Patient outcomes after surgery in 17 Latin American countries (LASOS): a 7 day prospective cohort study

*Latin American Surgical Outcomes Study (LASOS) group**

Summary

Background Access to safe surgical treatment across Latin America is limited by underfunded and fragmented health systems. Epidemiological data are required to describe surgical activity and patient outcomes.

Methods We did this 7 day prospective cohort study in 17 Latin American countries, collecting data describing inpatient surgery in adults (aged ≥18 years). The primary outcome was in-hospital postoperative complications within 30 days after surgery. Secondary outcomes were in-hospital mortality, duration of hospital stay, and admission to critical care within 30 days after surgery. This study is registered with ClinicalTrials.gov, NCT05169164.

Findings Between June 1, 2022, and April 30, 2023, we included 22126 patients (mean age 49·7 years [SD 18·2]; 9260 [41·9%] male and 12866 [58·1%] female; 10180 [46·0%] White) from 284 hospitals. Of the 22126 patients, 657 (3·0%) patients for the outcome of complications and 380 (1·7%) patients for mortality had missing data. Most patients were low risk (American Society of Anesthesiologists [ASA] grade I or II: 17311 [78·7%] of 21979 patients), undergoing non-major surgery (14944 [68·0%] of 21986 patients), and on an elective basis (14837 [67·5%] of 21988 patients). Despite this low-risk profile, 3163 (14·6%) of 21632 patients developed postoperative complications resulting in 477 (2·2%) deaths. The most frequent complication category was infection, affecting 1795 (8·2%) patients. The high mortality from complications (failure to rescue) of 15·1% (477 deaths in 3163 patients with complications) suggests significant problems with postoperative care. 2978 (13·6%) patients were admitted to a critical unit immediately after surgery, but 180 (37·7%) of 477 patients who died never received critical care. Patients with complications had a median hospital stay of 8 days (IQR 3–18), compared with 2 days (1–3) for patients without complications. Postoperative mortality and complications were strongly associated with increasing ASA grade, urgency of surgery, and grade of surgery (intermediate and major).

Interpretation Patients receiving inpatient surgery in Latin America experienced high mortality rates, likely relating to standards of ward care after surgery. Given the rising demand for surgical treatments, resource-efficient measures are urgently needed to improve patient outcomes after surgery across Latin America.

Funding None.

Lancet Glob Health 2025; 13: e635–45

This online publication has been corrected. The corrected version first appeared at thelancet.com/lancetgh on May 12, 2025

For the Spanish translation of the abstract see Online for appendix 1

For the Portuguese translation of the abstract see Online for appendix 2

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Introduction

Diseases requiring surgical treatment are estimated to account for one-third of the global disease burden.[1] As health-care system utilisation and the volume of surgical procedures increase, numerous challenges are faced in extending access to safe, timely, affordable surgery in the Global South, in particular relating to human resources.[2] Postoperative complications are a significant cause of death and long-term health issues. Survivors of surgical complications often experience decreased longevity and a decline in quality of life.[3]

Latin America, which comprises 33 countries and 14 territories, remains under-represented in perioperative research, resulting in a substantial gap in our understanding of this region's surgical activity, which limits health-care policy making for surgical care. Latin American countries are characterised by a vast diversity in sociocultural, ethnic, geographical, and governance factors. The majority of these countries face underfunded health systems, inconsistent public health investment, and uneven health-care workforce distribution.[4] These problems influence health-care provision and affect the demographic profile of patients requiring surgery. Although the broader impact of these underfunded and fragmented health systems on health outcomes has been described,[5] their specific effects on surgical outcomes remain unclear, underscoring the need for more comprehensive data.

Previous epidemiological studies[6–8] adopted a pragmatic methodology, including clinical staff to collect prospective, reliable data across different continents and varied hospital contexts. The International Surgical Outcomes Study (ISOS)[7] and the African Surgical Outcomes Study (ASOS)[8] both identified challenges with delivering safe surgical care in low-income and middle-income countries (LMICs). The perioperative adverse outcomes arise due to a cascade of events initiated by complications, influenced by a multitude of factors

Research in context

Evidence before this study

There are few international epidemiological studies of surgical outcomes, particularly in the Global South. The International Surgical Outcomes Study and the African Surgical Outcomes Study both identified challenges with delivering safe surgical care in low-income and middle-income countries. In Africa, patients are twice as likely to die after surgery, despite being younger with fewer comorbid diseases and undergoing less complex procedures. We searched PubMed without language restrictions from Jan 1, 2000, to Dec 31, 2023, with the terms "Latin America" AND "surgical procedures" AND "postoperative complications" OR "postoperative period" and synonyms. We found no scientific reports of of large international epidemiological data describing surgical activity and postoperative patient outcomes for Latin American countries.

Added value of this study

The Latin American Surgical Outcomes Study provides detailed data describing outcomes experienced by more than 22 000 consecutive patients undergoing elective and non-elective inpatient surgery in 17 Latin American nations. These data show that one in seven surgical patients had notable postoperative complications, most frequently hospital acquired infection. The incidence of complications was similar to that in high-income countries; however, the mortality among patients developing complications (failure to rescue) was much higher. One in seven patients who developed complications after surgery subsequently died without leaving hospital, compared with one in 15 for hospitals in North America. Patients who had complications also stayed in the hospital four times longer than those who did not. One-third of patients who died after surgery were not admitted to a critical care unit at any stage during their hospital stay.

Implications of all the available evidence

Patients undergoing surgery in Latin American countries have similar complication rates to those in high-income countries but are more likely to die as a result of these complications. This finding indicates problems with medical and nursing care on the hospital wards after surgery, as well as limited access to critical care facilities. We know that prompt recognition of physiological deterioration among surgical patients who develop complications can dramatically improve survival rates. Although much can be achieved through staff training and improved hospital procedures, adequate staffing is often a key barrier to improving failure-to-rescue rates. Given the rising demand for surgical treatments and the constraints of finite resources, further research is needed to support the likely reasons for high mortality rates after surgery in Latin America, and to develop context-specific solutions to improve care for patients who have complications.

concerning patient characteristics, surgical procedures, and the efficiency of the organisations in promptly recognising and managing adverse events.[9,3,4] In Africa, patients are twice as likely to die after surgery compared with the global average,[10,11] despite being younger with fewer comorbid diseases and undergoing fewer complex procedures. The availability of objective data has enabled clinicians, researchers, and health-care policy makers to prioritise issues of utmost importance to patients and society, as well as to design and test interventions targeting the potential root causes of these problems.[12]

For more on **LASOS** see www.lasos-study.org

The objective of our Latin American Surgical Outcomes Study (LASOS) was to provide a perspective on postoperative outcomes in the continent with one of the highest income disparities worldwide. We conducted a 7 day cohort study of adults undergoing inpatient surgery in Latin America to provide robust data about the surgical population, perioperative mortality rate, operative volume, and postoperative complications.

Methods

Study design and participants

LASOS is an international, multicentre, prospective, cohort study of patients aged 18 years and older undergoing any form of inpatient surgery in hospitals in Latin American Countries, conducted over a 7 day period. This study is registered with ClinicalTrials.gov, NCT05169164. Our findings are reported in accordance with STROBE. A collaborative network of more than 1507 health-care professionals was established across Latin America through personal invitations to colleagues, national and hospital leaders, a website, and an X (formerly Twitter) feed to increase visibility of our proposal. In each country, we aimed to recruit as many hospitals as possible using a convenience sampling strategy. All patients undergoing elective and non-elective surgery with a planned overnight hospital stay after surgery during the study week were eligible for inclusion. Patients undergoing planned day surgery or radiological procedures not requiring anaesthesia were excluded. The primary ethics approval was obtained from the Institutional Review Board of the Instituto do Coração InCor, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo (São Paulo, Brazil; protocol number 5·235·873), and the study methods have been previously published.[13] All participating hospitals subsequently secured local research ethics approval before commencing the study. We collected only anonymised routine clinical data, with no patient identifiers. Data collection was undertaken by clinical staff. In keeping with previous studies utilising this same design, individual patient consent was not required. The study protocol and all information for participants are provided on the LASOS website.

Procedures

Hospital-specific data included structural variables such as the number of hospital beds, number of operating rooms, number of critical care beds, the ratio of nurses to patients, and variables associated with processes such as WHO surgical safe checklist application, type of hospital (university or not), residency programmes (yes or no), and funding model (public, private, or mixed). Data describing consecutive patients were collected on paper case record forms until hospital discharge and censored 30 days after surgery for patients who remained in the hospital. Data were anonymised by generating a unique numeric code (LASOS ID) and transcribed by local investigators onto an internet-based electronic case record form hosted by the Critical Care and Perioperative Medicine Research Group at Queen Mary University of London. Variables (ie, surgical severity and complications) were predefined and available for all collaborators on the LASOS website (appendix 3 p 26).

We carefully replicated the design of the international studies (the European Surgical Outcomes Study, ISOS, and ASOS[6–8]) using an almost identical patient dataset and outcome definitions for direct comparisons of surgical outcomes data from Latin America with the current global standard. The senior investigators from these studies provided technical, operational, and intellectual assistance to ensure we followed the design of previous studies. Local investigators at each centre enrolled all adult patients aged 18 years and older who were scheduled for elective and emergency surgery during a predefined period of 1 week during a 10 month period. Data collection was censored for patients who remained in the hospital on day 30. Data on sex and ethnicity were collected from the patients' medical records. Local investigators were given technical and operational support by national coordinators and via the LASOS website that provided key documentation, including the protocol and guidance on study procedures. Local investigators completed an operating theatre case record form for each eligible patient who was then followed up until hospital discharge for data describing hospital stay, admission to critical care, and in-hospital mortality (appendix 3 p 34). Investigators were granted immediate access to their uncleaned data once these were locked following entry and were encouraged to review them for accuracy and completeness.[6–8]

Outcome measures

The primary outcome measure was in-hospital postoperative complications. Complications were assessed according to predefined criteria,[14] and were graded as mild, moderate, or severe (appendix 3 p 29). Secondary outcomes were death after a postoperative complication (failure to rescue) and in-hospital mortality within 30 days after surgery, duration of hospital stay, and admission to critical care within 30 days after surgery. Outcomes were evaluated during the patient's hospital stay through active review and by complementing the review of medical record. 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, censored at 30 days after surgery for patients who remain 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). Baseline data of complications, mortality, and failure to rescue were compared among studies with similar target populations but in different contexts, such as the USA (National Surgical Quality Improvement Program [NSQIP] cohort)[11] and Africa (ASOS cohort).[8]

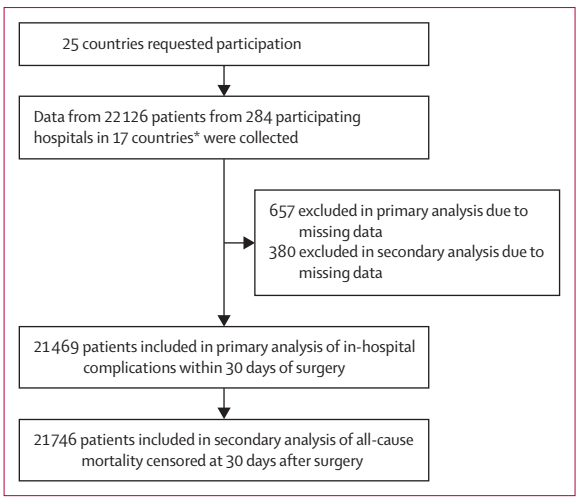

Figure 1: **Latin American Surgical Outcomes Study recruitment**
*Argentina, Barbados, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

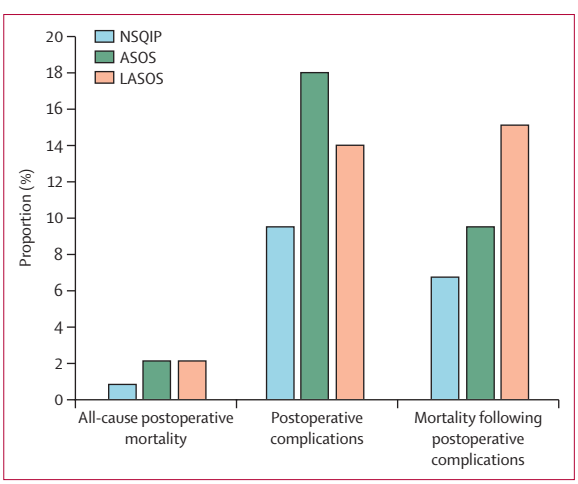

Figure 2: **Surgical mortality, postoperative complications, and mortality after postoperative complications (failure to rescue) after elective or non-elective surgeries in international cohorts**
Data were extracted from: ASOS,[7] NSQIP,[8] and LASOS.[11] ASOS=African Surgical Outcomes Study. LASOS=Latin American Surgical Outcomes Study. NSQIP=National Surgical Quality Improvement Program.

	Total (N=22 126)	Patients with no postoperative complications (n=18 469)	Patients with postoperative complications (n=3163)	Patients who survived (n=21 440)	Patients who died (n=477)
Age, years	n=22 126	n=18 469	n=3163	n=21 440	n=477
Mean (SD)	49·7 (18·2)	48·6 (17·9)	55·8 (18·5)	49·4 (18·1)	63·3 (15·9)
Median (IQR)	48 (35–64)	47 (34–63)	58 (41–70)	48 (34–64)	65 (54–74)
Sex	n=22 126	n=18 469	n=3163	n=21 440	n=477
Male	9260 (41·9%)	7354 (39·8%)	1689 (53·4%)	8913 (41·6%)	262 (54·9%)
Female	12 866 (58·1%)	11 115 (60·2%)	1474 (46·6%)	12 527 (58·4%)	215 (45·1%)
Current smoker	3037 (13·7%)	2341 (12·7%)	615 (19·4%)	2898 (13·5%)	111 (23·3%)
Ethnicity	n=22 126	n=18 469	n=3163	n=21 440	n=477
Afro-descendant	1378 (6·2%)	1066 (5·8%)	278 (8·8%)	1320 (6·2%)	48 (10·1%)
White	10 180 (46·0%)	8646 (46·8%)	1356 (42·9%)	9919 (46·3%)	205 (43·0%)
Indigenous	349 (1·6%)	281 (1·5%)	56 (1·8%)	332 (1·5%)	4 (0·8%)
Other	6136 (27·7%)	5006 (27·1%)	968 (30·6%)	5904 (27·5%)	146 (30·6%)
Unknown	4083 (18·5%)	3470 (18·8%)	505 (16·0%)	3965 (18·5%)	74 (15·5%)
Comorbid disease	n=22 126	n=18 469	n=3163	n=21 440	n=477
Coronary artery disease	983 (4·4%)	647 (3·5%)	313 (9·9%)	915 (4·3%)	59 (12·4%)
Heart failure	554 (2·5%)	336 (1·8%)	201 (6·4%)	506 (2·4%)	44 (9·2%)
Diabetes	3394 (15·3%)	2551 (13·8%)	766 (24·2%)	3233 (15·1%)	133 (27·9%)
Cirrhosis	107 (0·5%)	51 (0·3%)	55 (1·7%)	86 (0·4%)	21 (4·4%)
Metastatic cancer	1060 (4·8%)	778 (4·2%)	263 (8·3%)	994 (4·6%)	65 (13·6%)
Hypertension	6949 (31·4%)	5393 (29·2%)	1412 (44·6%)	6646 (31·0%)	259 (54·3%)
Stroke	385 (1·7%)	235 (1·3%)	145 (4·6%)	350 (1·6%)	35 (7·3%)
COPD or asthma	950 (4·3%)	745 (4·0%)	173 (5·5%)	894 (4·2%)	48 (10·1%)
HIV/AIDS	162 (0·7%)	123 (0·7%)	38 (1·2%)	151 (0·7%)	10 (2·1%)
Chronic renal disease	847 (3·8%)	522 (2·8%)	304 (9·6%)	765 (3·6%)	75 (15·7%)
Active tuberculosis	44 (0·2%)	29 (0·2%)	14 (0·4%)	40 (0·2%)	3 (0·6%)
Other	6872 (31·1%)	5515 (29·9%)	1228 (38·8%)	6630 (30·9%)	202 (42·3%)
SARS-CoV-2 infection in past 6 weeks	206 (0·9%)	146 (0·8%)	51 (1·6%)	194 (0·9%)	11 (2·3%)
Blood results					
Haemoglobin	n=17 116	n=13 880	n=2861	n=16 524	n=455
Mean (SD)	12·7 (2·2)	13·0 (2·0)	11·7 (2·5)	12·8 (2·1)	10·5 (2·7)
Median (IQR)	12·9 (11·8–14·2)	13·0 (11·8–14·3)	11·8 (9·8–13·5)	13·0 (11·5–14·2)	10·0 (8·6–12·2)
Creatinine	n=15 141	n=12 095	n=2714	n=14 599	n=440
Mean (SD)	91·9 (102·9)	87·1 (94·0)	113·3 (134·4)	90·3 (100·6)	142·6 (150·0)
Median (IQR)	70·7 (59·2–88·4)	70·7 (59·2–88·4)	76·9 (58·4–106·1)	70·7 (59·2–88·4)	88·4 (61·4–159·1)
ASA physical status score*	n=21 979	n=18 398	n=3157	n=21 355	n=477
I	5130 (23·3%)	4721 (25·7%)	333 (10·5%)	5077 (23·8%)	18 (3·8%)
II	12 181 (55·4%)	10 719 (58·3%)	1240 (39·3%)	12 016 (56·3%)	88 (18·4%)
III	3990 (18·2%)	2721 (14·8%)	1161 (36·8%)	3756 (17·6%)	204 (42·8%)
IV	626 (2·8%)	220 (1·2%)	389 (12·3%)	476 (2·2%)	145 (30·4%)
V	52 (0·2%)	17 (0·1%)	34 (1·1%)	30 (0·1%)	22 (4·6%)
Anaesthetic technique	n=22 126	n=18 469	n=3163	n=21 440	n=477
General	12 799 (57·8%)	10 365 (56·1%)	2206 (69·7%)	12 350 (57·6%)	397 (83·2%)
Spinal	6453 (29·2%)	5717 (30·9%)	611 (19·3%)	6378 (29·7%)	33 (6·9%)
Epidural	1471 (6·6%)	1240 (6·7%)	199 (6·3%)	1454 (6·8%)	11 (2·3%)
Sedation	3237 (14·6%)	2797 (15·1%)	406 (12·8%)	3193 (14·9%)	40 (8·4%)
Local or regional	2376 (10·7%)	1995 (10·8%)	357 (11·3%)	2316 (10·8%)	54 (11·3%)
Surgical procedure	n=21 975	n=18 423	n=3155	n=21 386	n=475
Orthopaedic (non-spine)	3705 (16·9%)	3151 (17·1%)	493 (15·6%)	3662 (17·1%)	32 (6·7%)
Breast	531 (2·4%)	500 (2·7%)	24 (0·8%)	526 (2·5%)	0

(Table 1 continues on next page)

	Total (N=22 126)	Patients with no postoperative complications (n=18 469)	Patients with postoperative complications (n=3163)	Patients who survived (n=21 440)	Patients who died (n=477)
(Continued from previous page)					
Gynaecology	2005 (9·1%)	1852 (10·1%)	117 (3·7%)	1987 (9·3%)	4 (0·8%)
Urology and kidney	2108 (9·6%)	1814 (9·8%)	257 (8·1%)	2084 (9·7%)	19 (4·0%)
Upper gastrointestinal	1647 (7·5%)	1309 (7·1%)	321 (10·2%)	1574 (7·4%)	66 (13·9%)
Lower gastrointestinal	2082 (9·5%)	1627 (8·8%)	425 (13·5%)	2006 (9·4%)	68 (14·3%)
Hepatobiliary	1432 (6·5%)	1271 (6·9%)	147 (4·7%)	1407 (6·6%)	24 (5·1%)
Vascular	817 (3·7%)	603 (3·3%)	194 (6·1%)	772 (3·6%)	40 (8·4%)
Head and neck	1249 (5·7%)	1068 (5·8%)	163 (5·2%)	1212 (5·7%)	35 (7·4%)
Plastics or cutaneous	1052 (4·8%)	878 (4·8%)	163 (5·2%)	1030 (4·8%)	19 (4·0%)
Neurosurgery (non-spine)	552 (2·5%)	352 (1·9%)	185 (5·9%)	480 (2·2%)	69 (14·5%)
Thoracic	427 (1·9%)	295 (1·6%)	123 (3·9%)	393 (1·8%)	32 (6·7%)
Cardiac	614 (2·8%)	380 (2·1%)	215 (6·8%)	569 (2·7%)	40 (8·4%)
Spinal	509 (2·3%)	420 (2·3%)	79 (2·5%)	500 (2·3%)	9 (1·9%)
Other	1222 (5·6%)	1048 (5·7%)	149 (4·7%)	1202 (5·6%)	16 (3·4%)
Caesarean section	2023 (9·2%)	1855 (10·1%)	100 (3·2%)	1982 (9·3%)	2 (0·4%)
Urgency of surgery	n=21 988	n=18 443	n=3161	n=21 414	n=476
Elective	14 837 (67·5%)	13 045 (70·7%)	1557 (49·3%)	14 626 (68·3%)	156 (32·8%)
Urgent	6267 (28·5%)	4846 (26·3%)	1293 (40·9%)	5996 (28·0%)	234 (49·2%)
Emergency	884 (4·0%)	552 (3·0%)	311 (9·8%)	792 (3·7%)	86 (18·1%)
Severity of surgery	n=21 986	n=18 433	n=3156	n=21 398	n=476
Minor	4830 (22·0%)	4208 (22·8%)	564 (17·9%)	4741 (22·2%)	77 (16·1%)
Intermediate	10 114 (45·7%)	8710 (47·3%)	1250 (39·6%)	9939 (46·4%)	139 (29·2%)
Major	7042 (31·8%)	5515 (29·9%)	1342 (42·5%)	6718 (31·4%)	260 (54·6%)
WHO surgical safety checklist before incision	n=21 961	n=18 423	n=3163	n=21 390	n=475
Number of patients to whom checklist was applied	20 024 (91·2)	16 813 (91·3%)	2870 (90·7%)	19 532 (91·3%)	416 (87·6%)
Laparoscopic surgery	n=19 966	n=16 581	n=3056	n=19 417	n=474
Number of patients who had a laparoscopic surgery	4477 (22·4%)	4045 (24·4%)	387 (12·7%)	4435 (22·8%)	33 (6·9%)
Primary indication of surgery	n=19 975	n=16 589	n=3057	n=19 426	n=474
Infective	2605 (13·0%)	1746 (10·5%)	819 (26·8%)	2489 (12·8%)	104 (21·9%)
Trauma	2658 (13·3%)	2196 (13·2%)	413 (13·5%)	2590 (13·3%)	59 (12·4%)
Cancer	2981 (14·9%)	2418 (14·6%)	510 (16·7%)	2881 (14·8%)	86 (18·1%)
Other	11 731 (58·7%)	10 229 (61·7%)	1315 (43·0%)	11 466 (59·0%)	225 (47·5%)
Critical care immediately after surgery	n=22 126	n=18 169	n=3163	n=21 440	n=477
Number of patients who had critical care immediately after surgery	2978 (13·6%)	1597 (8·6%)	1288 (40·7%)	2643 (12·3%)	321 (67·7%)
Anaesthetic complications	n=22 126	n=18 469	n=3163	n=21 440	n=477
Failed intubation	34 (0·2%)	26 (0·1%)	7 (0·2%)	32 (0·1%%)	1 (0·2%)
Aspiration	14 (0·1%)	7 (<0·1%)	7 (0·2%)	11 (0·1%)	3 (0·6%)
Cardiac arrest	27 (0·1%)	1 (<0·1%)	25 (0·8%)	13 (0·1%)	14 (2·9%)
Severe hypoxia	25 (0·1%)	9 (<0·1%)	15 (0·5%)	21 (0·1%)	4 (0·8%)

All data presented as n (%) unless otherwise stated. ASA=American Society of Anesthesiologists. COPD=chronic obstructive pulmonary disease. *ASA grades are defined as follows: I, a healthy patient; II, a patient with mild systemic disease that does not limit physical activity; III, a patient with severe systemic disease that limits physical activity; IV, a patient with severe systemic disease that is a constant threat to life; and V, a moribund patient who is not expected to survive without the operation.

Table 1: **Baseline patient characteristics**

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. We anticipated that a minimum sample size of 10 000 patients would provide a sufficient number of events for construction of a robust continental logistic regression model.[15] Although this

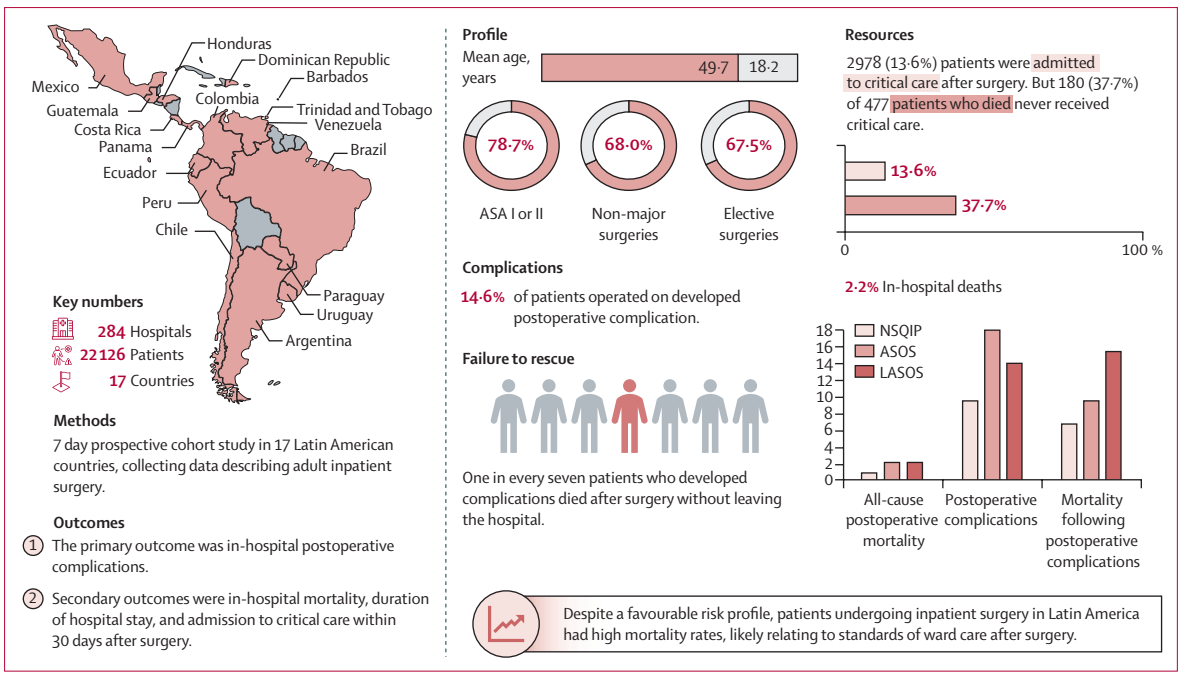

Figure 3: **LASOS infographic**
ASA=American Society of Anesthesiologists. ASOS=African Surgical Outcomes Study. LASOS=Latin American Surgical Outcomes Study. NSQIP=National Surgical Quality Improvement Program.

study could provide an estimate of continental mortality, the study was not designed to investigate differences in postoperative complication rates or mortality between countries.

Data are presented as mean (SD) and median (IQR) for continuous data, number (%) for binary data, or odds ratios (ORs) with 95% CIs. The primary outcome for this study was in-hospital complications within 30 days of surgery. We estimated the association between surgical procedure (exposure) and complications (outcome) after adjustment for covariates such as age, sex, American Society of Anesthesiologists (ASA) classification, smoking status, comorbid diseases, urgency, and severity of surgery. The adjusted analysis was performed using initially a three-level mixed effects logistic regression model. Patients were entered at the first level, hospitals at the second level, and countries at the third level. However, due to over-stratification, which led to non-convergence, we used a two-level mixed effects logistic regression model with patients at first level and hospitals at second level. This model accounted for correlation between patients in the same hospital and country. The following variables were included as fixed factors in the model: age, sex, current smoker, surgical procedure, ASA, coronary artery disease, heart failure, diabetes, cirrhosis, stroke, chronic obstructive pulmonary disease (COPD) or asthma, other comorbid disease, and severity and urgency of surgery. Factors were selected for biological plausibility and scientific rationale. For the adjusted analyses, Hosmer-Lemeshow goodness-of-fit statistics were used to test model calibration and multicollinearity was assessed using the variance inflation factor. A variance inflation factor of more than 10, which was considered to exhibit important multicollinearity, was excluded from the analysis. Model discrimination was assessed using the area under the receiver operating characteristic curve. The results of the model were reported as adjusted OR (95% CI). The analysis of secondary outcomes was performed similarly to the primary analysis. All analyses were conducted in Stata version 14.

Role of the funding source

There was no funding source for this study.

Results

Between June 1, 2022, and April 30, 2023, data describing 22126 patients were collected from 284 hospitals in 17 Latin American countries: Argentina, Barbados, Brazil, Chile, Costa Rica, Colombia, Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela (figures 1, 2). Due to missing data for the complications and mortality outcomes, 21469 patients were analysed in the primary analysis of in-hospital complications, and 21746 patients were analysed in the secondary analysis of all-cause mortality. Five countries were classified as a high-income group, ten as an upper-middle-income group, and two as a low-middle-income

	Number of patients with available data	Patients with complications	Mild severity	Moderate severity	Severe severity	Mortality for patients who developed complications
Infection						
Superficial surgical site*	21 966 (99·3%)	803 (3·7%)	295 (1·3%)	342 (1·6%)	166 (0·8%)	37/802 (4·6%)
Deep surgical site*	21 965 (99·3%)	688 (3·1%)	113 (0·5%)	309 (1·4%)	266 (1·2%)	76/685 (11·1%)
Body cavity*	21 966 (99·3%)	371 (1·7%)	86 (0·4%)	153 (0·7%)	132 (0·6%)	73/370 (19·7%)
Pneumonia*	21 966 (99·3%)	367 (1·7%)	58 (0·3%)	152 (0·7%)	157 (0·7%)	101/365 (27·7%)
Urinary tract*	21 966 (99·3%)	269 (1·2%)	90 (0·4%)	127 (0·6%)	52 (0·2%)	34/267 (12·7%)
Bloodstream*	21 965 (99·3%)	405 (1·8%)	77 (0·4%)	145 (0·7%)	183 (0·8%)	127/403 (31·5%)
Total infectious complications†	NA	2903 (100%)	719 (24·8%)	1228 (42·3%)	956 (32·9%)	231/2903 (8·0%)
Cardiovascular*						
Myocardial infarction*	21 967 (99·3%)	62 (0·3%)	16 (0·1%)	19 (0·1%)	27 (0·1%)	22/62 (35·5%)
Arrhythmia*	21 967 (99·3%)	269 (1·2%)	73 (0·3%)	129 (0·6%)	67 (0·3%)	62/268 (23·1%)
Pulmonary oedema*	21 967 (99·3%)	109 (0·5%)	25 (0·1%)	54 (0·2%)	30 (0·1%)	34/108 (31·5%)
Pulmonary embolism*	21 967 (99·3%)	56 (0·3%)	22 (0·1%)	20 (0·1%)	14 (0·1%)	12/56 (21·4%)
Stroke*	21 967 (99·3%)	60 (0·3%)	15 (0·1%)	11 (0·1%)	34 (0·2%)	27/60 (45·0%)
Cardiac arrest*	21 948 (99·2%)	295 (1·3%)	NA	NA	295 (1·3%)	248/295 (84·1%)
Total cardiovascular complications†	NA	851 (100%)	151 (17·7%)	233 (27·4%)	467 (54·9%)	278/851 (32·7%)
Other						
Gastrointestinal bleed*	21 963 (99·3%)	174 (0·8%)	62 (0·3%)	61 (0·3%)	51 (0·2%)	43/174 (24·7%)
Acute kidney injury*	21 964 (99·3%)	562 (2·6%)	175 (0·8%)	189 (0·9%)	198 (0·9%)	175/559 (31·3%)
Postoperative bleed*	21 933 (99·1%)	578 (2·6%)	NA	578 (2·6%)	0	80/577 (13·9%)
ARDS*	21 967 (99·3%)	256 (1·2%)	55 (0·3%)	70 (0·3%)	131 (0·6%)	102/255 (40·0%)
Anastomotic leak*	21 966 (99·3%)	141 (0·6%)	28 (0·1%)	48 (0·2%)	65 (0·3%)	31/140 (22·1%)
Other*	21 934 (99·1%)	1163 (5·3%)	452 (2·1%)	411 (1·9%)	365 (1·7%)	213/1223 (17·4%)
Total other complications†	NA	2939 (100%)	772 (26·3%)	1357 (46·2%)	810 (27·6%)	380/2939 (12·9%)
Total number of complications†	NA	6693 (100%)	1642 (24·5%)	2818 (42·1%)	2233 (33·4%)	477/6693 (7·1%)

Data presented as n (%) or n/N (%). ARDS=acute respiratory distress syndrome. NA=Not applicable. *Denominators are based on the number of patients with the associated complication. †Denominators are based on the total number of complications (some patients had more than one complication).

Table 2: **Postoperative complications and mortality for patients undergoing surgery**

group.[16] Participating hospitals had a median of 188 (IQR 101–368) beds, eight (IQR 5–13) operating rooms, and 23 (range 10–50) intensive care unit beds. The median critical care capacity (ratio of critical care beds to total hospital beds) was 12·6 (IQR 6·7–20·1). 201 (70·8%) hospitals had residency programmes, and 147 (51·8%) had accreditation certification (appendix 3 p 36).

The WHO safe surgery checklist or a similar surgical checklist was applied to 20 024 (91·2%) patients. 154 (54·2%) of the hospitals provided only government-funded health care, 107 [37·7%] only privately funded health care, and 23 (8·1%) were funded by both sources. Of the 22 126 patients, most were female (12 866 [58·1%] patients), young (mean age 49·7 years [SD 18·2]), and White (10 180 [46·0%] patients) with low perioperative risk profile (ASA grade I or II: 17 311 [78·7%] of 21 979 patients with data) and received elective (14 837 [67·5%] of 21 988 patients) and non-major (14 944 [68·0%] of 21 986 patients with data) surgeries. The most common specialties were orthopaedics (3705 [16·9%] of 21 975 patients with data) and gastrointestinal surgery (3729 [17·0%] of 21 975 patients with data). 2023 (9·2%) patients had caesarean section. General anaesthesia was the predominant anaesthetic technique (12 799 [57·8%] patients). Major anaesthetic related complications were uncommon, with the most frequent complication being failed intubation, which occurred in 34 (0·2%) patients. Baseline patient data are presented in table 1 and figure 3.

Postoperative complications occurred in 3163 (14·6%) patients and there were 477 (2·2%) deaths. The mortality in patients who developed complication (failure to rescue) was 15·1% (477 deaths in 3163 patients with complications). A descriptive comparison between the LASOS, ASOS,[8] and NSQIP[11] data is shown in figure 3. 2978 (13·6%) patients were admitted to a critical unit immediately after surgery and 1028 (32·6% of those who developed complications) were admitted to a critical care unit within 30 days of surgery. 180 (37·7%) 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 table 2. Of those patients with complications,

	Outcome: In-hospital complications within 30 days of surgery		Outcome: All-cause mortality censored at 30 days following surgery	
	Adjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Age	1·01 (1·00–1·01)	<0·001	1·03 (1·02–1·04)	<0·001
Sex				
Male	Reference	..	Reference	..
Female	0·82 (0·74–0·90)	<0·001	1·06 (0·86–1·32)	0·571
Current smoker	1·15 (1·02–1·30)	0·020	1·13 (0·87–1·48)	0·347
Surgical procedure				
Orthopaedic (non-spine)	Reference	..	Reference	..
Gynaecology	0·49 (0·31–0·77)	0·002	0·50 (0·17–1·46)	0·203
Urology and kidney	0·58 (0·46–0·74)	<0·001	0·97 (0·53–1·77)	0·917
Upper gastrointestinal	0·87 (0·72–1·04)	0·127	3·02 (1·88–4·84)	<0·001
Lower gastrointestinal	1·16 (0·97–1·40)	0·106	2·54 (1·60–4·04)	<0·001
Hepatobiliary	1·25 (1·06–1·49)	0·008	1·93 (1·06–3·52)	0·031
Vascular	0·81 (0·64–1·01)	0·059	1·89 (1·12–3·19)	0·017
Head and neck	1·08 (0·86–1·35)	0·518	3·94 (2·30–6·73)	<0·001
Plastics or cutaneous or breast	1·09 (0·87–1·36)	0·448	1·69 (0·91–3·15)	0·097
Neurosurgery (non-spine)	1·70 (1·35–2·12)	<0·001	5·13 (3·12–8·42)	<0·001
Thoracic	1·53 (1·20–1·97)	<0·001	4·65 (2·66–8·12)	<0·001
Cardiac	1·62 (1·24, 2·12)	<0·001	1·76 (1·01–3·06)	0·047
Spinal	1·31 (1·01–1·69)	0·040	2·55 (1·15–5·61)	0·020
Caesarean section	1·25 (0·94–1·67)	0·127	0·18 (0·04–0·77)	0·021
Other	0·23 (0·17–0·30)	<0·001	1·38 (0·72–2·63)	0·330
ASA physical status score				
I	Reference	..	Reference	..
II	1·56 (1·35–1·81)	<0·001	1·42 (0·83–2·42)	0·195
III	3·61 (3·05–4·28)	<0·001	5·09 (2·98–8·68)	<0·001
IV	10·84 (8·47–13·87)	<0·001	20·10 (11·39–35·49)	<0·001
V	14·58 (6·12–34·71)	<0·001	72·55 (28·08–187·44)	<0·001
Comorbid disease				
Coronary artery disease	1·09 (0·90–1·31)	0·381	0·86 (0·60–1·22)	0·390
Heart failure	1·10 (0·88–1·37)	0·416	1·06 (0·72–1·56)	0·774
Diabetes	1·22 (1·09–1·37)	<0·001	1·00 (0·78–1·27)	0·978
Cirrhosis	3·07 (1·96–4·83)	<0·001	4·85 (2·65–8·88)	<0·001
Stroke	1·67 (1·30–2·16)	<0·001	1·15 (0·74–1·78)	0·536
COPD or asthma	0·95 (0·77 –1·16)	0·590	1·45 (1·00–2·10)	0·048
Other	1·20 (1·08–1·32)	<0·001	1·12 (0·90–1·39)	0·324
Urgency of surgery				
Elective	Reference	..	Reference	..
Urgent	2·15 (1·94–2·38)	<0·001	2·83 (2·22–3·61)	<0·001
Emergency	3·16 (2·58–3·86)	<0·001	3·64 (2·51–5·28)	<0·001
Severity of surgery				
Minor	Reference	..	Reference	..
Intermediate	1·18 (1·04–1·34)	0·012	0·73 (0·53–1·01)	0·059
Major	2·29 (1·99–2·65)	<0·001	1·41 (1·02–1·94)	0·038

Area under the receiver operating characteristic curve of 0·8272 (95% CI 0·81948–0·83494) for postoperative complication and of 0·9252 (95% CI 0·91385–0·93656) for postoperative deaths. Two-level mixed effects logistic regression model with patients at first level and hospitals at second level. ASA=American Society of Anesthesiologists. COPD=chronic obstructive pulmonary disease. OR=odds ratio.

Table 3: **Multivariable mixed effects logistic regression models for factors independently associated with postoperative complications and mortality**

1584 (50·2%) patients were ASA grade III or higher, 1604 (50·7%) patients underwent non-elective surgery, and 1342 (42·5%) underwent major surgeries. Infectious complications were the most frequent, affecting 1795 (8·2%) patients. Cardiovascular complications occurred in 646 (2·9%) patients and were associated with the highest mortality per 100 patients (32·7%). The median length of stay for those who developed complications was 8 days (IQR 3–18), compared with 2 days (1–3) for those without complications.

The models describing complication and mortality are shown in table 3. The two-level mixed effects logistic regression models with patients at first level and hospitals at second level had excellent discrimination (C-statistic corrected for optimism of 0·83 [95% CI 0·82–0·83] for the outcome postoperative complications and of 0·93 [0·91–0·94] for postoperative mortality). We identified the following fixed factors associated with both postoperative complications and mortality: age, increasing ASA grade, urgency of surgery, extent of surgery (ie, intermediate, major), cirrhosis, COPD or asthma, and the specialties of gastrointestinal, vascular, neurosurgery, thoracic, and cardiac surgery (table 3). A small proportion of patients had missing data for the outcome of complications (657 [3·0%]) and for mortality (380 [1·7%]). We performed a complete case analysis in which patients with missing outcomes or factors included in the model were excluded.

Discussion

This international prospective cohort study provided detailed outcome data on a sample of more than 22 000 consecutive patients undergoing elective or non-elective inpatient surgery across 17 Latin American countries. The key finding was that one in seven patients developed a significant complication and one in every seven patients who developed complications died after surgery without leaving the hospital (failure to rescue). Infections were the most common complication, affecting 1795 (8·2%) patients. Patients with complications stayed in the hospital four times longer than those without complications, exacerbating the strain on already overburdened health-care systems. The use of intensive care resources has been inconsistent, with 180 (37·7%) patients who died never being admitted to the intensive care unit at any stage after surgery. These findings highlight that poor surgical outcomes in Latin America are a serious public health issue and underscore the need for significant improvements in postoperative care processes.

This extensive Latin American study aimed to gather data on surgical patient profiles and postoperative outcomes. The postoperative mortality rate in LASOS was 2·2% (477 deaths), which is consistent with previous estimates from mixed international cohorts for unselected patient populations undergoing inpatient surgery, which typically ranges between 0·5% and 4%.[6–8,17,18] The mortality

rate found in the LASOS study was as expected, given the inclusion of countries at different stages of development, ranging from low-income to high-income, each with significant variations in health-care systems, both public and private, across most nations. Also, the incidence of postoperative complications (3163 [14·6%]) seen in LASOS aligned closely with rates documented in large international cohorts.[7,8,19] Nevertheless, caution is needed when comparing datasets across different settings due to expected variability in the occurrence of complications. Inherent differences in case mix,[9] social determinants of health,[20] health-care infrastructure and organisation,[21] and safety culture[22] likely contribute to important differences in reported complications and subsequent mortality.[8,19,20] Nevertheless, our most important finding was that there was a significant occurrence of unrecognised post-operative physiological deterioration, resulting in a high failure-to-rescue rate of 15·1%. These increased rates are higher than those reported in some high-risk groups, such as older patients undergoing cardiac surgery,[23] and surpassed the rates of some mixed cohorts, such as the low-middle-income and high-income countries cohort (ISOS failure-to-rescue rate 2·8%)[7] or the American College of Surgeons NSQIP (failure-to-rescue rate 6·7%),[11] and even the incidence reported in the African cohort (ASOS failure-to-rescue rate 9·5%).[8]

Studies analysing the failure-to-rescue phenomenon have revealed that sudden physiological deterioration is uncommon, and the majority of patients who died after surgery had exhibited a gradual decline over several hours, with nursing staff faithfully documenting this deterioration (including increased heart rate, decreased blood pressure, increased respiratory rate, and diminished conscious level). Consequently, failure to rescue can be indicative of hospital performance rather than patient illness severity, and progressive deterioration in postoperative care presents an opportunity to identify, intervene, and potentially preserve patients' lives.[24,25] This rationale has led to the establishment of nurse-led and doctor-led critical care outreach teams as well as medical emergency teams in numerous countries. The implementation of these teams, in conjunction with the training of staff on standard wards, has resulted in a reduction in cardiac arrest and mortality rates.[26]

The worryingly high failure-to-rescue rates we found in Latin America reflect a combination of factors, including a higher proportion of critically ill surgical patients (21% with ASA ≥3 in LASOS *vs* 12·7% in ASOS) and frequent occurrence of surgeries in advanced or urgent conditions (32% of urgent or emergent surgeries). Additionally, there might be deficiencies in the escalation of care within surgical wards. These issues underscore the urgent need for further investigation into perioperative care pathways, as performing timely surgeries for those in greatest need is particularly challenging in fragmented health-care systems. Difficulties in accessing tertiary health-care systems cause distortions in surgical health care in LMICs, and as a result, unnecessary or low-value surgeries are still being performed.[27] This highlights a contrast with the trend towards shared decision making, risk-benefit assessment, and patient beliefs observed in high-income countries.[28]

Surgical complications diminish life expectancy and quality of life, hinder return to work, and lead to substantial financial burden.[29,30] Understanding the causes, associated factors, and nature of postoperative complications is crucial for focused interventions.[31] In our study, postoperative mortality and complications were strongly associated with increasing ASA grade, urgency of surgery, and grade of surgery (intermediate and major). Consistent with previous findings,[7,8] our study revealed that infections were the most common complication, occurring three times more often than cardiovascular issues. These high rates highlight the urgent awareness for better postoperative infection control, given the preventable nature and unnecessary suffering and burden to patients and systems.[32] The low rates of intensive care unit admission in patients who died highlight problems in postoperative rescue and intensive care unit allocation. Interventions to understand the particularities of patients at high risk,[33] to implement early risk assessment adoption and increase the escalation of care through building perioperative pathways[34,35] or alternatives to critical care resources[36] (eg, high-acuity postoperative units),[37] have been successfully tested in different contexts and could be tailored to the needs of the varied health resources and processes in Latin America.

Our study has several strengths. LASOS is a successful example of a large-scale, international, collaborative study. We enrolled many consecutive, varied patients across 284 hospitals in Latin America using a pragmatic design. With a straightforward case record form consisting primarily of categorical variables, we minimised the burden of data collection, fostering the collaboration among front-line caregivers. The denominator was the number of patients operated on rather than the total number of procedures, providing a robust insight of postoperative mortality rates, enabling comparative analysis with other international cohorts using similar methodologies.[6,10] This study also has some weaknesses. Although our study covered a substantial portion of Latin America, we used a convenience sampling strategy, which might not fully capture the complexities of surgical practice or population across the region. We approached colleagues in every eligible country to participate in contacting national medical societies, using international networks of medical colleagues, or public invitations on social media. However, the likelihood of rural hospitals in smaller towns being involved is low because participation is voluntary, contingent on local leadership, and requires the presence of research infrastructure that is often limited by a lack of strategic prioritisation and the shortage

of operational and human resources in these settings. Moreover, we did not capture data on patients who required surgery but were unable to access it. All of these factors make the comparisons with other international databases challenging. Additionally, the lower recorded complication rate might be attributed to suboptimal registries, postoperative misidentification of complications, and limited in-hospital follow-up. Although we planned to include every patient operated on during the study period in each hospital, we cannot be sure of the exact proportion of eligible patients included. Also, we did not comprehensively evaluate socioeconomic risk factors or hospital structure and process profiles, as this was beyond our study aims. Ultimately, we recognise that LASOS alone cannot answer every important question regarding surgical patient outcomes in Latin America. However, to our knowledge this is the first study to demonstrate that the surgical patient journey is an important issue that requires more careful examination. Our findings will direct future research to the best opportunities for improving patient outcomes and will build a case for funding further research across Latin America.

In conclusion, this international study of a large cohort of surgical patients across Latin America revealed a complication rate similar to that of high-income countries. However, the higher proportion of patients who died of complications after surgery suggests failure in postoperative care. These patients often have prolonged hospital stays in settings with insufficient critical care resources. Future high-level research should thoroughly evaluate the factors contributing to adverse surgical outcomes within Latin America's complex health-care systems. The wide variations in health-care infrastructure, health policy, and the impact of socioeconomic factors, all of which create very different contexts for surgical care, should be take into account.

Contributors

All authors were involved in the design and conduct of the study. Data collection and collation was done by the members of the LASOS study group (all members are listed in appendix 3 pp 2–25). AP did the data analysis, with input from RMP, LS, and LH. The report was drafted by LS, LH, and RMP, and revised after critical review by all authors.

Declaration of interests

RMP has received honoraria and a research grant from Edwards Lifesciences. SB has received honoraria from Baxter, BioPorto, bioMerieux, Norvartis, Sea Star Medical, and SphingoTex. BB has received a National Institute for Health Research Global Group grant. All other members of the LASOS study group declare no competing interests.

Data sharing

Individual participant data that underlie the results reported in this Article, after de-identification (text, tables, figures, and appendices), will be available beginning 9 months after article publication. Proposals should be directed to the corresponding authors (LS and LH) or the senior investigator (RMP) and will be evaluated by the steering committee.

For more on **LASOS** see www.lasos-study.org

For more on the **data repository** see https://www.qmul.ac.uk/ccpmg/

Acknowledgments

The LASOS study website and the data repository were maintained by the Critical Care and Perioperative Medicine Research Group at Queen Mary University of London.

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