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Quality and Patient Safety

Use of failure-to-rescue to identify international variation in postoperative care in low-, middle- and high-income countries: a 7-day cohort study of elective surgery

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Abstract

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

Methods. We analysed data collected during the International Surgical Outcomes Study, an international 7-day cohort study of adults undergoing elective inpatient surgery. Hospitals were ranked by 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. A total of 44 814 patients from 474 hospitals in 27 low-, middle-, and high-income countries were available for analysis. Of these, 7508 (17%) developed one or more postoperative complication, 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 among patients after they develop complications.

Conclusions. Comparison of failure-to-rescue rates across health care systems suggests the presence of preventable postoperative deaths. Using such metrics, developing nations could benefit from a data-driven approach to quality improvement, which has proved effective in high-income countries.

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Editor's key points

- The utility of failure-to-rescue as a quality measure for perioperative care was assessed in a secondary analysis of data from the International Surgical Outcomes Study.
- An overall failure-to-rescue rate of 2.8% was found for 44 814 low-, middle-, and high-income country patients undergoing elective surgery in 474 hospitals from 27 countries.
- Failure-to-rescue provides a useful quality measure for international comparisons of health care quality in elective surgery.

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

In developed countries, estimates of short-term mortality after surgery vary from 1% to 4%[7–11] and effective perioperative care is considered essential to safe provision of surgical treatments. Numerous studies have described important variations in survival following surgery.[10 12–14] 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 that can affect survival. Failure-to-rescue, defined as the hospital rate of death following a complication, is a metric that has been widely used to identify differences in the quality of perioperative care between hospitals within health care systems.[14–18] Important determinants of 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] 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 could 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] Our aim was to investigate failure-to-rescue as a metric of health care quality across different health care 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 organization

ISOS was a 7-day international cohort study.[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). Inclusion criteria were all adult patients (age ≥18 years) undergoing elective surgery with a planned overnight hospital stay. 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 patients and countries with ≥10 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] Data were censored at 30 days following surgery for patients who remained in the 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 (Q1–Q5) according to the volume of surgical procedures performed during the study week. Hospitals with the lowest procedural volume were placed in Q1 and hospitals with the highest procedural volume were placed in Q5. We calculated mortality, failure-to-rescue, and complication rates for each individual hospital and then took the average across all 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] 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 comorbid 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 [interquartile range (IQR)]. Odds ratios are presented with 95% confidence intervals. All analyses were performed using STATA 13 (StataCorp, College Station, TX, 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 χ^2 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 to 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, including 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, the UK, and the USA. Fewer than 10 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 44 814 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 (IQR 329–850) and 21 critical care beds (IQR 10–38). The median ratio of critical care beds to ward beds was 0.04 (IQR 0.02–0.06). A total of 310 hospitals (66%) were affiliated with a university. Seventy-seven per cent of hospitals provided only government-funded health care, 3% only privately funded health care, and 21% of hospitals were funded by both sources.

Clinical outcomes

A total of 7508 (17%) patients developed complications in hospital and 207 died before hospital discharge (0.5%), giving an overall failure-to-rescue rate of 2.8%. Of these, 5254 (12%) 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 (IQR 2–7) days, increasing to 8 (IQR 5–14) days among those patients who developed complications. A total of 4360 patients (9.7%) were admitted directly to critical care after surgery with a mean length of critical care stay of 0.3 (SD 1.7) days. A total of 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% to 11%, mortality varied almost three-fold between Q1 and Q5 (0.6% in Q2 *vs* 0.2% in Q5), 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 Q1). The output of the multivariable logistic regression model used to calculate the risk-adjusted complication rate for each hospital is presented in Supplementary Table S1. 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% in Q5 (Fig. 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 overall findings. The trend across quintiles was significant for all patient outcomes ($P<0.05$, χ^2 test for trend). The effect of removing minor complications from the primary analysis is presented in Supplementary Figure S1. 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 S2. Data describing failure-to-rescue rates in low- or middle- and high-income countries are presented in Supplementary Table S3.

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 health care systems. We identified important variations between hospitals in death following postoperative complications (failure-to-rescue) at an international level. Across the entire cohort, 1 in 35 patients who experienced a complication subsequently died without leaving the hospital, for 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, with 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 postoperative deaths when comparing health care systems at an international level. The use of failure-to-rescue alongside similar metrics could

Table 1 Baseline patient characteristics. ASA, American Society of Anesthesiologists physical status score; COPD, chronic obstructive pulmonary disease

	All patients (n=44 841)	Patients with complications (n=7508)	Patients with no complications (n=37 306)	Mortality in patients with complications (failure-to-rescue) (n=207)
Age (years), mean (SD)	55.3 (17.1)	61.8 (16.0)	54.1 (17.0)	69.1 (13.3)
Age (years), median (IQR)	57 (18–102)	64 (18–100)	55 (18–102)	73 (28-93)
Male, n (%)	20 458 (45.7)	3968 (52.9)	16 490 (44.2)	121 (58.5)
Female, n (%)	24,351 (54.3)	3539 (47.1)	20 812 (55.8)	86 (41.5)
Smoker (Y/N), n (%)	7913 (17.8)	1305 (17.5)	6608 (17.8)	47 (22.8)
ASA I, n (%)	11 227 (25.1)	848 (11.3)	10 379 (27.9)	1 (0.5)
ASA II, n (%)	22 265 (49.8)	3005 (40.1)	19 260 (51.7)	38 (18.4)
ASA III, n (%)	10 193 (22.8)	3090 (41.2)	7103 (19.1)	115 (55.6)
ASA IV, n (%)	1038 (2.3)	554 (7.4)	484 (1.3)	53 (25.6)
Minor, n (%)	8411 (18.8)	672 (8.9)	7739 (20.8)	14 (6.8)
Intermediate, n (%)	20 203 (45.1)	2494 (33.2)	17 709 (47.5)	56 (27.1)
Major, n (%)	16 175 (36.1)	4336 (57.8)	11 839 (31.8)	137 (66.2)
Laparoscopic surgery, n (%)	7087 (15.8)	905 (12.1)	6182 (16.6)	16 (7.7)
Surgical procedure category, n (%)				
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 and gynaecology	5674 (12.7)	554 (7.4)	5120 (13.7)	6 (2.9)
Urology and kidney	4871 (10.9)	720 (9.6)	4151 (11.1)	10 (4.8)
Upper gastrointestinal	1986 (4.4)	485 (6.5)	1501 (4.0)	29 (14.0)
Lower gastrointestinal	3073 (6.9)	748 (10.0)	2325 (6.2)	32 (15.5)
Hepatobiliary	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 and neck	6510 (14.5)	674 (9.0)	5836 (15.7)	12 (5.8)
Plastics and 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)
Comorbid disease, n (%)				
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	18 607 (41.6)	4134 (55.2)	14 464 (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 (%)

Outcome	All patients (n=44 814)	Patients admitted to critical care immediately after surgery (n=4360)	Patients not admitted to critical care immediately after surgery (n=39 935)
Mortality	207/44 814 (0.5%)	105/4360 (2.4%)	99/39 935 (0.2%)
Complication	7508/44 814 (17%)	2198/4360 (50%)	5270/39 935 (13%)
Critical care admission to treat complication	1233/7508 (16%)	857/2198 (39%)	365/5270 (6.9%)
Failure-to-rescue	207/7508 (2.8%)	105/2198 (4.8%)	99/5270 (1.9%)

facilitate a data-driven approach to quality improvement in low- and middle-income countries.

The failure-to-rescue metric does not define poor care, rather it is an indicator of where poor care might exist. To be useful the metric must be applied at the hospital level across large populations, where risk adjustment is more difficult. Interpretation must be cautious, as with mortality and other outcomes that are routinely used to compare the performance

Table 3 Comparison of hospital factors, process measures, and patient outcomes for participating hospitals ranked in quintiles according to patient procedural volume

	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 (h), median (IQR)	1 (1–2)	1 (1–2)	1 (1–2)	1 (0–2)	1 (0–1)
Critical care admission directly after surgery, n (%)	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, n (%)	274/9016 (3.0)	248/9118 (2.7)	264/9048 (3.0)	284/8940 (3.2)	163/8692 (1.9)
Duration of hospital stay (days), 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, n (%)	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, n (%)	645 (7.1)	575 (6.3)	536 (5.9)	782 (8.7)	550 (6.3)
Cardiac complications, n (%)	354 (3.9)	307 (3.4)	385 (4.3)	389 (4.4)	199 (2.3)
Other complications, n (%)	1049 (11.6)	1069 (11.7)	1081 (12.0)	1089 (12.2)	448 (5.2)
Death, n (%)	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

of health care 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] as well as emergency surgery.[29] Traditionally the prevention of postoperative 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 quality of care is emphasized 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 health care 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, commencing appropriate treatment, including resuscitation, in order to prevent their death.[14] Hospitals with the greatest complication rates do not necessarily have the greatest mortality, indicating the role perioperative care can play in avoiding preventable deaths. Because the metric primarily reflects patient care once complications have developed, it is less sensitive to differences in case mix and the problems associated with inadequate risk adjustment.[14] However, comparisons between hospitals using failure to rescue do rely on accurate monitoring of postoperative complications and consistent coding between different hospitals.[30]

Anecdotally, the term 'failure-to-rescue' has led to reluctance among some clinicians to accept this metric because of the perception of implicit criticism. Nonetheless, this measure is now recognized as an important marker of quality of care for surgical patients and has been used, in particular, to assess the effect of nurse staffing levels.[20] Studies of failure-to-rescue rates have identified substantial variations between hospitals within countries and/or specific subgroups of surgical patients.[15–18] The current data now confirm the relevance of failure-to-rescue as a quality measure for international comparisons of health care, including low-, middle-, and high-income countries.

A failure-to-rescue rate of 2.8% was lower than previous reports, which may have been more focused on more severe complications and major surgery,[15 31] whereas the current analysis included all complications in all patients undergoing

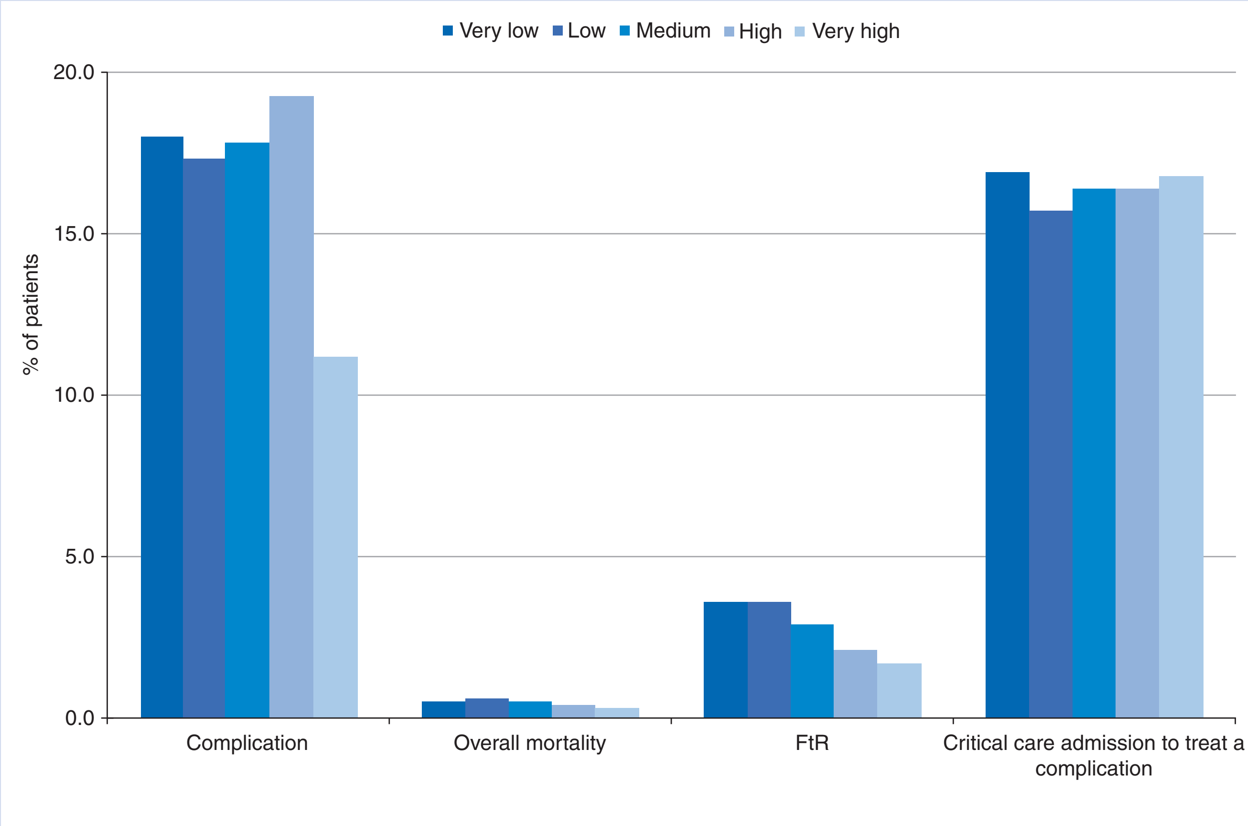

Fig 1 Variation in rates of complications, mortality, failure-to-rescue (FtR), and critical care admission for 44 814 patients in 497 hospitals across 27 countries, ranked in quintiles according to patient procedural volume.

inpatient 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. While 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] and the need remains for robust audit and public reporting of outcomes after all surgery worldwide.[33]

Failure-to-rescue is 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 31] There are data to suggest a relationship between failure-to-rescue and the provision of good quality critical care,[28 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 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 of critical care beds.[36] Another health care registry study from the UK identified regional variations in postoperative mortality, which appeared to be related to provision and utilization of postoperative critical care.[37] The need for unplanned admission to critical care to treat postoperative complications is associated with a significant increase in mortality.[10 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] and common medical emergencies.[40] These observations have driven service reconfigurations in various countries, but remain controversial. Activity volume might simply be a surrogate for structure and process measures of care rather than quality, and the causality of the relationship could simply reflect the possibility that hospitals with better outcomes can 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 comparing a large and heterogeneous group of hospitals.

Strengths of this study include the large number of consecutive patients enrolled worldwide. By developing a simple data set consisting primarily of categorical variables, we were able to minimize 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 that 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, while avoiding the

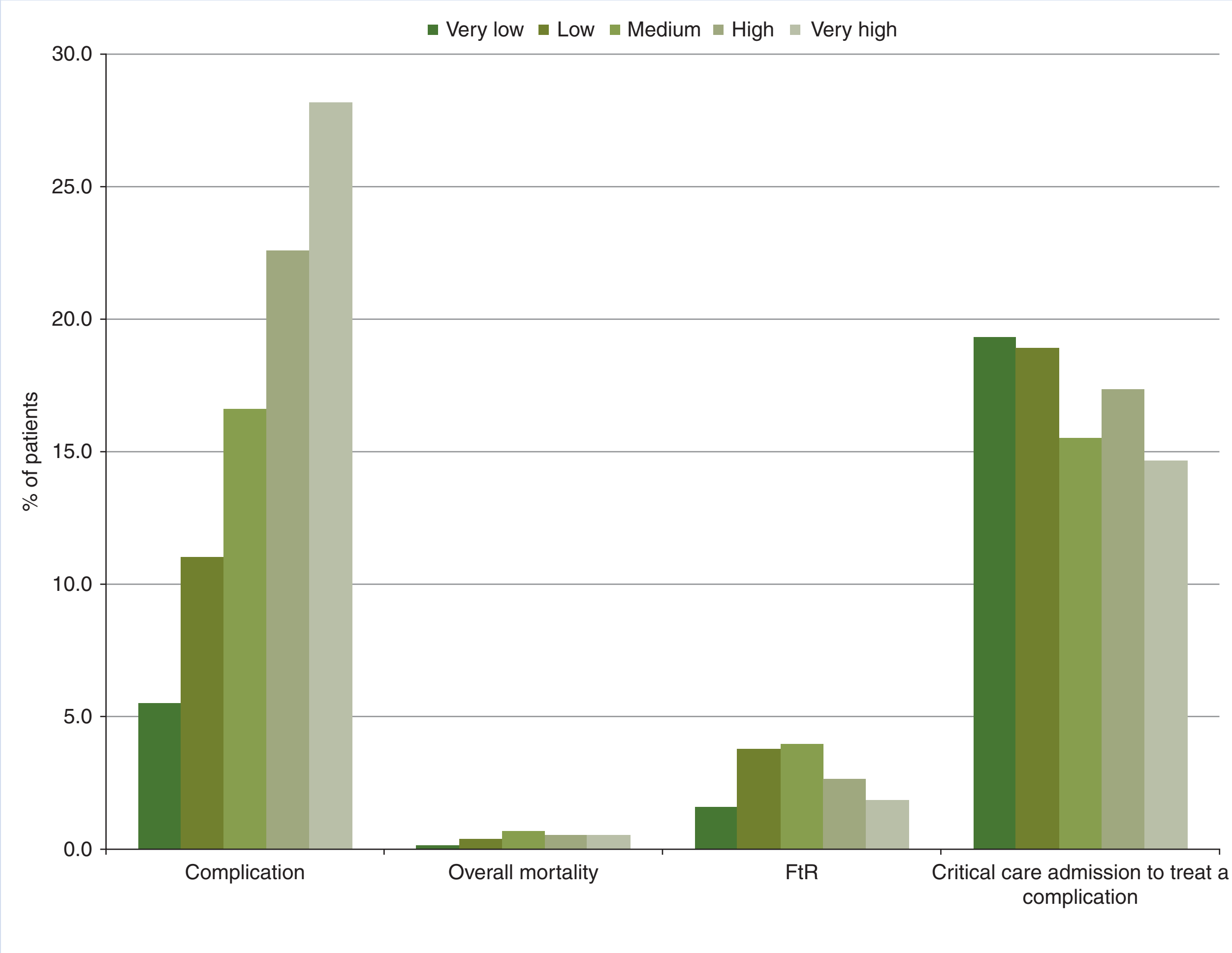

Fig 2 Variation in rates of complications, mortality, failure-to-rescue (FtR), and critical care admission for 44 814 patients in 497 hospitals across 27 countries, ranked in quintiles according to risk adjusted complication rates.

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.

The study also has a number of weaknesses. Overall complication rates were slightly lower than those previously reported in the USA.[15] This could 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 that 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 while smaller, low-volume centres were underrepresented. This might be more important for the low- and middle-income countries that 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 postoperative 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 1 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] 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 as 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 health care 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 health care 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 could support developing nations in the use of data-driven approaches to quality improvement that 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 health care. Further research is needed to develop cost-effective ways to audit and deliver high-quality perioperative care in resource-limited environments.

Author contributions

ISOS investigators were entirely responsible for study design, conduct, and data analysis. All authors had full data access and are solely responsible for data interpretation, drafting and critical revision of the manuscript, and the decision to submit for publication.

Supplementary material

Supplementary material is available at *British Journal of Anaesthesia* online.

Declarations of interest

R.P. holds research grants and has given lectures and/or performed consultancy work for Nestle Health Sciences, BBraun, Medtronic, GlaxoSmithKline, and Edwards Lifesciences, and is a member of the Associate Editorial Board of the *British Journal of Anaesthesia*. W.B. has given lectures for AbbVie and performed consultancy work for Medtronic/Covidien and his department holds unrestricted research grants from Medtronic and Boston Scientific. A.H. has given lectures for Edwards Lifesciences and performed consultancy work for BBraun and UPmed. C.H. has given lectures for Edwards Lifesciences. I.G. has given lectures and/or performed consultancy work for Covidien, AbbVie, Merck Sharp & Dohme, BBraun, Pfizer, AstraZeneca, Antibiotice, and Fresenius. R.A.B. received travel funding from CSL Behring and fees from AbbVie for preparation of educational material and lectures. R.A.B. is a clinical consultant for Philips Research and a member of the Associate Editorial Board of the *British Journal of Anaesthesia*. All other authors declare they have no conflicts of interest.

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