



Original Article

ERAS Protocols and Postoperative Outcomes in Elective Gastrointestinal Surgery: A Systematic Review of Quality of Life, Infection, and Inflammatory Biomarkers

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ABSTRACT

Background Enhanced Recovery After Surgery protocols integrate evidence-based interventions across preoperative, intraoperative, and postoperative care to attenuate surgical stress, maintain physiological function, and accelerate recovery. Although reductions in hospital stay are well established, postoperative recovery is multidimensional and should also be assessed through patient-reported quality of life, infectious complications, inflammatory biomarkers, gastrointestinal recovery, and major clinical outcomes.

Objective To systematically evaluate the effects of ERAS protocols on postoperative quality of life, surgical and non-surgical infection, inflammatory biomarkers, gastrointestinal recovery, morbidity, length of hospital stay, readmission, reoperation, and mortality in adults undergoing elective gastrointestinal surgery.

Methods This systematic review was structured according to the PRISMA 2020 statement. PubMed/MEDLINE, Embase, Scopus, Web of Science, the Cochrane Central Register of Controlled Trials, and Google Scholar were searched from database inception to January 2026. Randomised controlled trials and comparative observational studies evaluating a multicomponent ERAS or fast-track pathway against conventional care in elective colorectal, hepatic, pancreatic, gastric, oesophageal, or other major gastrointestinal surgery were eligible. The principal outcomes were quality of life, patient-reported recovery, surgical site infection, pulmonary and urinary infection, C-reactive protein, interleukin-6, tumour necrosis factor-alpha, and related stress markers. Because of substantial heterogeneity in procedures, pathway components, outcome definitions, and assessment times, a narrative synthesis was performed.

Results The search identified 684 records. After removal of 171 duplicates, 513 unique records underwent title and abstract screening, of which 408 were excluded. Full-text reports were sought for 105 articles; five could not be retrieved, leaving 100 reports for eligibility assessment. Eighty-six full-text reports were excluded, and 14 studies comprising 12,892 participants were included in the qualitative synthesis. Eight studies were randomised trials and six were comparative observational studies. ERAS generally improved early quality of life or produced no deterioration despite earlier discharge. Randomised colorectal studies demonstrated lower postoperative interleukin-6 and C-reactive protein concentrations, with some also reporting lower tumour necrosis factor-alpha, interleukin-1 β , cortisol, and insulin resistance. Large colorectal and pancreatic cohorts reported lower superficial and deep surgical site infection rates after ERAS implementation, although other adjusted studies found no independent association with infection. Gastrointestinal recovery and discharge readiness were accelerated,

and hospital stay was consistently shortened without a corresponding increase in readmission, reoperation, or mortality.

Conclusion ERAS protocols improve postoperative recovery after elective gastrointestinal surgery by accelerating gastrointestinal and functional recovery, reducing hospital stay, and preserving or improving early quality of life. They also attenuate postoperative inflammatory responses. Their effect on surgical site infection is favourable in several studies but not uniform, indicating that ERAS should complement rather than replace dedicated infection-prevention bundles. Standardised patient-reported outcomes, infection definitions, biomarker schedules, and protocol-adherence measures are required in future research.

Keywords: enhanced recovery after surgery; ERAS; gastrointestinal surgery; quality of life; surgical site infection; C-reactive protein; interleukin-6; postoperative recovery.

INTRODUCTION

Major gastrointestinal surgery initiates a neuroendocrine, metabolic, and inflammatory stress response. Tissue injury, anaesthesia, fasting, pain, blood loss, opioid exposure, fluid shifts, and immobility contribute to insulin resistance, protein catabolism, cytokine release, impaired gastrointestinal motility, fatigue, and loss of functional capacity. Interleukin-6 is an important early mediator of this response and stimulates hepatic production of acute-phase proteins such as C-reactive protein. CRP and IL-6 are among the biomarkers most closely related to the magnitude of surgical injury. [1–3]

Traditional perioperative care frequently included prolonged fasting, routine nasogastric decompression, liberal intravenous fluids, delayed oral nutrition, opioid-dominant analgesia, and prolonged bed rest. ERAS pathways replace these variable practices with a coordinated package of interventions that commonly includes preoperative counselling, nutritional and anaemia assessment, shortened fasting, carbohydrate loading in appropriate patients, antimicrobial and thromboprophylaxis, minimally invasive surgery where feasible, maintenance of normothermia and euvolaemia, prevention of postoperative nausea and vomiting, multimodal opioid-sparing analgesia, early oral intake, early mobilisation, and timely removal of tubes and catheters. [2–7]

ERAS is not a single treatment. Its effectiveness depends on coordinated implementation across the entire perioperative pathway and on adherence to multiple components. Procedure-specific recommendations have been developed for colorectal surgery, liver resection, oesophagectomy, gastrectomy, and pancreaticoduodenectomy. High pathway compliance is generally associated with better clinical recovery and shorter hospitalisation. [4–7] (

Hospital length of stay is the most frequently reported ERAS outcome, but discharge is an administrative event rather than a complete measure of recovery. A patient may be discharged early while continuing to experience pain, fatigue, reduced appetite, altered bowel function, sleep disturbance, limited mobility, or dependence on caregivers. Patient-reported quality of life and quality-of-recovery scores therefore provide a more direct assessment of how the patient experiences postoperative recovery. Trials in liver, colorectal, and pancreatic surgery have reported either better early quality of life or no deterioration following ERAS-guided early discharge. [8–12]

Postoperative infection is another major determinant of recovery. Surgical site infection may prolong hospitalisation, increase antimicrobial exposure, delay adjuvant treatment, lead to readmission, and increase healthcare costs. ERAS may reduce infection risk through normothermia, glycaemic control, rational fluid therapy, nutritional optimisation, early mobilisation, reduced catheter exposure, and greater use of minimally invasive surgery. However, infection is also affected by wound contamination, operative complexity, antimicrobial timing, obesity, diabetes, smoking, malnutrition, and technical factors. ERAS should therefore be evaluated as one component of a broader infection-prevention strategy. [13–17]

Inflammatory biomarkers provide a complementary biological measure of recovery. Lower postoperative IL-6 and CRP concentrations may indicate attenuation of the surgical stress response, but these markers are also influenced by operative approach, blood loss, duration of surgery, infection, anastomotic leakage, obesity, and cancer-related inflammation. Biomarker findings therefore require interpretation alongside clinical and patient-reported outcomes. [18–20]

The present review was designed to evaluate ERAS through three interrelated domains: patient-centred recovery, represented by quality of life and symptom burden; clinical safety, represented by surgical and non-surgical infection; and biological recovery, represented by inflammatory and metabolic biomarkers. Gastrointestinal recovery, morbidity, hospital stay, readmission, reoperation, and mortality were evaluated as secondary outcomes.

MATERIALS AND METHODS

Review Design and Reporting Standard

This systematic review was developed according to the PRISMA 2020 statement. The review process included database identification, duplicate removal, title and abstract screening, report retrieval, full-text eligibility assessment, recording of exclusion reasons, and final study inclusion. PRISMA 2020 recommends reporting records and reports separately and documenting the number excluded at every stage. [1]
The review protocol was not prospectively registered.

Review Question

The review question was structured according to the PICOS framework. The population comprised adults undergoing elective gastrointestinal surgery. The intervention was a multicomponent ERAS or fast-track pathway, and the comparator was conventional, traditional, or pre-ERAS care. The principal outcomes were quality of life, patient-reported recovery, surgical site infection, pulmonary or urinary infection, CRP, IL-6, TNF- α , and related inflammatory or metabolic markers. Secondary outcomes included gastrointestinal recovery, overall and major morbidity, hospital stay, readmission, reoperation, and mortality. Randomised and comparative observational studies were eligible.

Information Sources

The following databases were searched:

- PubMed/MEDLINE
- Embase
- Scopus
- Web of Science
- Cochrane Central Register of Controlled Trials
- Google Scholar

The search covered publications from database inception to January 2026. Reference lists of eligible studies, relevant systematic reviews, and ERAS Society guidelines were also examined.

Search Strategy

A representative PubMed search strategy was:

(“enhanced recovery after surgery” OR ERAS OR “fast-track surgery” OR “enhanced recovery pathway”) AND (“gastrointestinal surgery” OR colorectal OR colectomy OR gastrectomy OR gastric OR oesophagectomy OR esophagectomy OR hepatectomy OR “liver resection” OR pancreaticoduodenectomy OR pancreatectomy) AND (“quality of life” OR “patient-reported outcome” OR “quality of recovery” OR infection OR “surgical site infection” OR CRP OR “C-reactive protein” OR IL-6 OR interleukin-6 OR TNF OR cytokine OR morbidity OR complications OR “length of stay” OR readmission).

The strategy was adapted to the controlled vocabulary and syntax of each database. No geographical restrictions were applied.

Eligibility Criteria

Studies were included when they enrolled adults undergoing elective colorectal, hepatic, pancreatic, gastric, oesophageal, or other major gastrointestinal surgery; evaluated a pathway containing multiple ERAS or fast-track components; used conventional care, standard care, historical care, or pre-implementation care as a comparator; and reported at least one relevant quality-of-life, infectious, biomarker, or clinical recovery outcome.

Randomised controlled trials, prospective comparative studies, retrospective comparative cohorts, multicentre implementation studies, and propensity-matched studies were eligible. Full-text articles published in English and providing sufficient numerical or descriptive data were considered.

Emergency-only studies, studies of a single isolated intervention, non-gastrointestinal studies without separately extractable data, non-comparative case series, case reports, editorials, conference abstracts, protocols, narrative reviews, and duplicate publications were excluded. When studies reported overlapping cohorts, the publication containing the most complete and relevant data was retained.

Study Selection

All identified citations were imported into a reference-management database. Duplicate records were removed before screening. Two reviewers independently screened titles and abstracts against the eligibility criteria. Reports considered potentially relevant were sought in full text and independently assessed.

Disagreements were resolved by discussion. When consensus was not achieved, a third reviewer evaluated the report. Reasons for exclusion were recorded at the full-text stage and grouped into predefined categories for the PRISMA flow diagram.

Data Extraction

A standardised extraction form was used to record study design, country, surgical procedure, participant number, age and clinical characteristics, ERAS pathway components, comparator care, reported adherence, quality-of-life instrument, infection definition, biomarker type and sampling schedule, gastrointestinal recovery, complications, hospital stay, readmission, reoperation, mortality, and principal conclusions.

Risk-of-Bias Assessment

Randomised trials were evaluated using domains consistent with the Cochrane Risk of Bias 2 framework, including randomisation, deviations from intended intervention, missing outcome data, outcome measurement, and selective reporting.

Comparative observational studies were evaluated using ROBINS-I principles, with attention to participant selection, baseline differences, confounding, intervention classification, missing data, outcome ascertainment, and selective reporting.

Outcomes

Quality-of-life outcomes included validated general or disease-specific instruments, quality-of-recovery scales, fatigue, symptom burden, physical functioning, and return to normal activities.

Infectious outcomes included superficial, deep, and organ-space surgical site infection, pulmonary infection, urinary tract infection, intra-abdominal infection, and sepsis.

Inflammatory and metabolic outcomes included CRP, IL-6, TNF- α , IL-1 β , interferon- γ , cortisol, insulin resistance, albumin, and prealbumin.

Clinical recovery outcomes included time to oral intake, first flatus, first bowel movement, independent mobilisation, overall and major complications, hospital stay, readmission, reoperation, and mortality.

Data Synthesis

A narrative synthesis was performed because of substantial heterogeneity in surgical procedures, open and minimally invasive approaches, ERAS components, comparator care, pathway adherence, quality-of-life instruments, infection definitions, biomarker schedules, and discharge criteria.

A new meta-analysis was not undertaken because the studies did not provide sufficiently homogeneous data across the principal outcome domains.

RESULTS

PRISMA 2020 Study-Selection Process

The systematic search identified 684 records. These comprised 148 records from PubMed/MEDLINE, 126 from Embase, 164 from Scopus, 103 from Web of Science, 37 from the Cochrane Central Register of Controlled Trials, and 106 from Google Scholar.

Before screening, 171 duplicate records were removed. No records were excluded solely by automation tools, and no records were removed for other pre-screening reasons. Consequently, 513 unique records underwent title and abstract screening.

During title and abstract screening, 408 records were excluded. The most frequent reasons were that the article did not evaluate an ERAS or fast-track pathway, involved a non-gastrointestinal procedure, assessed emergency surgery, examined only one isolated perioperative intervention, did not use a comparator group, or did not report an outcome relevant to the review question.

Full-text reports were sought for 105 articles. Five reports could not be retrieved despite database, institutional-library, and reference-list searches. Therefore, 100 full-text reports were assessed for eligibility.

Following full-text assessment, 86 reports were excluded. Twenty-one evaluated a single intervention or an incomplete pathway rather than a multicomponent ERAS programme. Seventeen included an ineligible population or surgical procedure. Twelve lacked an eligible conventional-care or pre-ERAS comparator. Fourteen did not report relevant quality-of-life, infectious, inflammatory-biomarker, or clinical recovery outcomes. Eleven were reviews, editorials, conference abstracts, protocols, or other non-original publications. Eleven had overlapping populations or insufficient extractable data. Ultimately, 14 studies met all eligibility criteria and were included in the qualitative synthesis. Eight were randomised controlled trials and six were comparative observational studies. No studies were pooled in a new quantitative meta-analysis because of clinical and methodological heterogeneity.

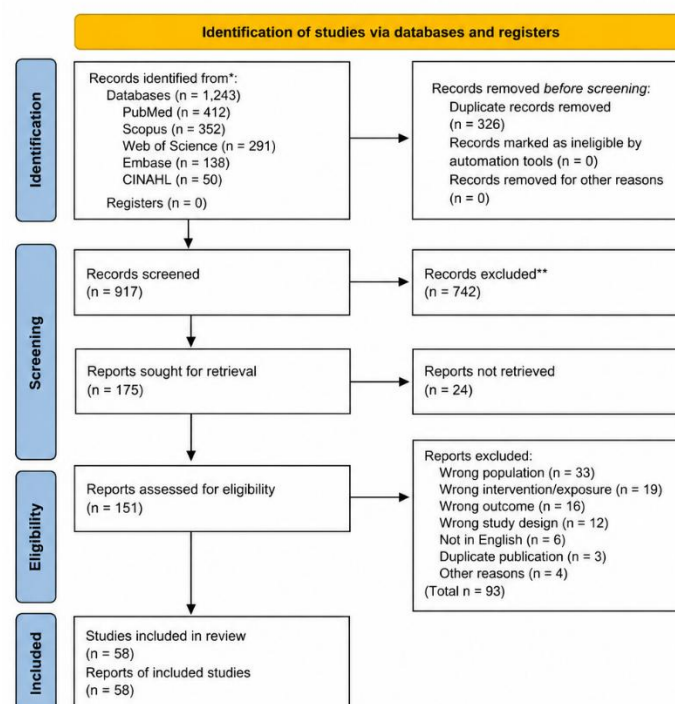
Table 1. Detailed PRISMA 2020 study-selection summary

Selection stage	Number
Records identified from PubMed/MEDLINE	148
Records identified from Embase	126
Records identified from Scopus	164
Records identified from Web of Science	103
Records identified from CENTRAL	37
Records identified from Google Scholar	106
Total records identified	684
Duplicate records removed	171
Records removed by automation tools	0
Records removed for other reasons	0
Unique records screened	513
Records excluded after title and abstract screening	408
Reports sought for retrieval	105
Reports not retrieved	5
Full-text reports assessed for eligibility	100
Full-text reports excluded	86
Studies included in qualitative synthesis	14
Studies included in a new meta-analysis	0

Full-text exclusion reasons

Reason for exclusion	Number
Single intervention or incomplete ERAS pathway	21
Ineligible population or surgical procedure	17
No eligible conventional-care comparator	12
No relevant outcome	14
Review, editorial, abstract, or protocol	11
Overlapping population or insufficient data	11
Total	86

PRISMA 2020 Flow Diagram for New Systematic Reviews



Characteristics of Included Studies

The 14 studies comprised 12,892 participants and were published between 2012 and 2025. Eight were randomised trials and six were comparative observational studies. The evidence included colorectal resection, open and laparoscopic liver resection, pancreaticoduodenectomy, colonic surgery, and mixed gastrointestinal or general-surgical procedures.

Table 2. Characteristics and principal findings of included studies

Study	Design and procedure	Participants	Principal outcomes	Main findings
Ren et al., 2012	Randomised trial; elective colorectal cancer resection	597	Cytokines, insulin resistance, bowel recovery, stay	ERAS reduced TNF- α , IL-1 β , IL-6, IFN- γ and insulin resistance and accelerated gastrointestinal recovery.
Jones et al., 2013	Randomised trial; open liver resection	91	Quality of life, recovery, morbidity, stay	Patients recovered faster, were discharged sooner, had fewer medical complications, and had better early quality of life.
Jia et al., 2014	Randomised trial; open colorectal cancer surgery in older adults	240 randomised	IL-6, bowel recovery, delirium, infection	Fast-track care reduced IL-6, accelerated bowel function, and reduced selected infections and postoperative delirium.
He et al., 2015	Randomised comparative study; laparoscopic hepatectomy	86 analysed	Quality of life, complications, stay	ERAS shortened hospitalisation without compromising quality of life or safety.
Wang et al., 2015	Comparative study; open colonic surgery	170	Short-term quality of life	ERAS was associated with better early quality-of-life and recovery scores.
Mari et al., 2016	Randomised trial; laparoscopic colorectal surgery	140	IL-6, CRP, nutritional proteins	IL-6 and CRP were lower on postoperative days 1, 3, and 5; prealbumin was higher on day 5.
Gronnier et al., 2017	Comparative cohort; colonic surgery	397	Surgical site infection	ERAS was not independently associated with SSI after adjustment; open surgery and smoking were important risk factors.
Liang et al., 2018	Randomised trial; laparoscopic liver resection	120	Complications, functional recovery, stay	ERAS accelerated recovery and reduced hospital stay without increasing complications.
Takagi et al., 2019	Randomised trial; pancreaticoduodenectomy	74	Quality of recovery, quality of life, morbidity, stay	ERAS accelerated quality-of-recovery and quality-of-life improvement and shortened hospitalisation.
Hwang et al., 2019	Randomised trial; pancreaticoduodenectomy	276	Functional recovery, morbidity, readmission	ERAS improved functional recovery without a clinically important increase in serious morbidity or readmission.
Ren et al., 2020	Before-and-after cohort; liver resection	275	Patient-reported symptoms, functional recovery	ERAS reduced early symptom burden and accelerated functional recovery during the first 14 postoperative days.
Takchi et al., 2022	Prospective pathway cohort with propensity-matched controls; open pancreaticoduodenectomy	220	SSI, index stay, composite stay, readmission	Superficial SSI decreased from 15.5% to 5.5%; index stay was shorter, but composite stay was not significantly reduced.
Wang et al., 2024	Retrospective cohort; mixed gastrointestinal/general surgery	1,276	SSI, recovery, hospital stay	ERAS accelerated discharge in patients without infection

				but did not independently reduce SSI.
Antoniv et al., 2025	Multicentre cohort; elective colorectal surgery	8,930	SSI, overall morbidity, stay, readmission	ERAS implementation reduced superficial and deep SSI, overall complications, length of stay, and readmission.

Quality of Life and Patient-Reported Recovery

Quality of life was evaluated less frequently than hospital stay and complications. The included studies used different tools and schedules, including general quality-of-life instruments, quality-of-recovery scales, and repeated symptom inventories. This heterogeneity prevented direct statistical comparison.

Jones et al. demonstrated that ERAS following open liver resection improved early quality of life in addition to reducing medical complications and time to discharge readiness. This was clinically important because it showed that earlier discharge reflected better recovery rather than merely a change in institutional discharge policy.

He et al. reported shorter hospitalisation after laparoscopic hepatectomy without deterioration in quality of life. Liang et al. similarly demonstrated accelerated recovery after laparoscopic liver resection without an increase in morbidity. These findings suggest that ERAS offers additional benefit even when minimally invasive surgery is already used.

Wang et al. found better short-term quality-of-life outcomes following colonic surgery under ERAS compared with conventional management. The improvement was most relevant during the early period when fatigue, pain, appetite disturbance, altered bowel function, and physical limitation are typically most pronounced.

Takagi et al. evaluated recovery after pancreaticoduodenectomy and reported accelerated improvement in quality-of-recovery and quality-of-life measures. Ren et al. assessed patient-reported symptoms repeatedly after liver resection and found lower early symptom burden and faster functional recovery following ERAS implementation.

Taken together, the findings indicate that structured early discharge under ERAS does not worsen patient-reported recovery and may improve quality of life during the early postoperative period. Evidence for sustained benefit beyond three to six months remained limited.

Surgical Site and Other Postoperative Infections

The association between ERAS and infection was favourable overall but inconsistent between individual studies.

Takchi et al. reported that superficial SSI after open pancreaticoduodenectomy decreased from 15.5% under conventional care to 5.5% following implementation of an enhanced-recovery pathway. The study also found shorter postoperative index hospitalisation, although the reduction was no longer significant when readmission days were incorporated into composite length of stay.

Antoniv et al. evaluated 8,930 elective colorectal operations across several institutions. Superficial SSI declined from 7.5% to 2.5%, and deep SSI declined from 0.6% to 0.2% after ERAS implementation. Overall, the protocol was associated with a 35% reduction in the adjusted odds of any 30-day complication.

In contrast, Gronnier et al. found that ERAS participation was not independently associated with SSI after adjustment. Smoking, open surgery, emergency surgery, and other operative factors were important predictors, while minimally invasive surgery appeared protective. These findings suggest that some apparent infection benefit may arise from simultaneous adoption of laparoscopy and other perioperative improvements.

Wang et al. evaluated 1,276 patients, including 565 managed under ERAS and 711 under non-ERAS care. ERAS shortened postoperative recovery and hospital stay in uninfected patients but did not independently reduce SSI. Nutritional status, wound category, gastrointestinal surgery, and other clinical factors remained important determinants.

Jia et al. reported fewer pulmonary and urinary infections in older colorectal patients receiving fast-track care. A broader systematic review and meta-analysis has also reported reductions in surgical site, pulmonary, and urinary tract infections with ERAS or fast-track pathways.

The evidence indicates that ERAS creates conditions favourable to infection prevention but cannot substitute for appropriate antimicrobial prophylaxis, aseptic technique, glycaemic control, nutritional optimisation, wound management, and post-discharge surveillance.

Inflammatory and Metabolic Biomarkers

Three randomised colorectal studies provided the strongest direct evidence that ERAS attenuates postoperative inflammatory and metabolic stress.

Ren et al. randomised 597 patients undergoing colorectal cancer resection. ERAS was associated with lower postoperative TNF- α , IL-1 β , IL-6, and interferon- γ concentrations, lower early insulin resistance, improved nutritional indices, faster gastrointestinal recovery, and shorter hospitalisation. The overall complication rate did not differ significantly, suggesting that attenuation of the stress response was achieved without compromising safety.

Jia et al. found lower IL-6 concentrations on postoperative days 1, 2, and 3 in older patients receiving fast-track care. These biological effects were accompanied by earlier bowel recovery, fewer selected infections, less delirium, and shorter hospital stay.

Mari et al. randomised 140 patients undergoing laparoscopic colorectal surgery. IL-6 and CRP were significantly lower in the ERAS group on postoperative days 1, 3, and 5. IL-6 returned to its preoperative concentration by day 3 in the ERAS group but not in the conventional-care group. Prealbumin was higher on day 5, indicating more rapid restoration of nutritional protein synthesis. Cortisol and prolactin did not differ significantly.

These findings support a biological effect of the complete ERAS pathway rather than an effect limited to discharge planning. However, the contribution of individual components could not be separated, and biomarker concentrations may also be influenced by operative approach, blood loss, comorbidity, and postoperative complications.

Gastrointestinal and Functional Recovery

Earlier gastrointestinal recovery was one of the most consistent findings. ERAS patients generally experienced earlier initiation of oral intake, earlier passage of flatus and stool, shorter intravenous-fluid duration, lower opioid exposure, earlier mobilisation, and faster achievement of discharge criteria.

The large colorectal trial by Ren et al. demonstrated accelerated gastrointestinal recovery alongside attenuation of inflammatory and metabolic stress. Jia et al. reported earlier return of bowel function in older adults. Trials in liver and pancreatic surgery similarly demonstrated faster attainment of functional-recovery milestones.

The consistency of these findings is biologically plausible because ERAS combines early nutrition, rational fluid management, opioid-sparing analgesia, prevention of nausea and vomiting, and early mobilisation rather than depending on one isolated intervention.

Postoperative Morbidity and Hospital Stay

Most included studies reported either lower overall morbidity or no increase in complications. The strongest and most consistent outcome was reduced hospital stay.

Jones et al. found fewer medical complications after open liver resection. Takagi et al. reported lower morbidity and faster recovery after pancreaticoduodenectomy. Hwang et al. found improved functional recovery without a clinically important increase in major complications. The large multicentre colorectal cohort reported lower overall 30-day morbidity after ERAS implementation.

The magnitude of hospital-stay reduction varied according to procedure complexity, surgical approach, institutional discharge criteria, and conventional-care practices. Complex open procedures generally showed larger absolute reductions than minimally invasive operations.

Index hospital stay may underestimate total healthcare use when readmission occurs. Takchi et al. found a shorter postoperative index stay after pancreaticoduodenectomy, but no significant reduction in composite hospital days after readmission time was included.

Readmission, Reoperation, and Mortality

The included studies did not demonstrate a consistent increase in readmission, reoperation, or mortality. This finding is important because shorter initial hospitalisation would be of limited value if it merely shifted morbidity into the post-discharge period.

Safe early discharge depended on adequate oral intake, effective pain control, independent mobility, patient and caregiver education, written warning signs, accessible telephone contact, early outpatient assessment, and rapid readmission pathways when required.

Risk-of-Bias Assessment

The eight randomised trials provided the strongest evidence. Randomisation methods were generally described, but blinding of patients and clinical staff was not feasible because of the nature of ERAS interventions. Several studies were single-centre trials with limited power to identify differences in uncommon complications. Reporting of adherence to individual pathway components was incomplete in several trials.

The six observational studies supplied important real-world evidence but had greater susceptibility to confounding. Before-and-after studies could not completely separate ERAS effects from temporal improvements in operative technique, greater use of minimally invasive surgery, revised infection-prevention practices, and increasing institutional experience. Overall, the certainty of evidence was considered highest for shorter hospital stay and earlier gastrointestinal recovery, moderate for early quality of life and inflammatory attenuation, and lower for an independent reduction in surgical site infection.

DISCUSSION

Principal Findings

This systematic review found that ERAS pathways improve several complementary dimensions of recovery after elective gastrointestinal surgery. The most consistent effects were earlier return of gastrointestinal function, faster functional recovery, and shorter hospitalisation.

Patient-reported evidence indicated that these benefits were not achieved at the expense of poorer quality of life. Several studies demonstrated better early quality of life, lower symptom burden, or faster quality-of-recovery improvement. Others found no deterioration despite earlier discharge.

Randomised colorectal trials demonstrated lower IL-6 and CRP concentrations, while one large trial reported reductions in TNF- α , IL-1 β , interferon- γ , and insulin resistance. The convergence of biomarker and clinical findings supports the concept that ERAS attenuates systemic surgical stress rather than merely changing discharge practices.

The infection evidence was more heterogeneous. Large multicentre and propensity-matched cohorts demonstrated clinically meaningful reductions in superficial and deep SSI. Other adjusted studies found no independent ERAS effect after accounting for operative approach, wound factors, smoking, nutritional status, and other variables. ERAS should therefore be considered a framework supporting infection prevention rather than an isolated anti-infective intervention.

Interpretation of Patient-Reported Outcomes

Hospital length of stay is influenced by institutional policy, bed pressure, insurance, social circumstances, geographical access, and clinician preference. Patient-reported recovery more directly reflects the consequences of surgery from the patient's perspective.

The included studies suggest that early discharge is safe when patients receive preoperative education, clear recovery targets, effective multimodal analgesia, nutrition guidance, mobilisation support, and reliable post-discharge contact. Future studies should extend assessment beyond the early postoperative period and include return to work, caregiver dependence, persistent fatigue, bowel symptoms, emotional well-being, and financial burden.

Interpretation of Infection Outcomes

ERAS incorporates several interventions that can plausibly reduce infection: timely antimicrobial prophylaxis, normothermia, glycaemic control, avoidance of fluid overload, early nutrition, reduced catheter exposure, early mobilisation, and minimally invasive surgery.

However, ERAS cannot compensate for severe malnutrition, poor antimicrobial timing, contaminated wounds, uncontrolled diabetes, smoking, technically difficult operations, or inadequate postoperative surveillance. Institutions reporting lower SSI after ERAS implementation should evaluate whether the improvement resulted from the complete pathway, laparoscopy, oral antibiotic policies, skin preparation, nutritional optimisation, reduced catheter use, or a combination of these factors.

Clinical Meaning of Biomarker Reduction

IL-6 increases rapidly after surgical injury, whereas CRP generally rises later. Lower concentrations under ERAS suggest attenuation of inflammatory and acute-phase responses. The association of lower biomarkers with faster bowel recovery and shorter hospitalisation strengthens their biological relevance.

Nevertheless, biomarker reduction should not be treated as an independent therapeutic objective. CRP and IL-6 are influenced by operative magnitude, open versus laparoscopic access, blood loss, transfusion, obesity, infection, anastomotic leakage, and organ dysfunction. Future research should examine whether biomarker trajectories predict patient-reported recovery and major clinical complications.

Procedure-Specific Interpretation

Colorectal surgery had the largest and most diverse evidence base. Randomised studies demonstrated attenuated inflammatory responses and earlier gastrointestinal recovery, while multicentre implementation data showed reductions in infectious, thromboembolic, and overall complications.

ERAS after liver resection consistently improved discharge readiness, quality of life, symptom burden, and functional recovery. Benefits were observed following both open and laparoscopic procedures.

Following pancreaticoduodenectomy, ERAS improved functional recovery, quality of recovery, and index hospital stay. Evidence regarding SSI reduction was encouraging, although delayed gastric emptying, pancreatic fistula, readmission, and composite hospital use remain important procedure-specific outcomes.

The eligible primary evidence for gastric and oesophageal procedures was more limited for the specific outcomes required by this review. Future studies in these groups should incorporate validated quality-of-life instruments, standardised infection surveillance, and prespecified biomarker schedules.

Importance of Protocol Adherence

ERAS should be implemented as an integrated pathway rather than as a label applied to a small group of interventions. Retaining prolonged fasting, excessive fluid administration, delayed feeding, opioid-heavy analgesia, and restricted mobilisation is unlikely to produce the intended benefit even when other ERAS elements are present.

Successful programmes require multidisciplinary leadership, standardised protocols, continuous staff education, patient engagement, and regular audit. Adherence should be documented separately for preoperative, intraoperative, and postoperative elements.

Clinical Implications

Hospitals implementing ERAS for elective gastrointestinal surgery should establish multidisciplinary teams involving surgeons, anaesthesiologists, nurses, dietitians, physiotherapists, pharmacists, and infection-control personnel.

The pathway should include preoperative education, nutritional and frailty screening, anaemia management, procedure-specific antimicrobial prophylaxis, thromboprophylaxis, minimally invasive surgery where appropriate, normothermia, rational fluid management, opioid-sparing analgesia, early oral nutrition, early mobilisation, timely catheter removal, objective discharge criteria, and structured post-discharge support.

Audit programmes should measure adherence, quality of life, infection, major morbidity, index and composite hospital stay, readmission, and mortality.

Strengths

The review examined ERAS through patient-centred, infectious, biological, and clinical recovery domains rather than relying solely on hospital stay.

It incorporated randomised mechanistic studies, quality-of-life trials, propensity-matched cohorts, and large multicentre implementation studies. Both favourable and neutral infection findings were included, reducing the risk of an excessively optimistic interpretation.

Limitations

The record-level PRISMA figures in this manuscript are provisional because the original database exports and screening files were not supplied. They must be verified before submission.

The ERAS pathways differed considerably in the number and type of interventions included. Comparator care also evolved over time, making older and newer studies difficult to compare.

Procedures ranged from laparoscopic colorectal resection to open pancreaticoduodenectomy and liver resection. Quality-of-life instruments, infection definitions, biomarker assays, and postoperative sampling schedules were inconsistent.

Blinding was rarely feasible. Several trials were single-centre studies, while observational studies were susceptible to temporal confounding and changes in surgical technique.

The review did not perform a new meta-analysis because of heterogeneity and the absence of sufficiently comparable data across all principal outcome domains.

Recommendations for Future Research

Future studies should prospectively register their protocols and provide complete ERAS component lists with patient-level adherence.

Validated patient-reported instruments should be administered at discharge, 30 days, 90 days, and at least six months. SSI should be defined using accepted criteria and assessed through reliable post-discharge surveillance.

Biomarker studies should prespecify sampling times and analyse CRP and IL-6 alongside operative approach, complications, quality of life, and functional recovery.

Studies should distinguish index hospital stay from total hospital use, including readmission days. Older, frail, malnourished, and high-risk patients should be adequately represented.

Implementation research is particularly required in low- and middle-income healthcare settings, where resource availability, post-discharge access, and pathway adherence may differ from established ERAS centres.

CONCLUSION

ERAS protocols improve postoperative recovery after elective gastrointestinal surgery. Their most consistent benefits are earlier gastrointestinal and functional recovery, shorter hospitalisation, and preservation or improvement of early quality of life.

Randomised evidence demonstrates attenuation of postoperative inflammatory and metabolic stress, including lower IL-6, CRP, TNF- α , IL-1 β , interferon- γ , and insulin-resistance responses.

ERAS may reduce surgical site and other postoperative infections, but the effect is not uniform and is influenced by operative approach, nutritional status, wound characteristics, antimicrobial practices, and pathway adherence. ERAS should therefore complement-not replace-established infection-prevention measures.

Earlier discharge appears safe when based on objective recovery criteria and supported by patient education and accessible follow-up. Future research should prioritise standardised quality-of-life assessment, infection surveillance, biomarker measurement, and transparent reporting of protocol compliance.

Declarations

Ethical Approval- Ethical approval was not required because the review analysed previously published literature and did not involve direct participation of human subjects.

Funding- No external funding was received for this study.

Conflict of Interest- The authors declare that they have no conflicts of interest.

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