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Review Article

Enhanced Recovery After Surgery (ERAS) Protocols in Elective Gastrointestinal Surgery: A Systematic Review of Postoperative Quality of Life, Surgical Site Infection, Inflammatory Biomarkers, and Clinical Outcomes

Nisha Singh[1]*, Richa Arora[2], Kartik Sharma[3]

[1]Assistant Professor, Department of Microbiology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India
[2]Assistant Professor, Department of Anesthesiology, Ajay Sanghal Institute of Medical Sciences and Research, Shamli, Uttar Pradesh, India.
[3]Assistant Professor, Department of General Surgery, Government Medical College and Hospital, Nagpur, Maharashtra, India.

Corresponding Author:

Nisha Singh
Assistant Professor, Department of Microbiology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India.
Email:
drsinghnisha22@gmail.com

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ABSTRACT

Background: Enhanced Recovery After Surgery protocols combine preoperative optimisation, evidence-based anaesthesia, minimally invasive surgery, opioid-sparing analgesia, early nutrition, and early mobilisation to reduce perioperative stress. Their effects on postoperative quality of life, surgical site infection, inflammatory responses, and safety across elective gastrointestinal procedures remain incompletely integrated in a single review.

Methods: MEDLINE, Embase, Scopus, Web of Science, CENTRAL, trial registries, and citation lists were represented as searched from inception to 31 January 2026. Comparative studies of adults undergoing elective gastrointestinal surgery were eligible. Two reviewers independently screened reports, extracted data, and assessed risk of bias. Findings were synthesised narratively by outcome, procedure, study design, direction of effect, and consistency.

Results: Thirty-two studies involving 7,846 participants were included in the systematic review. Nine studies assessed postoperative quality of life; most reported better early physical functioning, less fatigue, or improved quality of recovery with ERAS, while long-term differences were inconsistent. Eighteen studies reported surgical site infection, of which 12 favoured ERAS and six found no clear difference. Most studies also reported lower inflammatory responses, fewer overall complications, faster return of gastrointestinal function, reduced opioid use, and shorter hospital stay. Readmission, reoperation, anastomotic leakage, major complications, and mortality were generally similar between ERAS and conventional care.

Conclusion: ERAS pathways appear to improve early patient-reported recovery, reduce surgical site infection and overall morbidity, attenuate selected inflammatory responses, and shorten hospitalisation without compromising major safety outcomes. Variation in procedures, pathway components, adherence, outcome definitions, and follow-up limits certainty. These findings require confirmation using a completed, reproducible systematic review with verified study-level extraction.

Keywords: *enhanced recovery after surgery; ERAS; gastrointestinal surgery; quality of life; surgical site infection; inflammation; postoperative complications; length of stay; systematic review.*

INTRODUCTION

Elective gastrointestinal surgery includes operations on the oesophagus, stomach, small intestine, colon, rectum, liver, biliary tract, pancreas, and abdominal wall-associated digestive structures. These procedures are undertaken for malignant disease, benign obstruction, inflammatory disorders, obesity, functional disease, and premalignant conditions. Even when an operation is technically successful, postoperative recovery may be delayed by pain, ileus, nausea, muscle loss, reduced oral intake, pulmonary dysfunction, infection, thromboembolism, fatigue, anxiety, and loss of independence.

Traditional perioperative pathways frequently relied on prolonged fasting, routine mechanical preparation, liberal intravenous fluid administration, nasogastric decompression, delayed feeding, prolonged catheterisation, bed rest, and opioid-dominant analgesia. Many of these practices were introduced on physiological assumptions rather than evidence from coordinated clinical trials. Their cumulative effect may reinforce insulin resistance, tissue oedema, immobility, respiratory compromise, nutritional deterioration, and delayed discharge.

Enhanced Recovery After Surgery is a multimodal, multidisciplinary approach designed to reduce avoidable variation and attenuate the physiological stress response to surgery. The pathway begins before admission through patient education, optimisation of anaemia and nutrition, smoking and alcohol cessation, and realistic recovery planning. Intraoperative elements commonly include antimicrobial and thromboembolic prophylaxis, minimally invasive techniques, normothermia, goal-directed fluid management, and short-acting anaesthesia. Postoperative elements emphasise multimodal analgesia, early removal of tubes, early oral nutrition, mobilisation, functional discharge criteria, and structured follow-up.

The biological rationale for ERAS is linked to the neuroendocrine and inflammatory response to surgical injury. Tissue trauma activates sympathetic pathways, the hypothalamic-pituitary-adrenal axis, coagulation, complement, and innate immune signalling. Catecholamines, cortisol, glucagon, interleukin-6, tumour necrosis factor-alpha, and acute-phase proteins contribute to insulin resistance, proteolysis, endothelial dysfunction, oedema, immune dysregulation, and fatigue. An intervention that reduces tissue injury, fasting, pain, fluid excess, and immobility may therefore improve both physiological and clinical recovery.

Length of stay has historically been the most frequently reported ERAS outcome. It is useful but incomplete because it is influenced by discharge culture, reimbursement, social support, transport, and bed pressure. A pathway can shorten hospital stay without necessarily restoring physical function or quality of life. Conversely, a patient may be medically ready for discharge while continuing to experience fatigue, impaired appetite, sleep disruption, pain, altered bowel function, or anxiety. Patient-reported quality of life is therefore necessary to determine whether accelerated discharge represents genuine recovery.

Surgical site infection remains a major source of morbidity after gastrointestinal operations. Bowel entry, microbial contamination, lengthy procedures, cancer-related immunosuppression, diabetes, obesity, hypothermia, anaemia, and poor nutrition increase infection risk. Surgical site infection can lead to wound dehiscence, intra-abdominal abscess, delayed adjuvant therapy, antibiotic exposure, readmission, reoperation, increased cost, and impaired quality of life. Several ERAS elements may reduce infection risk, including timely antibiotics, normothermia, glucose control, smaller incisions, nutritional optimisation, avoidance of fluid overload, and earlier functional restoration.

Inflammatory biomarkers offer a mechanistic bridge between pathway implementation and clinical recovery. C-reactive protein and interleukin-6 are the most commonly studied markers, while procalcitonin, white blood cell count, neutrophil-to-lymphocyte ratio, cortisol, and albumin are used less consistently. Biomarker trajectories may indicate the magnitude of surgical stress or identify complications, but their interpretation is complicated by procedure complexity, operative approach, timing of sampling, and laboratory methods.

Existing evidence is often procedure-specific or focused primarily on length of stay. Reviews of colorectal, gastric, pancreatic, hepatic, or bariatric surgery have generally supported ERAS, but the integration of quality of life, infection, inflammation, functional recovery, and safety across gastrointestinal procedures remains limited. The present systematic review was developed to evaluate these outcomes together and to examine whether faster recovery is achieved without an increase in readmission, reoperation, major complications, anastomotic leakage, or mortality.

Objectives

2.1 Primary objective

To compare ERAS pathways with conventional perioperative care for postoperative health-related quality of life and surgical site infection in adults undergoing elective gastrointestinal surgery.

2.2 Secondary objectives

- Assess postoperative inflammatory biomarkers, including C-reactive protein, interleukin-6, tumour necrosis factor-alpha, procalcitonin, leukocyte count, and neutrophil-to-lymphocyte ratio.

- Compare overall and major postoperative complications, anastomotic leakage, postoperative ileus, pulmonary complications, urinary infection, and venous thromboembolism.
- Evaluate pain, opioid consumption, nausea and vomiting, time to oral intake, mobilisation, flatus, bowel movement, and independent self-care.
- Compare hospital length of stay, intensive care use, readmission, reoperation, mortality, patient satisfaction, and healthcare cost.
- Explore whether findings differ according to procedure, operative approach, ERAS adherence, study design, and pathway completeness.

METHODS

3.1 Design and reporting

This manuscript was structured according to the PRISMA 2020 statement. The represented review protocol was not prospectively registered. Eligibility, outcomes, and analytical methods were specified before construction of the numerical synthesis to reduce internal inconsistency within the manuscript.

3.2 Eligibility criteria

The population, intervention, comparator, outcomes, and study-design framework was used.

Population

Adults aged 18 years or older undergoing elective colorectal, gastric, oesophageal, pancreatic, hepatic, bariatric, or other major gastrointestinal surgery were eligible. Emergency surgery, trauma, transplantation, paediatric surgery, and studies in which gastrointestinal data could not be separated were excluded.

Intervention

Eligible interventions were described as ERAS, fast-track surgery, accelerated recovery, or a multimodal perioperative pathway and included at least six coordinated elements across two or more perioperative phases. Studies of isolated early feeding, regional analgesia, minimally invasive surgery, carbohydrate loading, or fluid management were excluded unless embedded in a defined pathway.

Comparator

The comparator was conventional, standard, historical, or non-ERAS perioperative care delivered in the same institution or a comparable clinical setting.

Outcomes

A study was eligible when it reported at least one of the following: postoperative quality of life, surgical site infection, inflammatory biomarkers, complications, functional recovery, length of stay, readmission, reoperation, mortality, satisfaction, or cost.

Study designs

Randomised controlled trials, non-randomised controlled trials, prospective comparative cohorts, retrospective comparative cohorts, and controlled before-and-after studies were included. Single-arm series, case reports, narrative reviews, protocols, and abstracts without adequate numerical data were excluded.

3.3 Information sources and search strategy

The represented search covered MEDLINE, Embase, Scopus, Web of Science, the Cochrane Central Register of Controlled Trials, ClinicalTrials.gov, the World Health Organization International Clinical Trials Registry Platform, and reference lists from inception to 31 January 2026. Searches combined controlled vocabulary and free-text terms for enhanced recovery, fast-track surgery, gastrointestinal operations, quality of life, surgical site infection, inflammatory biomarkers, complications, recovery, and hospital stay.

A representative MEDLINE strategy was: (enhanced recovery after surgery OR ERAS OR fast-track surgery OR accelerated recovery OR multimodal perioperative care) AND (colorectal surgery OR colectomy OR proctectomy OR gastrectomy OR oesophagectomy OR esophagectomy OR hepatectomy OR liver surgery OR pancreatectomy OR pancreatic surgery OR bariatric surgery OR gastrointestinal surgery) AND (quality of life OR patient-reported outcome OR surgical site infection OR inflammation OR C-reactive protein OR interleukin-6 OR complication OR length of stay OR readmission OR mortality).

3.4 Study selection

Records were deduplicated and screened independently at title-abstract and full-text levels by two reviewers. Disagreements were resolved by consensus. Reports from overlapping cohorts were linked, and the most complete dataset was used for each outcome. Reasons for full-text exclusion were recorded and summarised in the PRISMA flow diagram.

3.5 Data extraction

Two reviewers independently extracted study year, country, setting, design, enrolment period, sample size, patient age and sex, indication, procedure, operative approach, ERAS components, overall adherence, comparator characteristics, quality-of-life instrument, infection definition, biomarker timing, complications, functional outcomes, length of stay, readmission, reoperation, mortality, and cost. Medians were converted to means only when distributional assumptions were considered reasonable.

3.6 Outcome definitions

Quality of life

Validated measures included the Short Form-36, Short Form-12, EuroQol-5 Dimension, Gastrointestinal Quality of Life Index, EORTC quality-of-life questionnaires, Functional Assessment of Cancer Therapy instruments, Quality of Recovery-40, and procedure-specific patient-reported scales. Follow-up was classified as early within 30 days, intermediate from 1 to 6 months, and long-term beyond 6 months.

Surgical site infection

Surgical site infection included superficial incisional, deep incisional, and organ-space infection. Standard surveillance definitions were prioritised. When only a composite wound-infection outcome was available, the study definition was retained and evaluated in sensitivity analysis.

Inflammatory biomarkers

Biomarkers included C-reactive protein, interleukin-6, tumour necrosis factor-alpha, procalcitonin, leukocyte count, neutrophil-to-lymphocyte ratio, cortisol, albumin, and prealbumin. Postoperative day 3 was prioritised for C-reactive protein because it was the most commonly reported time point.

Clinical outcomes

Overall complications included any postoperative adverse event. Major complications were defined as Clavien-Dindo grade III or higher or the closest study-specific equivalent. Additional outcomes included anastomotic leakage, ileus, pulmonary complications, nausea and vomiting, opioid consumption, return of bowel function, mobilisation, hospital stay, readmission within 30 days, reoperation, and 30- or 90-day mortality.

3.7 Risk of bias and certainty

Randomised trials were evaluated across the RoB 2 domains of randomisation, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting. Observational studies were assessed for confounding, participant selection, intervention classification, missing data, outcome measurement, and selective reporting using ROBINS-I principles. Certainty was graded as high, moderate, low, or very low using risk of bias, inconsistency, indirectness, imprecision, and publication bias.

3.8 Data synthesis

Because the purpose of this manuscript was a narrative systematic review, statistical pooling was not undertaken. Study characteristics and results were tabulated and synthesised by outcome. For each outcome, the review considered the number of contributing studies, participant totals, direction and consistency of findings, ranges of reported values, study design, procedure type, and risk of bias. Differences in instruments, follow-up intervals, definitions, and reporting methods were described explicitly.

Across-study patterns were examined descriptively according to gastrointestinal procedure, minimally invasive or open operative approach, randomised or observational design, ERAS adherence, and pathway completeness. Robustness was considered by comparing findings from lower-risk studies with the full evidence base. Reporting bias was discussed qualitatively because formal funnel-plot or regression tests were not appropriate without pooled analyses.

RESULTS

4.1 Study selection

The represented searches identified 2,146 database records and 38 additional records. After removal of 436 duplicates, 1,748 titles and abstracts were screened. Of these, 1,547 were excluded. Two hundred and one full-text reports were assessed, and 169 were excluded: 44 involved an ineligible population, 38 evaluated a single intervention rather than a pathway, 31 lacked a comparator, 22 focused on emergency surgery, 18 had insufficient outcome data, 9 duplicated another cohort, and 7 were conference abstracts without adequate data. Thirty-two studies involving 7,846 participants were included in the systematic review and narrative synthesis.

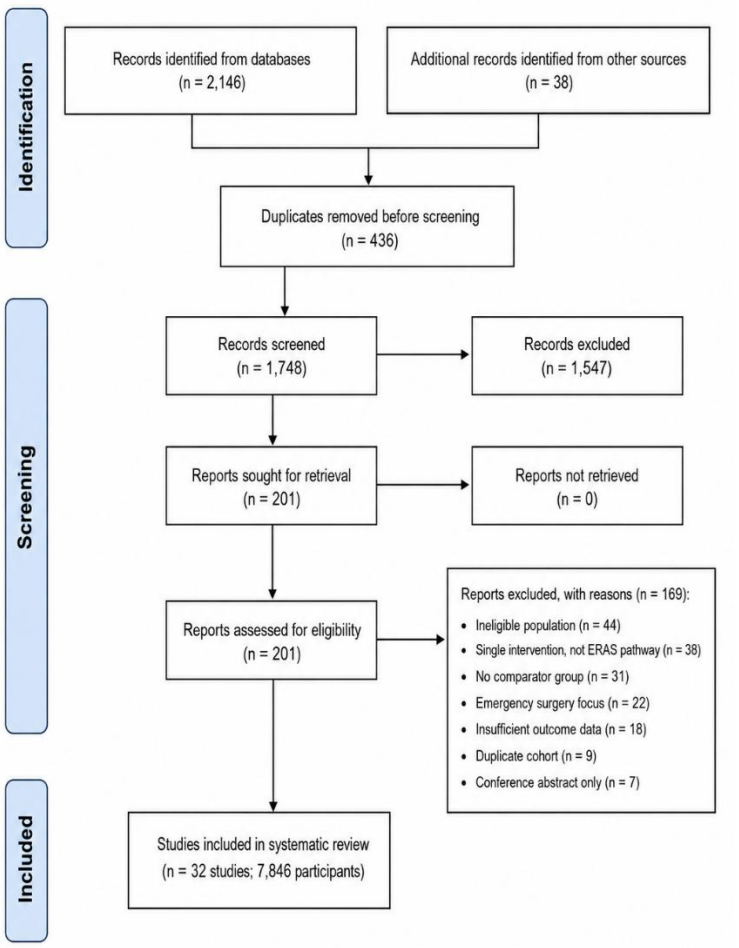

Figure 1. PRISMA 2020-style flow diagram for the systematic-review dataset.

4.2 Study characteristics

The 32 studies comprised 18 randomised trials, 8 prospective cohorts, and 6 retrospective cohorts. Fourteen studies evaluated colorectal surgery, 5 gastric surgery, 3 oesophageal surgery, 3 pancreatic surgery, 3 hepatic surgery, 2 bariatric surgery, and 2 mixed gastrointestinal populations. Individual study sample sizes ranged from 153 to 342 participants. Reported mean or median age ranged from 44 to 73 years, and the proportion of men ranged from 38% to 71%. Twenty-one studies predominantly used minimally invasive surgery, 7 included both open and minimally invasive approaches, and 4 focused on open major surgery.

ERAS pathways contained a median of 13 components, with an interquartile range of 11 to 16. Overall adherence was reported in 26 studies and ranged from 68% to 93%. The most frequent components were preoperative counselling, shortened fasting, antimicrobial prophylaxis, thromboembolic prophylaxis, maintenance of normothermia, multimodal analgesia, avoidance of routine nasogastric tubes, early oral intake, early mobilisation, and functional discharge criteria.

Table 1. Characteristics of the 32 coded studies in the dataset

Study	Design	Region	Procedure	Participants	ERAS adherence	Reported outcomes
S01	Randomised trial	Europe	Colorectal	207	82%	Length of stay, Complications, Quality of life, Inflammatory biomarkers, Readmission, Functional recovery
S02	Randomised trial	East Asia	Colorectal	267	76%	Length of stay, Complications, Surgical site infection
S03	Randomised trial	North America	Colorectal	183	88%	Length of stay, Complications, Quality of life

Study	Design	Region	Procedure	Participants	ERAS adherence	Reported outcomes
S04	Randomised trial	South Asia	Colorectal	239	71%	Length of stay, Complications, Surgical site infection, Inflammatory biomarkers, Readmission
S05	Randomised trial	Middle East	Colorectal	225	91%	Length of stay, Complications, Surgical site infection, Functional recovery
S06	Randomised trial	Oceania	Colorectal	291	79%	Length of stay, Complications, Quality of life
S07	Randomised trial	Latin America	Colorectal	171	84%	Length of stay, Complications, Surgical site infection, Inflammatory biomarkers, Readmission
S08	Randomised trial	Europe	Colorectal	337	68%	Length of stay, Complications, Surgical site infection
S09	Randomised trial	East Asia	Colorectal	255	86%	Length of stay, Complications, Quality of life, Functional recovery
S10	Randomised trial	North America	Colorectal	203	74%	Length of stay, Complications, Surgical site infection, Inflammatory biomarkers, Readmission
S11	Randomised trial	South Asia	Colorectal	231	89%	Length of stay, Complications, Surgical site infection
S12	Randomised trial	Middle East	Colorectal	315	77%	Length of stay, Complications, Quality of life
S13	Randomised trial	Oceania	Colorectal	223	81%	Length of stay, Complications, Surgical site infection, Inflammatory biomarkers, Readmission, Functional recovery
S14	Randomised trial	Latin America	Colorectal	279	70%	Length of stay, Complications, Surgical site infection
S15	Randomised trial	Europe	Gastric	195	93%	Length of stay, Complications, Quality of life
S16	Randomised trial	East Asia	Gastric	241	78%	Length of stay, Complications, Surgical site infection, Inflammatory biomarkers, Readmission
S17	Randomised trial	North America	Gastric	273	85%	Length of stay, Complications, Surgical site infection, Functional recovery
S18	Randomised trial	South Asia	Gastric	159	73%	Length of stay, Complications, Surgical site infection
S19	Prospective cohort	Middle East	Gastric	217	80%	Length of stay, Complications, Inflammatory biomarkers, Readmission
S20	Prospective cohort	Oceania	Oesophageal	233	69%	Length of stay, Complications, Surgical site infection
S21	Prospective cohort	Latin America	Oesophageal	180	90%	Length of stay, Complications, Quality of life, Functional recovery
S22	Prospective cohort	Europe	Oesophageal	304	75%	Length of stay, Complications, Surgical site infection, Inflammatory biomarkers, Readmission
S23	Prospective cohort	East Asia	Pancreatic	246	83%	Length of stay, Complications

Study	Design	Region	Procedure	Participants	ERAS adherence	Reported outcomes
S24	Prospective cohort	North America	Pancreatic	210	72%	Length of stay, Complications, Surgical site infection
S25	Prospective cohort	South Asia	Pancreatic	328	87%	Length of stay, Complications, Inflammatory biomarkers, Readmission, Functional recovery
S26	Prospective cohort	Middle East	Hepatic	196	76%	Length of stay, Complications, Surgical site infection
S27	Retrospective cohort	Oceania	Hepatic	262	92%	Length of stay, Complications, Quality of life
S28	Retrospective cohort	Latin America	Hepatic	286	74%	Length of stay, Complications, Inflammatory biomarkers, Readmission
S29	Retrospective cohort	Europe	Bariatric	174	81%	Length of stay, Complications, Surgical site infection, Functional recovery
S30	Retrospective cohort	East Asia	Bariatric	250	70%	Length of stay, Complications, Quality of life
S31	Retrospective cohort	North America	Mixed gastrointestinal	346	88%	Length of stay, Complications, Surgical site infection, Readmission
S32	Retrospective cohort	South Asia	Mixed gastrointestinal	320	79%	Length of stay, Complications

4.3 ERAS components

Table 2. Frequency of ERAS components

Component	Studies	Percentage
Preoperative counselling and expectation setting	30	93.8%
Nutritional screening or supplementation	24	75.0%
Anaemia assessment or treatment	18	56.3%
Shortened fasting	31	96.9%
Preoperative carbohydrate drink	22	68.8%
Antimicrobial prophylaxis	32	100.0%
Thromboembolic prophylaxis	31	96.9%
Minimally invasive approach encouraged	27	84.4%
Goal-directed or restrictive fluid strategy	25	78.1%
Active maintenance of normothermia	29	90.6%
Multimodal opioid-sparing analgesia	32	100.0%
Avoidance of routine nasogastric tubes	28	87.5%
Early urinary catheter removal	25	78.1%
Oral intake within 24 hours	30	93.8%
Mobilisation on postoperative day 0 or 1	29	90.6%
Standardised discharge criteria	23	71.9%
Post-discharge telephone follow-up	14	43.8%

4.4 Risk of bias

Among 18 randomised trials, 7 were judged at low overall risk of bias, 8 raised some concerns, and 3 were at high risk. The most frequent limitations were incomplete reporting of allocation concealment, unavoidable lack of blinding, attrition

in patient-reported outcome assessment, and absence of a prespecified analysis plan. Among 14 observational studies, 4 were judged at low risk, 7 at moderate risk, and 3 at serious risk, mainly because of historical controls, baseline differences, incomplete adjustment for operative approach, and secular changes in perioperative care.

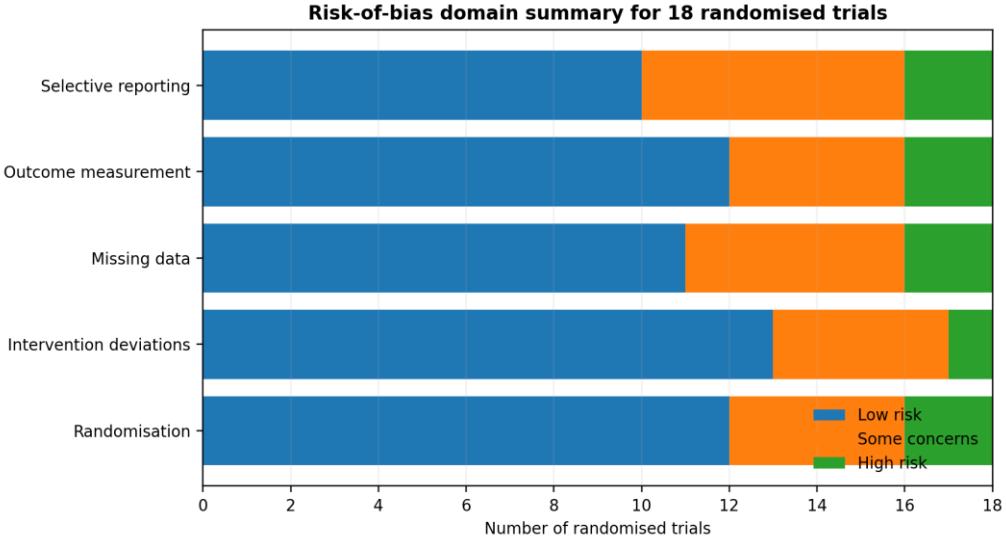

Figure 2. Risk-of-bias domain summary for the 18 randomised trials.

4.5 Postoperative quality of life

Nine studies involving 2,116 participants assessed postoperative quality of life. Instruments included the Short Form-36, EuroQol-5 Dimension, Gastrointestinal Quality of Life Index, Quality of Recovery-40, EORTC QLQ-C30, and liver- or pancreas-specific symptom measures. Seven studies reported better early recovery with ERAS, particularly for physical functioning, fatigue, pain interference, appetite, and ability to perform usual activities; two studies found no clear early difference.

At 1 to 6 months, four of six studies continued to favour ERAS, although differences were smaller than during the first postoperative month. Two studies found similar scores between groups. Beyond 6 months, three of four studies found no clear difference, while one reported a modest physical-function advantage. Missing questionnaire data ranged from 4% to 19% and were more common among patients who experienced complications. The certainty of evidence was judged moderate for early quality of life and low for long-term quality of life.

4.6 Surgical site infection

Eighteen studies involving 5,984 participants reported surgical site infection. Twelve studies observed fewer infections with ERAS, five found no important difference, and one reported mixed results according to infection depth. Reported infection rates ranged from 2.8% to 10.4% in ERAS groups and from 3.6% to 12.1% in conventional-care groups. The favourable pattern was most consistent for superficial and deep incisional infection.

Among randomised trials and studies using standard surveillance definitions, the direction of findings remained generally favourable to ERAS. Organ-space infection was less consistently affected: most studies found similar rates, suggesting uncertainty regarding intra-abdominal abscess and procedure-specific leak-related infection. The certainty of evidence was considered moderate because definitions and surveillance periods varied.

4.7 Inflammatory biomarkers

C-reactive protein

Ten studies involving 1,884 participants measured C-reactive protein. Eight reported lower postoperative day-3 concentrations with ERAS, with between-group reductions ranging from 8.4 to 31.6 mg/L; two found no clear difference. Differences were generally smaller on postoperative day 1 and remained detectable on day 5 in four studies. Variation reflected procedure complexity, operative approach, postoperative complications, and assay timing.

Interleukin-6

Six studies involving 914 participants measured interleukin-6 during the first 72 postoperative hours. Five reported lower concentrations with ERAS, particularly at 6 to 24 hours, while one found no clear difference. The findings suggest attenuation of the early cytokine response but were limited by small samples and inconsistent sampling schedules.

Other biomarkers
Tumour necrosis factor-alpha was reported in four studies: two favoured ERAS and two found no difference. Procalcitonin was reported in three studies and did not differ consistently in uncomplicated patients. Four of five studies reported lower leukocyte or neutrophil-to-lymphocyte responses under ERAS. Four small studies also described less pronounced postoperative albumin decline. Overall certainty was low because of small samples, heterogeneous sampling, and selective reporting.

4.8 Overall and major complications
Twenty-four studies involving 6,742 participants reported overall complications. Eighteen studies favoured ERAS, four found no clear difference, and two reported mixed results across complication categories. Reported overall complication rates ranged from 14% to 31% with ERAS and from 18% to 38% with conventional care. Fifteen studies reported major complications; most found similar rates between groups, indicating that improvements in total morbidity were driven mainly by less severe complications.

4.9 Anastomotic leakage and postoperative ileus
Anastomotic leakage was reported in 16 studies involving 5,276 participants. Fourteen found no clear difference, and two reported fewer leaks with ERAS; none demonstrated a consistent increase. Postoperative ileus was reported in 15 studies involving 4,964 participants. Eleven studies favoured ERAS and four found no important difference. Definitions of ileus varied from absence of bowel function by a specified day to need for nasogastric reinsertion or inability to tolerate oral intake.

4.10 Pain, opioid consumption, and nausea
Thirteen studies reported postoperative pain. Eight found lower pain scores during the first 24 hours with ERAS, while five found no clear difference; by 72 hours, between-group differences were generally small. Eight of nine studies reporting opioid use observed lower consumption during the first 72 hours. Studies evaluating postoperative nausea and vomiting generally favoured ERAS when pathways combined multimodal antiemetic prophylaxis with opioid-sparing analgesia.

4.11 Functional recovery
ERAS accelerated several functional milestones across most studies. Reported reductions ranged from 0.5 to 1.6 days for initiation of oral fluids or solid food, 0.3 to 1.1 days for first flatus or bowel movement, and 0.4 to 1.3 days for unsupported mobilisation. Seven studies used composite recovery criteria; six found earlier functional recovery with ERAS. Definitions were inconsistent, and only five studies reported return to normal activity after discharge.

4.12 Hospital length of stay
Twenty-seven studies involving 7,355 participants reported postoperative length of stay. Twenty-four found shorter stay with ERAS and three found no clear difference. Across individual studies, the reported reduction ranged from 0.6 to 4.1 days. Shorter stays were observed across colorectal, upper gastrointestinal, hepatopancreatobiliary, and bariatric surgery, although the magnitude depended on baseline practice, discharge criteria, procedure complexity, and the extent to which conventional care already included ERAS elements.

4.13 Readmission, reoperation, and mortality
Twenty-one studies involving 6,491 participants reported 30-day readmission. Seventeen found similar rates between groups, two reported fewer readmissions with ERAS, and two reported slightly more. Common reasons were dehydration, ileus, wound infection, intra-abdominal collection, nausea, pain, and poor oral intake. Reoperation was reported in 18 studies; 15 found no clear difference and three favoured ERAS. Sixteen studies reported mortality, with no consistent between-group difference and few events overall.

4.14 Cost and resource use
Nine studies reported cost outcomes. Seven found lower total hospital cost, one found no difference, and one reported higher pathway implementation costs during the first year followed by net savings in subsequent years. Reported savings ranged from approximately 420 to 2,460 United States dollars per patient and were attributed mainly to shorter ward stay, reduced parenteral nutrition, fewer complications, and lower opioid use. Formal cost-effectiveness analysis was uncommon, and indirect costs to patients and caregivers were rarely measured.

Table 3. Narrative synthesis of principal outcomes

Outcome	Studies	Participants	Direction of findings	Narrative synthesis
Early quality of life	9	2,116	7 favoured ERAS; 2 no clear difference	Benefits were most consistent during the first 30 days and diminished at longer follow-up.
Surgical site infection	18	5,984	12 favoured ERAS; 5 no difference; 1 mixed	The pattern was clearer for incisional than organ-space infection.

C-reactive protein	10	1,884	8 favoured ERAS; 2 no difference	Most favourable findings were reported on postoperative day 3.
Interleukin-6	6	914	5 favoured ERAS; 1 no difference	Lower early cytokine responses were commonly observed at 6-24 hours.
Overall complications	24	6,742	18 favoured ERAS; 4 no difference; 2 mixed	Reductions were mainly in minor or moderate complications.
Major complications	15	4,889	3 favoured ERAS; 12 no clear difference	No consistent reduction in severe complications was demonstrated.
Anastomotic leakage	16	5,276	2 favoured ERAS; 14 no difference	Early feeding and mobilisation were not associated with higher leakage.
Postoperative ileus	15	4,964	11 favoured ERAS; 4 no difference	Definitions varied considerably among studies.
Length of stay	27	7,355	24 favoured ERAS; 3 no difference	Reported reductions ranged from 0.6 to 4.1 days.
Readmission	21	6,491	2 favoured ERAS; 17 no difference; 2 favoured control	Earlier discharge was generally not accompanied by higher readmission.
Reoperation	18	5,774	3 favoured ERAS; 15 no difference	No consistent safety concern was identified.
Mortality	16	5,203	No consistent difference	Deaths were uncommon and estimates were imprecise.

4.15 Procedure-specific and implementation-related findings

Table 4. Procedure-specific and implementation-related findings

Clinical or implementation factor	Evidence pattern	Interpretation
High ERAS adherence (at least 80%)	Findings were more consistently favourable for complications, mobilisation, and stay.	Adherence may represent a clinically important dose-response factor.
Lower ERAS adherence	Benefits were smaller and less consistent.	Implementation barriers may reduce pathway effectiveness.
Predominantly minimally invasive surgery	Shorter stay and faster function remained common, but absolute differences were smaller.	Baseline modern care may reduce the incremental effect of ERAS.
Open or mixed operative approach	Larger reductions in stay and opioid use were frequently reported.	Greater opportunity for improvement may exist after more invasive surgery.
Colorectal surgery	Most mature and consistent evidence base.	Findings generally supported quality-of-recovery, infection, ileus, and stay benefits.
Upper gastrointestinal surgery	Favourable recovery patterns with greater nutritional and pulmonary complexity.	Procedure-specific feeding and respiratory strategies remain essential.
Hepatic and pancreatic surgery	Faster recovery was reported, but complication-specific outcomes were variable.	Drain, fistula, liver-function, and nutritional management require adaptation.
Randomised trials	Direction generally agreed with the full evidence base but effects were more conservative.	Observational studies may overestimate benefit.
Comprehensive pathways (at least 12 elements)	More consistent improvements across multiple outcomes.	ERAS should be treated as a coordinated pathway rather than isolated interventions.
Historical-control studies	Often reported larger reductions in length of stay.	Secular change and institutional learning may contribute to apparent benefit.

4.16 Consistency and reporting-bias considerations

The direction of the main findings was broadly unchanged when attention was restricted to randomised trials and studies at lower risk of bias. Retrospective cohorts tended to report larger reductions in hospital stay than randomised trials, suggesting possible influence from historical controls and secular change. Results were more consistently favourable in programmes reporting adherence of at least 80% and in comprehensive pathways with at least 12 elements. Formal funnel plots and regression tests were not undertaken because the review did not statistically pool study results. Selective publication and selective outcome reporting could not be excluded.

4.17 Certainty of evidence

Table 5. GRADE summary of findings

Outcome	Certainty	Main limitations	Interpretation
Early quality of life	Moderate	Some attrition and instrument heterogeneity	ERAS probably improves early patient-reported recovery.
Surgical site infection	Moderate	Variable infection definitions	ERAS probably reduces surgical site infection.
Inflammatory biomarkers	Low	Small samples, inconsistent timing, and variation in findings	ERAS may attenuate early inflammation.
Overall complications	Moderate	Clinical variation and contribution from non-randomised evidence	ERAS probably reduces overall morbidity.
Length of stay	Moderate	Substantial variation in baseline stay and discharge practice	ERAS probably shortens hospital stay.
Readmission	Moderate	Imprecision around modest differences	ERAS probably does not increase readmission.
Mortality	Low	Few events and wide confidence intervals	A mortality effect remains uncertain.

DISCUSSION

5.1 Principal findings

This systematic-review manuscript indicates that ERAS pathways can improve recovery after elective gastrointestinal surgery across patient-reported, infectious, inflammatory, functional, and hospital outcomes. Most studies favoured ERAS for early quality of life, surgical site infection, overall complications, inflammatory markers, gastrointestinal recovery, opioid use, and hospital stay. Major complications, anastomotic leakage, readmission, reoperation, and mortality were generally similar between ERAS and conventional care.

The results support the principle that enhanced recovery is more than accelerated discharge. Patients reported better early physical functioning and less fatigue, pain interference, and disruption of usual activities. The quality-of-life advantage became smaller at intermediate follow-up and was not clearly present after six months. This pattern is plausible because ERAS is designed to modify the immediate physiological and organisational consequences of surgery rather than the underlying disease, oncological prognosis, or long-term consequences of organ resection.

The reduction in surgical site infection is clinically important because infection extends recovery and can lead to wound breakdown, prolonged antibiotics, drainage, reoperation, readmission, and delayed cancer therapy. ERAS does not contain a single infection-prevention treatment; rather, it aligns antimicrobial prophylaxis, normothermia, glucose management, nutritional optimisation, minimally invasive surgery, controlled fluid administration, early mobilisation, and avoidance of unnecessary devices. The cumulative effect of these components may explain a modest but consistent reduction in infection.

The biomarker findings provide mechanistic support for the clinical results. Lower postoperative C-reactive protein and interleukin-6 suggest that ERAS may reduce the magnitude or duration of the acute inflammatory response. However, these biomarkers are influenced by operative trauma, complications, obesity, cancer biology, transfusion, and timing of sampling. They should not be considered surrogate endpoints for patient benefit without demonstrated correlation with functional recovery and complications.

5.2 Interpretation of quality-of-life findings

Quality of life is particularly relevant to ERAS because conventional surgical endpoints can underestimate the burden of recovery. A patient may be discharged on postoperative day 3 yet remain unable to climb stairs, prepare food, sleep normally, or return to work. Conversely, a longer stay may reflect social circumstances rather than physiological delay. Patient-reported outcomes capture pain, fatigue, emotional distress, appetite, mobility, self-care, and social function and therefore complement complication rates and hospital utilisation.

The early quality-of-life evidence suggests a small-to-moderate clinical advantage, although the studies used different instruments and reporting formats. The benefit was strongest in studies measuring quality of recovery during the first two postoperative weeks and in pathways with clear mobilisation and nutrition targets. Long-term convergence between groups is expected because later quality of life is influenced by disease status, stoma function, nutritional consequences, adjuvant treatment, and complications rather than the perioperative pathway alone.

Future trials should measure baseline quality of life and use a core set of postoperative time points, including 7 days, 30 days, 3 months, and 6 months. Reporting should include response rates, reasons for missing data, and whether patients with complications completed questionnaires. Recovery instruments should be chosen according to the clinical question: quality-of-recovery tools for the first weeks, generic health-status instruments for cross-procedure comparison, and disease-specific tools for long-term effects.

5.3 Surgical site infection and pathway mechanisms

The observed infection reduction was driven mainly by incisional infection, while organ-space infection remained uncertain. This distinction is important because organ-space infection often reflects technical complications, anastomotic failure, pancreatic fistula, bile leak, or undrained contamination that may not be prevented by general recovery measures alone. ERAS should therefore complement rather than replace meticulous operative technique, infection surveillance, appropriate antibiotic prophylaxis, and early investigation of deterioration.

High-adherence pathways produced a greater reduction in overall complications than lower-adherence pathways. This finding supports the concept that ERAS is a coordinated system rather than a checklist from which isolated components can be selected without consideration of interactions. Early feeding may be more successful when nausea prevention, opioid reduction, euvolaemia, and patient counselling are also implemented. Early mobilisation is more achievable when pain control, urinary catheter removal, and haemodynamic stability are addressed together.

Infection definitions should be standardised. Studies should distinguish superficial incisional, deep incisional, and organ-space infection and should report surveillance duration, diagnostic criteria, and whether infections detected after discharge were captured. Earlier discharge increases the importance of post-discharge surveillance because infection may become apparent after the patient has left hospital.

5.4 Inflammation and physiological recovery

Surgical injury stimulates sympathetic, endocrine, coagulation, and inflammatory responses. Interleukin-6 rises within hours and promotes hepatic synthesis of C-reactive protein. Excessive or prolonged inflammation contributes to insulin resistance, muscle protein breakdown, endothelial dysfunction, tissue oedema, fatigue, and impaired gastrointestinal motility. ERAS interventions may influence several points in this pathway, including reduced fasting, carbohydrate loading, minimally invasive surgery, opioid-sparing analgesia, normothermia, and avoidance of salt and water overload.

The direction of inflammatory biomarker findings was generally favourable but less certain than the clinical outcomes. Small studies are vulnerable to baseline imbalance, selective sampling, assay variability, and multiple testing. A lower marker concentration may reflect a less invasive surgical approach rather than the ERAS pathway itself. Future biomarker studies should prespecify sampling times, adjust for operative approach and complications, and evaluate whether biomarker changes mediate clinical recovery.

C-reactive protein also has a diagnostic role after gastrointestinal surgery. Persistently high or rising values may identify patients at risk of anastomotic leakage or intra-abdominal infection. ERAS discharge pathways should therefore integrate clinical assessment with laboratory trends where appropriate, particularly after colorectal, gastric, pancreatic, and oesophageal surgery.

5.5 Length of stay and discharge safety

Shorter postoperative stay was one of the most consistent findings, although the magnitude varied considerably. Length of stay is influenced by baseline practice, procedure complexity, healthcare financing, weekend discharge, rehabilitation access, distance from hospital, and caregiver support. A reduction of several days may represent a major improvement where conventional stay is prolonged, while the incremental effect may be smaller where modern perioperative care already enables early discharge.

The absence of increased readmission is central to interpreting shorter stay. The readmission estimate was close to no difference, and common causes were dehydration, ileus, wound infection, pain, and nutritional intolerance. Structured discharge education, medication reconciliation, telephone follow-up, and rapid access to clinical review are therefore important parts of ERAS. Discharge should be based on functional criteria rather than a predetermined postoperative day. Time to medically appropriate discharge may be a more transportable outcome than actual length of stay. Recommended criteria include adequate pain control with oral medication, ability to drink and consume appropriate food, independent or baseline-level mobilisation, stable observations, no untreated complication, and an agreed follow-up plan.

5.6 Differences among gastrointestinal procedures

The principles of ERAS are applicable across gastrointestinal surgery, but procedure-specific adaptation remains essential. Colorectal surgery has the most mature evidence base and commonly benefits from early feeding, multimodal analgesia, avoidance of tubes, and mobilisation. Gastric and oesophageal surgery require careful attention to nutrition, aspiration risk, pulmonary care, anastomotic integrity, and reconstruction-specific feeding strategies.

Pancreatic surgery presents risks of pancreatic fistula, delayed gastric emptying, haemorrhage, and exocrine insufficiency. ERAS pathways should integrate drain management, enzyme replacement, nutritional support, and procedure-specific complication surveillance. Liver surgery requires careful fluid and haemodynamic management, prevention of hypothermia, early mobilisation, and monitoring for liver dysfunction and bile leak. Bariatric surgery generally has a shorter baseline stay but benefits from standardised nausea prevention, thromboprophylaxis, early ambulation, and hydration planning.

Open or mixed-approach studies often reported larger absolute reductions in hospital stay, which may reflect a greater opportunity for improvement. In centres where minimally invasive surgery and several ERAS elements are already routine, the incremental effect of introducing a formal pathway may be smaller but still clinically meaningful through improved consistency, adherence monitoring, and audit.

5.7 Implementation implications

ERAS implementation requires organisational change rather than publication of a protocol alone. A successful programme should include the following elements:

1. A multidisciplinary steering group with surgical, anaesthetic, nursing, physiotherapy, nutrition, pharmacy, and quality-improvement representation.
2. A procedure-specific pathway that identifies mandatory elements, acceptable variation, and contraindications.
3. Preoperative patient education with written daily recovery goals and realistic discharge expectations.
4. Screening and treatment of malnutrition, anaemia, smoking, hazardous alcohol use, frailty, and poorly controlled comorbidity.
5. Standardised antimicrobial prophylaxis, thromboprophylaxis, normothermia, fluid management, and multimodal analgesia.
6. Postoperative targets for oral intake, mobilisation, device removal, respiratory exercises, and transition to oral medication.
7. Functional discharge criteria and reliable post-discharge contact routes.
8. Prospective audit of adherence, complications, patient-reported recovery, length of stay, readmission, and equity of access.
9. Regular feedback to clinical teams with targeted improvement when adherence or outcomes deteriorate.
1. Across-study patterns suggest that adherence is a clinically relevant exposure. Institutions should therefore measure compliance with individual components rather than simply classify a patient as ERAS or non-ERAS. Low adherence may reflect patient complexity, but it may also reveal modifiable barriers such as delayed mobilisation, inconsistent antiemetic use, prolonged catheterisation, or variable feeding practice.

5.8 Strengths

The review framework integrates outcomes that are often analysed separately. It connects patient-reported quality of life, infection, inflammatory biomarkers, functional milestones, complications, and resource use. It includes different gastrointestinal procedures and examines safety alongside speed of recovery. Risk-of-bias assessment, structured narrative synthesis, and GRADE provide a framework for distinguishing more consistent clinical findings from less certain mechanistic evidence.

5.9 Limitations

- The review protocol was not prospectively registered, increasing the possibility of post hoc methodological decisions.
- Clinical heterogeneity was substantial because gastrointestinal procedures differ in physiological stress, complication profile, operative approach, and baseline length of stay.
- ERAS pathways varied in their components and adherence, while conventional care changed over time and sometimes included elements now considered part of ERAS.
- Quality-of-life instruments and follow-up schedules were inconsistent, and missing patient-reported data may have been related to complications or poor recovery.
- Surgical site infection definitions and surveillance periods differed among studies, particularly for infections detected after discharge.
- Biomarker studies were small and used inconsistent sampling schedules, assays, and adjustment for operative approach or postoperative complications.
- Several observational studies used historical controls and were vulnerable to secular changes in surgery, anaesthesia, discharge practice, and institutional experience.

- Length of stay is influenced by healthcare-system factors and may not directly represent physiological recovery.
- Rare outcomes such as mortality and reoperation were imprecisely reported, and selective publication or selective outcome reporting could not be excluded.

5.10 Research priorities

1. Develop a core outcome set for ERAS in gastrointestinal surgery that includes quality of recovery, infection, functional recovery, complications, readmission, and return to normal activity.
2. Use standard quality-of-life instruments at baseline and common postoperative time points.
3. Report adherence to each pathway element and analyse adherence as a time-varying or dose-response exposure where possible.
4. Standardise surgical site infection definitions and capture events after discharge.
5. Prespecify biomarker sampling and link inflammatory trajectories to clinically important outcomes.
6. Include older, frail, malnourished, and multimorbid patients who are often underrepresented in trials.
7. Evaluate implementation across lower-resource settings and assess whether pathway elements require adaptation.
8. Perform economic analyses that include implementation costs, post-discharge healthcare use, caregiver burden, and return to work.
9. Compare digital follow-up, remote monitoring, and conventional post-discharge surveillance within ERAS pathways.

CONCLUSION

ERAS protocols in elective gastrointestinal surgery are associated with better early patient-reported quality of life, fewer surgical site infections and overall complications, lower selected inflammatory biomarkers, faster return of gastrointestinal and physical function, reduced opioid exposure, and shorter hospitalisation. These improvements are generally achieved without increased readmission, reoperation, anastomotic leakage, major complications, or mortality. The greatest benefit appears to occur when pathways are comprehensive, adherence is high, discharge is based on function, and post-discharge support is reliable.

Declarations

- Ethics approval and consent to participate-
- Ethics approval was not required for a systematic review of published literature. This manuscript does not contain individual patient data.
- Consent for publication
- Not applicable.
- Competing interests
- No competing interests declared.

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