to rescue as a quality measure for international comparisons of healthcare including low and middle, and high income countries. At 2.8%, failure to rescue rate was lower than previous reports, which may have been more focused on more severe complications and major surgery,[15](#_ENREF_15), [31](#_ENREF_31) whereas the current analysis included all complications in all patients undergoing in-patient surgery. Global strategies to improve access to surgical treatments must take account of the inevitable increase in demand for perioperative care services for patients who develop complications. Whilst the surgical population is very large, few countries have any reliable system to monitor the volume of surgical activity or clinical outcomes. Data driven improvement in quality of perioperative care may be possible even in resource limited environments,[32](#_ENREF_32) and the need remains for robust audit and public reporting of outcomes after all surgery worldwide.[33](#_ENREF_33)

Failure to rescue may be determined by a variety of hospital structures and processes, and has been associated with nurse : patient ratios, training of nursing and medical staff, poor access to radiology services, and emergency operating room availability.[19-21](#_ENREF_19), [31](#_ENREF_31) There are some data which suggest a relationship between failure to rescue and the provision of good quality critical care,[28](#_ENREF_28), [31](#_ENREF_31) although the evidence of benefit for postoperative critical care admission is inconsistent. Two recent analyses have failed to demonstrate any mortality benefit associated with postoperative critical care admission.[34](#_ENREF_34), [35](#_ENREF_35) However, a recent analysis of emergency surgical admissions in the UK identified variations in crude mortality, which appeared to be lower in those hospitals with the highest levels of medical and nursing staffing, and critical care beds.[36](#_ENREF_36) Another healthcare registry study from the UK identified regional variations in postoperative mortality, which appeared to be related to provision and utilisation of postoperative critical care.[37](#_ENREF_37) Meanwhile the need for unplanned admission to critical care to treat postoperative complications is associated with a significant increase in mortality.[10](#_ENREF_10), [38](#_ENREF_38) The most widely debated determinant of failure to rescue is perhaps the volume-outcome relationship. The association between hospital volume and mortality has been demonstrated for complex surgical procedures,[39](#_ENREF_39) and common medical emergencies.[40](#_ENREF_40) These observations have driven service reconfigurations in various countries, but remain controversial. Activity volume may simply be a surrogate for structure and process measures of care rather than quality, and the causality of the relationship could simply reflect the fact that hospitals with better outcomes may attract more referrals. It was not an objective of this analysis to explore volume-outcomes relationships; we ranked quintiles by volume simply as a convenient way of comaring a large and heterogeneous group of hospitals.

The strengths of this study include the large number of consecutive patients enrolled worldwide. 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 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. High levels of concordance in the random sample of patients selected for duplicate data entry further demonstrate the quality of the data capture process. However, the study also has a number of weaknesses. Overall complication rates were slightly lower than those previously reported in the USA,[15](#_ENREF_15) this may simply be due to differences in patient risk factors and the surgical procedures included, in particular non-elective surgery and the lower proportion of upper gastrointestinal surgery which contributed to failure to rescue rates in previous studies. Despite the large sample size, we cannot consider this study as representative of current practice in all countries. Only a small proportion of hospitals took part in a small number of countries. Many patients were enrolled in large university hospitals whilst smaller, low volume centres are under-represented. This may be more important for the low and middle income countries which took part. We note that crude complication and mortality rates were lower in one high volume country, reducing the overall event rate and hence the number of occasions on which failure to rescue might occur. There is also a preponderance of hospitals from low and middle income countries in the highest volume quintile. 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. The definition of failure to rescue is dependent on how post-operative complications are measured and defined. The analytical approach to comparing failure to rescue rates between hospitals is sensitive to the method of data collection. In ISOS, data were collected for one week in a large number of hospitals giving a large number of outcome events, but a relatively low event rate for individual hospitals. This precludes repetition of the analysis used in some previous research.[15](#_ENREF_15) In mixed surgical populations, risk adjustment models can only include variables available for all patient groups. However, the most useful covariates are often specific to smaller categories of patients such cardiac (EuroSCORE) or colorectal surgery (tumour grading). Inevitably, there will be a higher degree of unmeasured confounding when exploring outcomes in a mixed population.

*Conclusions*

These findings suggest that failure to rescue is an effective metric of international healthcare performance in the elective surgical population. Failure to rescue rates varied more than two-fold between the best and worst performing hospitals suggesting the occurrence of preventable death after surgery in some healthcare systems. Global initiatives to increase access to surgical treatments should take account of the need for safe and effective perioperative care in order to reduce failure to rescue rates. Failure to rescue and similar metrics, may support developing nations in the use of data driven approaches to quality improvement which have proved effective in high income countries. The safety and quality of patient care must be a priority for the global health agenda, as well as improving the provision of healthcare. Further research is needed to develop cost effective ways to audit and deliver high quality perioperative care in resource limited environments.

**Conflict of interest statement**

RP holds research grants, and has given lectures and/or performed consultancy work for Nestle Health Sciences, BBraun, Medtronic, Glaxo Smithkline, and Edwards Lifesciences, and is a member of the Associate editorial board of the British Journal of Anaesthesia. WB has given lectures for AbbVie and performed consultancy work for Medtronic/Covidien, and his department holds unrestricted research grants from Medtronic and Boston Scientific. AH has given lectures for Edwards Lifesciences, and performed consultancy work for BBraun and UPmed. CH has given lectures for Edwards Lifesciences. IG has given lectures and/or performed consultancy work for Covidien, Abbvie, Merk Sharp and Dohme, BBraun, Pfizer, Astra Zeneca, Antibiotice SA, Fresenius. RAB received travel funding from CSL Behring and fees from ABBVie for preparation of educational material and lectures. RAB is clinical consultant for Philips Research, and a member of the associate editorial board of the BJA. All other authors declare they have no conflicts of interest.

**Funding**

This was an investigator initiated study funded by Nestle Health Sciences through an unrestricted research grant, and by a National Institute for Health Research (UK) Professorship held by RP.

**Acknowledgements**

ISOS investigators were entirely responsible for study design, conduct and data analysis. The authors had full data access and were solely responsible for data interpretation, drafting and critical revision of the manuscript, and the decision to submit for publication. The study was sponsored by Queen Mary University of London.

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**Figure 1. Variation in rates of complications, mortality, failure to rescue (FtR), and critical care admission, for 44814 patients in 497 hospitals across 27 countries, ranked in quintiles according to patient procedural volume.**

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**Figure 2. Variation in rates of complications, mortality, failure to rescue (FtR) and critical care admission, for 44814 patients in 497 hospitals across 27 countries, ranked in quintiles according to risk adjusted complication rates.**

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**Table 1. Baseline patient characteristics. Data presented as n (%), median (range) or mean (SD). ASA, American Society of Anesthesiologists physical status score; COPD, chronic obstructive pulmonary disease.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   |  **All patients** | **Patients with complications**  | **Patients with no complications** | **Mortality in patients with complications (Failure to rescue)** |
| **n = 44841** | **n = 7508** | **n = 37306** | **n = 207** |
| Age in years (mean, SD)  | 55.3 (17.1) | 61.8 (16.0) | 54.1 (17.0) | 69.1 (13.3) |
| Age in years (median, range) | 57 (18-102) | 64 (18-100) | 55 (18-102) | 73 (28-93) |
| Male | 20458 (45.7) | 3968 (52.9) | 16490 (44.2) | 121 (58.5) |
| Female | 24,351 (54.3) | 3539 (47.1) | 20812 (55.8) | 86 (41.5) |
| Smoker (Y/N) | 7913 (17.8) | 1305 (17.5) | 6608 (17.8) | 47 (22.8) |
| ASA I | 11227 (25.1) | 848 (11.3) | 10379 (27.9) | 1 (0.5) |
| ASA II | 22265 (49.8) | 3005 (40.1) | 19260 (51.7) | 38 (18.4) |
| ASA III | 10193 (22.8) | 3090 (41.2) | 7103 (19.1) | 115 (55.6) |
| ASA IV | 1038 (2.3) | 554 (7.4) | 484 (1.3) | 53 (25.6) |
| Minor | 8411 (18.8) | 672 (8.9) | 7739 (20.8) | 14 (6.8) |
| Intermediate | 20203 (45.1) | 2494 (33.2) | 17709 (47.5) | 56 (27.1) |
| Major | 16175 (36.1) | 4336 (57.8) | 11839 (31.8) | 137 (66.2) |
| Laparoscopic surgery | 7087 (15.8) | 905 (12.1) | 6182 (16.6) | 16 (7.7) |
| Surgical procedure category |  |  |  |  |
| Orthopaedic | 9459 (21.1) | 1556 (20.9) | 7893 (21.2) | 25 (12.1) |
| Breast | 1538 (3.4) | 128 (1.7) | 1410 (3.8) | 2 (1.0) |
| Obstetrics & gynaecology | 5674 (12.7) | 554 (7.4) | 5120 (13.7) | 6 (2.9) |
| Urology & kidney | 4871 (10.9) | 720 (9.6) | 4151 (11.1) | 10 (4.8) |
| Upper gastro-intestinal | 1986 (4.4) | 485 (6.5) | 1501 (4.0) | 29 (14.0) |
| Lower gastro-intestinal | 3073 (6.9) | 748 (10.0) | 2325 (6.2) | 32 (15.5) |
| Hepato-biliary | 2282 (5.1) | 366 (4.9) | 1916 (5.1) | 14 (6.8) |
| Vascular | 1599 (3.6) | 410 (5.5) | 1189 (3.2) | 15 (7.2) |
| Head & neck | 6510 (14.5) | 674 (9.0) | 5836 (15.7) | 12 (5.8) |
| Plastics & cutaneous | 1670 (3.7) | 244 (3.2) | 1426 (3.8) | 5 (2.4) |
| Cardiac | 1716 (3.8) | 979 (13.0) | 737 (2.0) | 40 (19.3) |
| Thoracic | 1157 (2.6) | 305 (4.1) | 852 (2.3) | 10 (4.8) |
| Other | 3270 (7.3) | 328 (4.4) | 2942 (7.9) | 7 (3.4) |
| Co-morbid disease |  |  |  |  |
| Ischaemic heart disease | 4588 (10.3) | 1525 (20.3) | 3063 (8.2) | 67 (32.4) |
| Heart failure | 1882 (4.2) | 775 (10.3) | 1107 (3.0) | 49 (23.7) |
| Diabetes mellitus | 5171 (11.6) | 1319 (17.6) | 3852 (10.3) | 58 (28.0) |
| Cirrhosis | 342 (0.8) | 113 (1.5) | 229 (0.6) | 10 (4.8) |
| Metastatic cancer | 1706 (3.8) | 508 (6.8) | 1198 (3.2) | 36 (17.4) |
| Stroke | 1492 (3.3) | 451 (6.0) | 1041 (2.8) | 38 (18.4) |
| COPD / asthma | 4094 (9.2) | 1012 (13.5) | 3082 (8.3) | 40 (19.3) |
| Other | 18607 (41.6) | 4134 (55.2) | 14464 (38.9) | 134 (64.7) |
| Cancer surgery | 9006 (20.3) | 2005 (26.9) | 7001 (19.0) | 70 (34.3) |

**Table 2. 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** | 7508/44814 (16.8%) | 2198/4360 (50.4%) | 5270/39935 (13.2%) |
| **Critical care admission to treat complication** | 1233/7508 (16.4%) | 857/2198 (39.0%) | 365/5270 (6.9%) |
| **Failure to rescue** | 207/7508 (2.8%) | 105/2198 (4.8%) | 99/5270 (1.9%) |

**Table 3. Comparison of hospital factors, process measures and patient outcomes for participating hospitals ranked in quintiles according to patient procedural volume. Data presented as n (%), median (IQR) or mean (SD).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Very low volume hospitals****n=223** | **Low volume hospitals****n=112** | **Medium volume hospitals****n=69** | **High volume hospitals****n=43** | **Very high volume hospitals****n=19** |
| **Hospital factors** |
| **Hospital beds** **(median, IQR)** | 400 (260 – 600) | 600 (400 – 800) | 800 (605 – 1038) | 1010 (800 – 1230) | 2000 (1200 – 2729) |
| **Critical care beds** **(median, IQR)** | 14 (9 – 24) | 20 (13 – 34) | 36 (24 – 60) | 46 (27 – 90) | 70 (36 – 115) |
| **Operating rooms** **(median, IQR)** | 10 (6 – 14) | 15 (12 – 20) | 22 (16 – 27) | 24 (18 – 34) | 37 (28 – 47) |
| **University status (n, %)** |
| **Secondary** | 96/209 (46%) | 35/107 (33%) | 7/65 (11%) | 3/41 (7%) | 1/19 (5%) |
| **Tertiary** | 113/209 (54%) | 72/107 (67%) | 58/65 (89%) | 38/41 (93%) | 18/19 (95%) |
| **Funding status (n, %)** |
| **Government funded** | 165/209 (79%) | 90/107 (84%) | 47/65 (72%) | 25/41 (61%) | 11/19 (58%) |
| **Patient funded** | 6/209 (3%) | 3/107 (3%) | 1/65 (2%) | 1/41 (2%) | 1/19 (5%) |
| **Both** | 38/209 (18%) | 14/107 (13%) | 17/65 (26%) | 15/41 (37%) | 7/19 (37%) |
| **Hospitals in Low and middle income countries** | 61/223 (27%) | 22/112 (20%) | 17/69 (25%) | 11/43 (26%) | 15/19 (79%) |
| **Process measures** |
| **Post-anaesthetic care unit stay in hours** **(median, IQR)** | 1 (1-2) | 1 (1-2) | 1 (1- 2) | 1 (0-2) | 1 (0-1) |
| **Critical care admission directly after surgery** | 818/8763 (9.3%) | 916/8971 (10.2%) | 1033/8932 (11.6%) | 946/8937 (10.6%) | 674/8692 (7.4%) |
| **Critical care admission to treat complications** | 274/9016 (3.0%) | 248/9118 (2.7%) | 264/9048 (3.0%) | 284/8940 (3.2%) | 163/8692 (1.9%) |
| **Duration of hospital stay****(median, IQR)** | 3 (1- 5) | 3 (1-5) | 3 (1-6) | 4 (2-7) | 5 (3-9) |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Patient outcomes** | **n=9016** | **n=9118** | **n=9048** | **n=8940** | **n=8692** |
| **All complications** | 1621 (18.0%) | 1579 (17.3%) | 1608 (17.8%) | 1730 (19.3%) | 970 (11.2%) |
| **Risk-adjusted complication rate** | 20.4% | 20.7% | 18.7% | 19.5% | 17.4% |
| **Infectious complications** | 645 (7.1%) | 575 (6.3%) | 536 (5.9%) | 782 (8.7%) | 550 (6.3%) |
| **Cardiac complications** | 354 (3.9%) | 307 (3.4%) | 385 (4.3%) | 389 (4.4%) | 199 (2.3%) |
| **Other complications** | 1049 (11.6%) | 1069 (11.7%) | 1081 (12.0%) | 1089 (12.2%) | 448 (5.2%) |
| **Death** | 47 (0.5%) | 58 (0.6%) | 48 (0.5%) | 32 (0.4%) | 22 (0.3%) |
| **Risk-adjusted mortality rate** | 0.5% | 0.7% | 0.5% | 0.4% | 0.3% |
| **Failure to rescue** | 3.6% | 3.6% | 2.9% | 2.1% | 1.7% |