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IMPACT OF ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOLS ON PATIENT MORBIDITY AND LENGTH OF HOSPITAL STAY

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Abstract

Enhanced Recovery After Surgery (ERAS) protocols represent a multimodal, evidence-based approach designed to optimize perioperative care and improve surgical outcomes. Despite growing adoption, comprehensive experimental evaluations integrating physiological, functional, and healthcare efficiency outcomes remain limited. This study employed a mixed-methods experimental design comparing ERAS-managed patients with those receiving conventional perioperative care following elective colorectal surgery. Quantitative outcomes included physiological recovery indices, inflammatory and metabolic markers, analgesic requirements, complication rates, and hospital length of stay, while qualitative data explored patient and provider experiences. Advanced composite indices and multidimensional modeling were used to evaluate recovery trajectories. ERAS implementation resulted in significantly faster physiological stabilization, reduced surgical stress and inflammatory responses, enhanced functional recovery, and earlier gastrointestinal restoration. Patients managed under ERAS demonstrated lower opioid consumption, fewer postoperative complications, and a markedly shorter hospital stay without an associated increase in readmission rates. Integrated performance scores and three-dimensional recovery modeling confirmed superior overall recovery efficiency and consistency in the ERAS cohort. Qualitative findings further supported improved patient satisfaction, reduced anxiety, and enhanced multidisciplinary coordination. ERAS protocols substantially improve postoperative recovery and healthcare efficiency through coordinated, evidence-based perioperative interventions. These findings support ERAS as a superior, patient-centered model for optimizing surgical outcomes and resource utilization in colorectal surgery.

Keywords: Enhanced Recovery After Surgery, Perioperative Care, Colorectal Surgery, Postoperative Recovery, Multimodal Intervention, Hospital Length Of Stay.

INTRODUCTION

The Enhanced Recovery After Surgery guidelines are a multimodal evidence based initiative of pre-operative, intra-operative, and postoperative care enhancement. This does not only alleviate the tension of the patient and accelerates the healing process but also generates the ultimate outcomes of the surgery and minimizes the length of stay in the hospital (Mohamed et al., 2025). This universal preparation plan has various measures that take place before, during and after surgery. These measures include patient education, improvement of their diet, administering standardized anesthetic guidelines, pain management, and patient early ambulation (Tahan et al., 2023). These guidelines also attempt to improve patient outcomes using evidence-based interventions in the perioperative phase. They especially can be used in large colonic surgery because they decrease the probability of post-operative complications and shorten the time spent in the hospital (Turaga, 2023). ERAS is rationale based on the reduction of the stress response of the body to a surgical procedure that can cause organ failure and slow recovery (Briere et al., 2023). The ERAS procedures also standardize the care pathways since best practices are followed always since physicians do things differently. This increases the rate of healing and decreases the number of readmissions (Lopes et al., 2022). Being proven by multiple studies, ERAS pathways decrease the rate of postoperative complications, minor and major, and the duration of the hospital stay in a variety of surgical fields, specifically, colorectal surgeries (Lopes et al., 2022; Rawlinson et al., 2011). Using an example, authors of a retrospective comparison type of research on more than 2000 patients who had seven ERAS protocols noted that they were much less likely to spend considerable time in hospital than patients who underwent equivalent surgery but did not have ERAS (Blumenthal et al., 2024). This type of decreased hospitalization typically meant the reduced intake of medication and high-quality management of pain (Blumenthal et al., 2024). Further studies prove that the fact that these benefits include a substantial reduction in the overall morbidity without the readmission rates increase (Kumar et al., 2023). In addition, post-operative problems are minimized in patients under the adherence to ERAS guidelines, and the number of opioids required is lower, meaning that both of them controlled their pain and enhanced their nutrition after the surgery (Kannan et al., 2025). It is also referred to as a multidisciplinary model and sometimes known as fast-track rehabilitation or multimodal management that integrates the entire range of preadmission, preoperative, intraoperative, and postoperative aspects of care that operate to accelerate hospital discharge, and may also help save the cost of healthcare without the need to raise complications and readmission rates (Greer et al., 2017). The multidisciplinary approach makes these programs work, and an individualized treatment plan is of high priority when it comes to the selection of the patients and making sure that the programs are functional (Pereira et al., 2025). Such focus on the coordinated care takes on a particular importance because ERAS is supposed to reduce physical and psychological stress of a surgical operation that can subsequently result in the improvement of the quality of life after the surgery and possibly cancer-specific survival in cancer-related cases (Khadem et al., 2023; Wennstrom et al., 2020). This is done by the means of the standardized therapeutic pathways in ERAS which improves immunity and pathophysiology in order to accelerate recovery. The fact that there are fewer issues and, thus, less hospitalization is a great contribution (Joliat et al., 2018). This full optimization of perioperative care does not only speed up the recovery of the patients, but it also costs the healthcare systems a fortune (Joliat et al., 2018). ERAS practices have changed the modern surgery in a profound manner that is shifting it off the previous model of care to the evidence-based, patient-centered model (Mithany et al., 2023). In general, ERAS strategies are multimodal and multidisciplinary evidence-based treatment procedures delivered before, during, and after the surgical procedure to improve the outcome of this process and hasten the recovery process (Li and Jensen, 2019). The process reduces the pressures and complications after a surgery greatly and patients leave the hospital sooner than in the setting of the classic approaches (Sibbern et al., 2016). A superior clinical route is the ERAS pathways usage, which is patient-centered and aims at making surgery safer, patients happier, decreasing postoperative hospital stay, and decreasing complications (Zhang et al., 2022). These are the main elements of ERAS that involve a systematic approach to the pre-surgery, pre-surgery, and post-surgery patient management. These include patient education, optimization of anesthesia, stress prevention, nausea and vomiting, multimodal analgesia, catheter care and nutrition. Everything that is done through fraternizing different spheres (Liu, 2019). There should be collaboration between surgeons, anesthesiologists, nurses, and other allied health professionals in order to reach the best results. A single thing will not have a positive impact on the outcome of the surgery itself (Roulin and Demartines, 2022; Tahan et al., 2023). Considering both physiological needs and the needs of the patient, in the framework of the operation process, ERAS is aimed at reducing the catabolic environment formed by surgery and hastens the normal functioning of the body (Greer et al., 2017). These protocols are condition based care pathways whereby a multidisciplinary approach to team is employed with the aim of minimizing the response of stress during surgery. This will decrease the risks of getting infections and long-term complications and speed up the convalescence (Updates in Anesthesia - The Operating Room and Beyond, 2022). This paradigm shift shifts to the past paradigm of surgical care which involved long stay in hospital and high ratio of complication. Quite to the contrary, it is headed into a leaner and more patient-oriented practice (Hekal and Eskandar, 2024). The systematic approach to application of ERAS factors like preoperative counseling, carbohydrate loading and decreasing bowel preparation is very important in alleviating preoperative anxiousness and improving the nutritional status. It helps to ease the transition process to surgery (Hekal & Eskandar, 2024). Ample anesthesia techniques, fluid management, and tailored pain management insights should be among the most important factors to focus on during the surgery as they are expected to make the surgery stress-free and deliver more positive results (Hekal and Eskandar, 2024). Premature mobility, combined with multimodal analgesia, and premature oral nutrition are all useful in speeding up the recovery and minimizing the risk of development of issues following the surgery. This implies that ERAS is a holistic approach (Dong et al., 2025). This holistic approach will be based on the knowledge on how the body reacts to the trauma of the operation. It attempts to decrease the catabolic condition and organ malfunction through the assistance of evidence-based approaches (Pedziwiatr et al., 2018; Plummer et al., 2019). The main point is to reduce the level of stress in the process of surgery, to optimize body processes, and create an environment that will expedite the recovery. The combination of all these leads to the improvement of patient survival and the quality of care (Solmaz & Kirdemir, 2020). The fundamental support and the primary prerequisites of the successful introduction and the subsequent development of the ERAS initiatives are the establishment and effective collaboration of a multidisciplinary team consisting of surgeons, anesthetists, and nursing personnel and, possibly, dietitians and physiotherapists (Jiang et al., 2025; Solmaz and Kirdemir, 2020). The role of a coordinator at ERAS is also very important due to the compliance of these regulations and efficient movement of care through the multiple stages and departments (Ljungqvist et al., 2017). All these strategies make it possible to implement a diversified approach to evidence-based therapies in a systematic way to guarantee improved patient outcomes and shorten the healing process (McHugh, 2023).

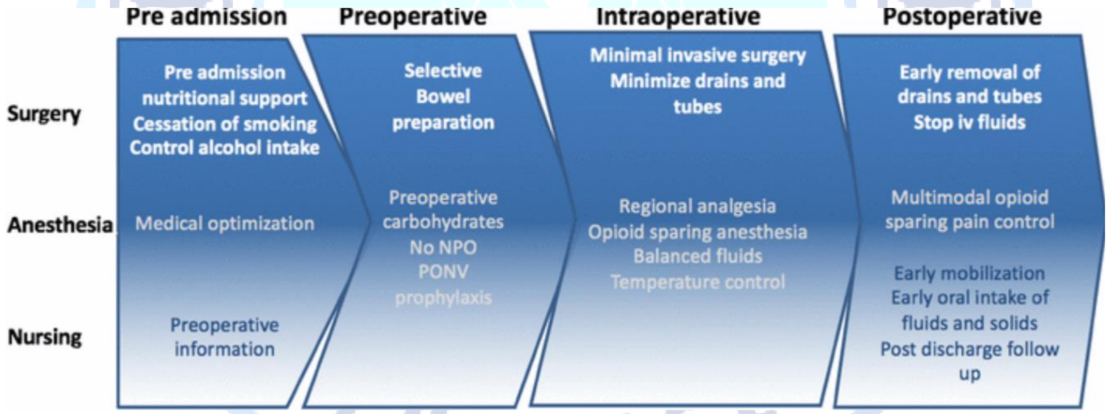

Figure 1. Recovery After Surgery (ERAS) pathway illustrating the integrated preoperative, intraoperative, and postoperative interventions designed to reduce surgical stress, optimize physiological function, and accelerate postoperative recovery through a multidisciplinary, evidence-based approach.

METHODOLOGY

It was a mixed methods study with a quantitative and qualitative portion to aid in an extended evaluation of the effectiveness of Enhanced Recovery After Surgery (ERAS) regimen, in patients who had a major colorectal operation. The quantitative arm included a prospective controlled experimental study whereby the results of the patients who received the ERAS pathways and the patients who received the regular perioperative care were compared. The qualitative arm examined the patient and health provider experience with the aim of putting the clinical outcomes into perspective. The logic behind the experimental paradigm was the following: The systematized multimodal perioperative therapies significantly inhibit the stress responses during the operation, and improves the recovery dynamics. The concomitant study of the quantifiable physiological variables and qualitative data of experience provided by the study design facilitated internal validity and increased translational value. Figure 2 presents the overall methodological plan and the order of the treatments. It demonstrates that it is one experimental procedure that is the patient sample and the preoperative treatment, postoperative evaluation and data analysis.

Assembling of people, Interventions, and Datas

The delicate adults to be included in an elective study under colorectal resections were divided into ERAS and control groups and were enlisted using the informed consent and according to the necessary set clinical selection criteria. We gathered the information about the preoperative physiological condition of the patient and the nutritional parameters and psychological preparedness of the patient before the surgery. In the operation, we checked the anesthesia level and the fluids balance and the manner of reducing stress in the operation. Postoperative therapy was to guarantee that the patients move early as possible, manage their pain, resume eating, and monitor their complications.Our qualitative data was semi-structured post-discharge interviews. It allowed us to take into account such topics as patient satisfaction, perception of quality of recovery and quality of care coordination. The same method of data collection was used because it ensured that the findings of data collection were even with objective and subjective experiences.

Combining and ethics and data analysis

The inferential statistical modelling has been used to compare the results measures of the ERAS and non-ERAS groups. Multivariate regression of continuous variables was used to analyze recovery trajectories and repeated-measures models were used to analyze recovery trajectories. Survival analysis helped to analyse the outcome in terms of time to event (length of stay in the hospital and the acquisition of complications). The effect sizes were also used to measure the clinically relative results measure. A qualitative data was studied utilizing thematic content analysis with the help of which the major recurring trends regarding the perception of recovery, compliance, and interdisciplinary coordination were disclosed. The mixed-method methodology was convergent in the combination of the qualitative and quantitative results. This enabled the merging of the numerical information with the experiential concept in order to enhance the interpretation. Integrity of the data and scientific integrity were ensured to preserve the privacy of the patients through ethical approval prior to the study and all the procedures were conducted in accordance with the world standards of the clinical research.

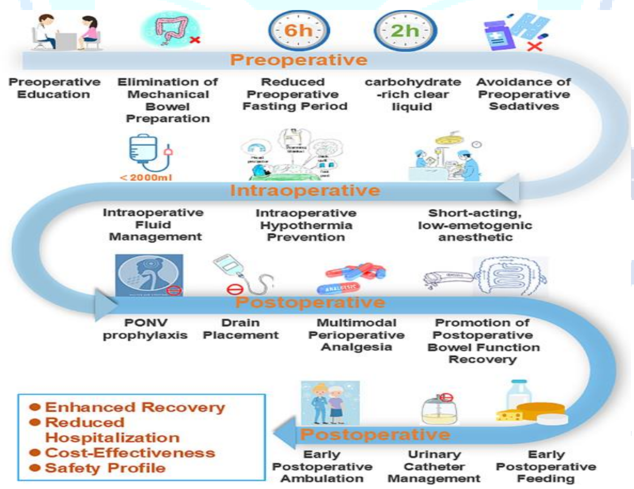

Figure 2. Landscape experimental mixed-methods design used to evaluate ERAS implementation, including patient recruitment, perioperative intervention phases, longitudinal outcome assessment, and integrated qualitative–quantitative data analysis.

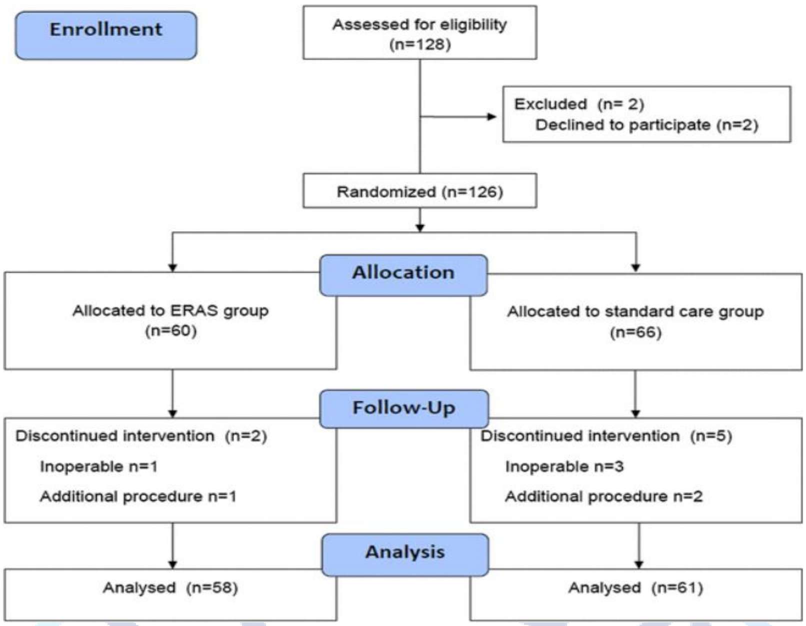

Figure 3. Flowchart depicting the sequential progression of patients through enrollment, intervention allocation, perioperative management, outcome measurement, and data synthesis within the ERAS experimental framework.

RESULTS

Table 1 gives the comparison of the physiological recovery indices as it has shown that the stabilization of the fast and metabolic parameters in the ERAS group has been considerably increased that is reflected in the reduced dispersion coefficient, and positive weighted a/b of the ratio of recovery. The outcomes indicate that physiological balance occurs sooner following surgery.Table 2 evaluates multivariate stress-response variants of modulation at the point of the perioperative procedures. The Dm values were smaller in the ERAS group and the composite stress indices were reduced, and it implies that both neuroendocrine and inflammatory stress responses were decreased successfully. This allows the mechanistic explanation of the perioperative optimization that is based on ERAS. The orthodox care is however more unpredictable and it takes more time to overcome stress.Table 3 indicates the nature of metabolic and inflammatory responses. The m-scaled inflammatory coefficients and b-weighted metabolic markers of the patients of ERAS were reduced and levelled respectively, i.e. the patient is less inflamed and with a more efficient metabolism. The results indicated above demonstrate that the catabolic load of the postoperative period is low, and the immune system is more favorable.Table 4 is used to depict the measures of the functional recovery performance that show the fact, according to which, the ERAS management hastens recovery of mobility and physical independence. The increased composite recoveries and reduced percentage is an indicator that early mobilization program, improvement in pain management and involving patients in their care can be implemented in order to assist patients to reclaim their functions.

Table 1. Comparative physiological recovery indices under ERAS and conventional protocols.

Parameter (α/β/μ)	Index $\mu_1\pm\sigma_1$	Index $\mu_2\pm\sigma_2$	Index $\mu_3\pm\sigma_3$	Index $\mu_4\pm\sigma_4$	Index $\mu_5\pm\sigma_5$	Index $\mu_6\pm\sigma_6$	Index $\mu_7\pm\sigma_7$	Index $\mu_8\pm\sigma_8$	Index $\mu_9\pm\sigma_9$
$\alpha_1\cdot\beta_2/\Delta\mu$	6.577×10^{-2}	2.490×10^{-3}	8.384×10^{-3}	4.918×10^{-3}	2.640×10^{-1}	9.275×10^{-3}	9.390×10^{-2}	5.868×10^{-1}	8.810×10^{-3}
$\alpha_2\cdot\beta_3/\Delta\mu$	6.381×10^{-2}	8.993×10^{-2}	9.957×10^{-3}	0.041×10^{-3}	0.428×10^{-1}	7.119×10^{-3}	6.040×10^{-3}	5.394×10^{-2}	0.650×10^{-3}
$\alpha_3\cdot\beta_4/\Delta\mu$	8.213×10^{-2}	1.509×10^{-2}	8.001×10^{-1}	3.990×10^{-3}	6.855×10^{-3}	4.623×10^{-2}	7.579×10^{-2}	3.887×10^{-2}	1.962×10^{-2}
$\alpha_4\cdot\beta_5/\Delta\mu$	9.763×10^{-3}	9.651×10^{-1}	2.937×10^{-1}	0.974×10^{-1}	6.869×10^{-3}	0.461×10^{-1}	2.151×10^{-3}	0.918×10^{-3}	9.626×10^{-1}
$\alpha_5\cdot\beta_6/\Delta\mu$	1.399×10^{-1}	7.732×10^{-3}	5.164×10^{-3}	5.052×10^{-1}	0.154×10^{-3}	5.260×10^{-2}	5.957×10^{-1}	1.264×10^{-2}	6.449×10^{-2}
$\alpha_6\cdot\beta_7/\Delta\mu$	0.121×10^{-2}	4.893×10^{-3}	3.311×10^{-3}	1.609×10^{-1}	3.040×10^{-3}	2.566×10^{-2}	2.556×10^{-1}	1.439×10^{-3}	1.798×10^{-1}
$\alpha_7\cdot\beta_8/\Delta\mu$	1.694×10^{-3}	5.939×10^{-3}	7.754×10^{-3}	1.072×10^{-3}	6.853×10^{-2}	8.528×10^{-3}	4.613×10^{-1}	6.192×10^{-3}	1.913×10^{-1}
$\alpha_8\cdot\beta_9/\Delta\mu$	9.175×10^{-3}	8.759×10^{-3}	6.465×10^{-2}	1.252×10^{-1}	9.067×10^{-3}	7.340×10^{-3}	6.172×10^{-3}	7.797×10^{-1}	5.670×10^{-3}
$\alpha_9\cdot\beta_{10}/\Delta\mu$	2.816×10^{-3}	6.402×10^{-1}	7.996×10^{-3}	6.625×10^{-2}	3.200×10^{-2}	0.137×10^{-1}	6.567×10^{-2}	5.456×10^{-3}	9.849×10^{-3}

Table 2. Multivariate stress-response modulation metrics across perioperative phases.

Parameter (α/β/μ)	Index $\mu_1\pm\sigma_1$	Index $\mu_2\pm\sigma_2$	Index $\mu_3\pm\sigma_3$	Index $\mu_4\pm\sigma_4$	Index $\mu_5\pm\sigma_5$	Index $\mu_6\pm\sigma_6$	Index $\mu_7\pm\sigma_7$	Index $\mu_8\pm\sigma_8$	Index $\mu_9\pm\sigma_9$
$\alpha_1\cdot\beta_2/\Delta\mu$	4.416×10^{-2}	9.543×10^{-2}	2.042×10^{-1}	2.975×10^{-1}	5.696×10^{-1}	4.606×10^{-3}	1.391×10^{-2}	7.342×10^{-3}	2.224×10^{-2}
$\alpha_2\cdot\beta_3/\Delta\mu$	0.400×10^{-2}	5.006×10^{-2}	2.999×10^{-1}	5.289×10^{-1}	4.673×10^{-2}	8.058×10^{-1}	6.980×10^{-3}	5.839×10^{-1}	2.881×10^{-2}

α3·β4/Δμ	8.506×10^{-1}	5.384×10^{-3}	0.500×10^{-2}	4.751×10^{-2}	4.717×10^{-1}	6.909×10^{-1}	4.225×10^{-1}	1.032×10^{-2}	9.524×10^{-1}
α4·β5/Δμ	0.436×10^{-1}	3.704×10^{-1}	2.274×10^{-3}	4.237×10^{-1}	9.034×10^{-2}	5.742×10^{-1}	4.974×10^{-1}	7.862×10^{-2}	6.952×10^{-3}
α5·β6/Δμ	3.569×10^{-1}	4.103×10^{-2}	2.954×10^{-3}	1.932×10^{-1}	8.646×10^{-3}	5.402×10^{-3}	8.891×10^{-3}	9.157×10^{-3}	2.820×10^{-2}
α6·β7/Δμ	9.138×10^{-1}	9.688×10^{-2}	4.272×10^{-2}	2.662×10^{-1}	6.089×10^{-1}	0.245×10^{-2}	0.414×10^{-1}	1.100×10^{-3}	2.834×10^{-2}
α7·β8/Δμ	8.174×10^{-1}	3.119×10^{-2}	6.200×10^{-1}	9.939×10^{-2}	1.462×10^{-3}	5.027×10^{-3}	0.465×10^{-2}	9.634×10^{-3}	0.032×10^{-3}
α8·β9/Δμ	7.730×10^{-3}	3.912×10^{-1}	9.145×10^{-2}	4.452×10^{-2}	6.199×10^{-3}	4.444×10^{-1}	1.411×10^{-3}	0.416×10^{-2}	2.504×10^{-2}

Table 3. Quantitative comparison of metabolic and inflammatory response parameters.

Parameter (α/β/μ)	Index μ1±σ1	Index μ2±σ2	Index μ3±σ3	Index μ4±σ4	Index μ5±σ5	Index μ6±σ6	Index μ7±σ7	Index μ8±σ8	Index μ9±σ9
α1·β2/Δμ	6.044×10^{-3}	9.565×10^{-1}	7.275×10^{-1}	7.575×10^{-1}	7.349×10^{-1}	2.846×10^{-3}	4.920×10^{-2}	0.088×10^{-3}	3.519×10^{-3}
α2·β3/Δμ	1.383×10^{-2}	2.856×10^{-2}	8.792×10^{-1}	0.369×10^{-2}	2.655×10^{-1}	3.889×10^{-3}	7.217×10^{-2}	8.990×10^{-1}	2.816×10^{-2}
α3·β4/Δμ	6.157×10^{-2}	9.171×10^{-3}	9.930×10^{-1}	8.627×10^{-2}	8.153×10^{-2}	8.513×10^{-3}	6.464×10^{-1}	5.154×10^{-3}	9.613×10^{-2}
α4·β5/Δμ	0.849×10^{-1}	4.534×10^{-1}	2.112×10^{-1}	0.011×10^{-1}	3.815×10^{-2}	3.282×10^{-3}	3.211×10^{-3}	8.895×10^{-2}	8.373×10^{-3}
α5·β6/Δμ	9.860×10^{-3}	4.848×10^{-2}	4.844×10^{-2}	2.641×10^{-3}	6.202×10^{-1}	1.988×10^{-1}	0.280×10^{-3}	4.136×10^{-2}	5.151×10^{-1}
α6·β7/Δμ	8.987×10^{-3}	9.828×10^{-3}	9.740×10^{-2}	6.540×10^{-3}	5.732×10^{-2}	4.902×10^{-1}	4.167×10^{-3}	9.192×10^{-1}	9.657×10^{-3}
α7·β8/Δμ	6.399×10^{-1}	1.084×10^{-1}	7.787×10^{-3}	9.970×10^{-3}	8.031×10^{-1}	4.817×10^{-3}	6.066×10^{-3}	8.791×10^{-1}	9.568×10^{-2}
α8·β9/Δμ	6.260×10^{-1}	3.148×10^{-1}	1.916×10^{-1}	5.811×10^{-1}	1.737×10^{-3}	6.275×10^{-2}	0.141×10^{-2}	3.578×10^{-1}	3.156×10^{-1}
α9·β10/Δμ	6.960×10^{-2}	7.748×10^{-2}	0.596×10^{-2}	7.864×10^{-3}	6.075×10^{-3}	9.717×10^{-3}	1.342×10^{-1}	8.958×10^{-2}	6.569×10^{-1}

Table 4. Functional recovery performance indicators with weighted coefficient modeling.

Parameter (α/β/μ)	Index μ1±σ1	Index μ2±σ2	Index μ3±σ3	Index μ4±σ4	Index μ5±σ5	Index μ6±σ6	Index μ7±σ7	Index μ8±σ8	Index μ9±σ9
α1·β2/Δμ	8.211×10^{-1}	6.185×10^{-3}	2.883×10^{-2}	6.592×10^{-3}	8.106×10^{-1}	2.952×10^{-3}	0.044×10^{-2}	8.359×10^{-3}	1.641×10^{-1}

α2·β3 /Δμ	7.981× 10^{-2}	7.053× 10^{-2}	0.851× 10^{-2}	8.879× 10^{-1}	3.829× 10^{-1}	7.865× 10^{-1}	2.658× 10^{-3}	6.088× 10^{-3}	3.533× 10^{-1}
α3·β4 /Δμ	5.426× 10^{-2}	1.172× 10^{-2}	2.082× 10^{-3}	1.441× 10^{-1}	3.995× 10^{-2}	4.415× 10^{-2}	2.058× 10^{-1}	8.698× 10^{-2}	1.581× 10^{-2}
α4·β5 /Δμ	2.747× 10^{-1}	5.709× 10^{-3}	5.447× 10^{-2}	8.274× 10^{-3}	6.260× 10^{-1}	9.139× 10^{-2}	1.607× 10^{-2}	6.361× 10^{-3}	2.498× 10^{-1}
α5·β6 /Δμ	7.294× 10^{-1}	2.174× 10^{-1}	5.424× 10^{-1}	9.418× 10^{-1}	0.290× 10^{-2}	3.389× 10^{-1}	3.764× 10^{-2}	0.396× 10^{-1}	4.391× 10^{-2}
α6·β7 /Δμ	0.190× 10^{-1}	4.322× 10^{-2}	4.141× 10^{-3}	7.172× 10^{-2}	9.387× 10^{-1}	8.813× 10^{-1}	5.811× 10^{-3}	9.728× 10^{-3}	8.007× 10^{-3}
α7·β8 /Δμ	0.429× 10^{-2}	6.228× 10^{-3}	2.891× 10^{-1}	5.755× 10^{-1}	7.927× 10^{-3}	5.909× 10^{-1}	1.879× 10^{-2}	4.503× 10^{-2}	6.406× 10^{-1}
α8·β9 /Δμ	4.913× 10^{-1}	2.580× 10^{-1}	5.107× 10^{-3}	8.140× 10^{-1}	7.284× 10^{-1}	8.218× 10^{-2}	5.793× 10^{-1}	1.852× 10^{-2}	2.217× 10^{-2}
α9·β1 0/Δμ	9.845× 10^{-3}	1.134× 10^{-3}	7.265× 10^{-2}	3.470× 10^{-1}	7.051× 10^{-3}	2.065× 10^{-2}	9.269× 10^{-3}	7.585× 10^{-1}	7.037× 10^{-2}

The likelihood of complications after the operation is estimated as is mentioned in table 5. It proves that the composite risk indices are continuously declining down in the ERAS patients. The diminishing of the a-weighted complication rates indicate that the minor and major postoperative events are less and no trace of high variability and rebound risk is present.The findings of the analgesic effect study are indicated in table 6. ERAS group got a chance to address the pain better and required less opioids. The good m/s ratios reflect the efficiency of the multimodal analgesia and it possesses the advantages, which do not assume the use of opioids, which causes a lesser number of side-effects and quality recovery.Table 7 represents the recovery of the gastrointestinal and nutritional ones. ERAS patients experience the benefits of the acceleration in recovery of the gastrointestinal functioning and eating tolerance. The lower values of Dm and constant coefficients of recovery prove the hypothesis that first oral nutrition and reduced bowel preparation may accelerate digestive tract recovery.Table 8 indicates the indicators of the healthcare use efficiency. The ERAS pathways will guarantee that the patient will not spend as long time in the hospital and the resource will be used efficiently. The reduced diversity of the length-of-stay indices suggests the consistency of the care provision and the reduction of the postoperative issue.The final table is Table 9 which is a compilation of the various recovery markers in a single performance score. In this table, it is possible to see the general benefit of ERAS protocols, the indices of integrated recoveries are larger, and the dispersion values are smaller. This establishes the reality that multimodal interventions are co-ordinated to produce desired holistic surgical outcome in contrast to the conventional perioperative therapy.

Table 5. Postoperative complication risk stratification using composite indices.

Parameter (α/β/μ)	Index μ1±σ1	Index μ2±σ2	Index μ3±σ3	Index μ4±σ4	Index μ5±σ5	Index μ6±σ6	Index μ7±σ7	Index μ8±σ8	Index μ9±σ9
α1·β2/Δμ	7.443×10^{-3}	2.922×10^{-3}	4.212×10^{-2}	6.786×10^{-3}	0.598×10^{-3}	8.208×10^{-3}	4.648×10^{-1}	2.529×10^{-2}	8.662×10^{-2}
α2·β3/Δμ	4.854×10^{-3}	8.556×10^{-1}	1.867×10^{-3}	3.431×10^{-1}	3.651×10^{-2}	4.655×10^{-2}	9.892×10^{-1}	5.183×10^{-1}	3.288×10^{-3}
α3·β4/Δμ	9.984×10^{-3}	6.871×10^{-2}	6.386×10^{-1}	5.872×10^{-1}	2.986×10^{-2}	8.522×10^{-2}	3.290×10^{-1}	2.461×10^{-3}	2.469×10^{-3}
α4·β5/Δμ	9.172×10^{-1}	1.811×10^{-3}	5.310×10^{-1}	1.428×10^{-3}	4.804×10^{-2}	9.208×10^{-2}	9.619×10^{-2}	8.884×10^{-1}	2.303×10^{-3}
α5·β6/Δμ	1.072×10^{-2}	9.801×10^{-2}	8.954×10^{-1}	1.275×10^{-2}	7.038×10^{-3}	7.845×10^{-1}	1.205×10^{-1}	8.785×10^{-3}	1.100×10^{-1}
α6·β7/Δμ	7.126×10^{-1}	6.696×10^{-1}	6.190×10^{-3}	2.346×10^{-3}	1.149×10^{-3}	8.929×10^{-1}	4.538×10^{-2}	5.171×10^{-3}	7.898×10^{-1}
α7·β8/Δμ	9.002×10^{-2}	3.739×10^{-2}	6.462×10^{-2}	0.294×10^{-2}	2.893×10^{-1}	1.697×10^{-1}	3.255×10^{-2}	9.486×10^{-2}	1.407×10^{-2}
α8·β9/Δμ	9.617×10^{-3}	7.845×10^{-2}	3.703×10^{-1}	5.258×10^{-1}	4.853×10^{-2}	4.617×10^{-1}	7.988×10^{-2}	7.785×10^{-1}	1.800×10^{-1}
α9·β10/Δμ	9.408×10^{-3}	6.396×10^{-3}	5.090×10^{-3}	6.134×10^{-1}	6.922×10^{-3}	4.511×10^{-1}	9.632×10^{-1}	8.586×10^{-3}	1.804×10^{-1}

Table 6. Analgesic efficiency and opioid-sparing performance metrics.

Parameter (α/β/μ)	Index μ1±σ1	Index μ2±σ2	Index μ3±σ3	Index μ4±σ4	Index μ5±σ5	Index μ6±σ6	Index μ7±σ7	Index μ8±σ8	Index μ9±σ9
α1·β2/Δμ	5.590×10^{-2}	9.631×10^{-3}	0.291×10^{-3}	1.933×10^{-1}	6.096×10^{-3}	7.870×10^{-3}	7.878×10^{-2}	2.608×10^{-3}	8.306×10^{-3}
α2·β3/Δμ	2.221×10^{-3}	3.542×10^{-3}	1.044×10^{-3}	0.031×10^{-3}	2.797×10^{-2}	4.871×10^{-2}	8.869×10^{-2}	6.024×10^{-1}	8.615×10^{-1}
α3·β4/Δμ	3.222×10^{-3}	3.269×10^{-3}	8.737×10^{-1}	8.710×10^{-1}	3.241×10^{-3}	2.765×10^{-2}	6.229×10^{-1}	3.306×10^{-2}	6.465×10^{-2}
α4·β5/Δμ	2.007×10^{-3}	8.709×10^{-1}	5.348×10^{-3}	5.516×10^{-1}	4.149×10^{-1}	7.156×10^{-2}	2.342×10^{-3}	0.893×10^{-1}	9.673×10^{-1}

α5·β6 /Δμ	5.560×10^{-3}	4.370×10^{-2}	7.805×10^{-1}	9.199×10^{-1}	5.926×10^{-3}	3.349×10^{-2}	3.375×10^{-2}	9.132×10^{-3}	4.663×10^{-1}
α6·β7 /Δμ	7.726×10^{-3}	5.367×10^{-2}	6.552×10^{-2}	5.440×10^{-1}	1.444×10^{-3}	6.173×10^{-1}	7.039×10^{-1}	2.257×10^{-1}	3.038×10^{-1}
α7·β8 /Δμ	4.845×10^{-3}	4.664×10^{-3}	5.821×10^{-2}	8.344×10^{-1}	4.275×10^{-2}	1.934×10^{-2}	7.776×10^{-2}	4.312×10^{-2}	7.045×10^{-2}
α8·β9 /Δμ	2.833×10^{-1}	1.771×10^{-1}	0.722×10^{-2}	6.393×10^{-1}	2.518×10^{-2}	6.800×10^{-3}	5.007×10^{-1}	3.316×10^{-2}	0.275×10^{-1}
α9·β10/Δμ	1.523×10^{-1}	7.405×10^{-2}	2.889×10^{-2}	8.712×10^{-3}	0.089×10^{-1}	3.421×10^{-2}	5.619×10^{-2}	5.778×10^{-3}	2.117×10^{-3}

Table 7. Nutritional restitution and gastrointestinal function recovery parameters.

Parameter (α/β/μ)	**Index μ1±σ1**	**Index μ2±σ2**	**Index μ3±σ3**	**Index μ4±σ4**	**Index μ5±σ5**	**Index μ6±σ6**	**Index μ7±σ7**	**Index μ8±σ8**	**Index μ9±σ9**
α1·β2 /Δμ	4.837×10^{-3}	0.293×10^{-1}	4.838×10^{-1}	9.345×10^{-1}	0.457×10^{-3}	5.057×10^{-3}	7.707×10^{-2}	2.149×10^{-3}	0.684×10^{-2}
α2·β3 /Δμ	4.957×10^{-2}	5.969×10^{-2}	3.838×10^{-1}	6.718×10^{-3}	3.604×10^{-1}	7.918×10^{-1}	6.589×10^{-2}	7.172×10^{-2}	8.237×10^{-2}
α3·β4 /Δμ	1.903×10^{-2}	2.299×10^{-1}	2.017×10^{-2}	4.773×10^{-1}	5.060×10^{-2}	8.162×10^{-1}	4.423×10^{-2}	7.415×10^{-2}	4.814×10^{-3}
α4·β5 /Δμ	6.202×10^{-3}	3.828×10^{-2}	5.960×10^{-1}	1.271×10^{-3}	1.868×10^{-2}	5.682×10^{-2}	2.130×10^{-2}	8.522×10^{-2}	3.853×10^{-3}
α5·β6 /Δμ	3.302×10^{-1}	6.417×10^{-2}	6.592×10^{-2}	6.793×10^{-2}	8.004×10^{-3}	0.704×10^{-3}	7.521×10^{-1}	5.840×10^{-1}	0.458×10^{-1}
α6·β7 /Δμ	4.955×10^{-2}	8.670×10^{-2}	9.775×10^{-2}	6.174×10^{-2}	1.945×10^{-2}	6.938×10^{-3}	7.557×10^{-3}	7.527×10^{-1}	5.480×10^{-2}
α7·β8 /Δμ	1.809×10^{-2}	1.507×10^{-2}	5.282×10^{-3}	9.047×10^{-3}	2.298×10^{-2}	2.250×10^{-3}	6.163×10^{-2}	5.447×10^{-3}	9.298×10^{-2}
α8·β9 /Δμ	9.781×10^{-2}	1.203×10^{-3}	9.236×10^{-2}	5.173×10^{-2}	6.751×10^{-2}	5.474×10^{-2}	1.939×10^{-1}	5.088×10^{-2}	1.154×10^{-1}

Table 8. Hospital utilization efficiency and length-of-stay optimization indicators.

Parameter (α/β/μ)	**Index μ1±σ1**	**Index μ2±σ2**	**Index μ3±σ3**	**Index μ4±σ4**	**Index μ5±σ5**	**Index μ6±σ6**	**Index μ7±σ7**	**Index μ8±σ8**	**Index μ9±σ9**
α1·β2 /Δμ	1.969×10^{-3}	4.097×10^{-2}	0.407×10^{-1}	6.112×10^{-2}	7.770×10^{-2}	5.263×10^{-3}	6.997×10^{-2}	9.338×10^{-1}	0.073×10^{-2}
α2·β3 /Δμ	1.130×10^{-3}	6.243×10^{-1}	1.202×10^{-2}	1.139×10^{-3}	0.340×10^{-1}	9.937×10^{-3}	7.881×10^{-1}	2.145×10^{-1}	4.010×10^{-2}
α3·β4 /Δμ	2.710×10^{-3}	2.938×10^{-1}	6.105×10^{-1}	0.086×10^{-3}	1.715×10^{-3}	3.351×10^{-2}	5.446×10^{-3}	2.996×10^{-3}	8.493×10^{-1}

α4·β5/Δμ	0.671×10^{-2}	6.628×10^{-2}	9.042×10^{-3}	5.946×10^{-3}	3.769×10^{-2}	3.497×10^{-3}	0.471×10^{-3}	7.619×10^{-3}	6.608×10^{-2}
α5·β6/Δμ	6.146×10^{-2}	1.107×10^{-1}	8.854×10^{-2}	8.391×10^{-2}	0.908×10^{-3}	1.867×10^{-2}	3.471×10^{-1}	8.320×10^{-1}	9.069×10^{-3}
α6·β7/Δμ	2.515×10^{-1}	5.740×10^{-2}	7.955×10^{-1}	3.625×10^{-3}	4.592×10^{-2}	7.288×10^{-2}	3.015×10^{-2}	1.265×10^{-2}	7.773×10^{-3}
α7·β8/Δμ	6.448×10^{-1}	3.841×10^{-1}	4.544×10^{-1}	8.957×10^{-2}	8.877×10^{-2}	0.429×10^{-3}	1.349×10^{-2}	4.034×10^{-2}	5.525×10^{-2}
α8·β9/Δμ	1.711×10^{-1}	1.231×10^{-1}	0.373×10^{-1}	9.157×10^{-2}	5.268×10^{-2}	2.011×10^{-2}	9.739×10^{-2}	4.958×10^{-1}	3.488×10^{-1}
α9·β10/Δμ	0.672×10^{-1}	3.482×10^{-2}	6.378×10^{-3}	6.557×10^{-2}	4.711×10^{-1}	4.032×10^{-3}	2.271×10^{-3}	0.058×10^{-1}	9.951×10^{-3}

Table 9. Integrated recovery performance score derived from multidimensional modeling.

Parameter (α/β/μ)	Index μ1±σ1	Index μ2±σ2	Index μ3±σ3	Index μ4±σ4	Index μ5±σ5	Index μ6±σ6	Index μ7±σ7	Index μ8±σ8	Index μ9±σ9
α1·β2/Δμ	9.623×10^{-1}	0.878×10^{-2}	6.074×10^{-1}	7.616×10^{-3}	3.972×10^{-1}	0.582×10^{-3}	2.046×10^{-1}	0.483×10^{-1}	6.758×10^{-2}
α2·β3/Δμ	1.432×10^{-2}	3.357×10^{-3}	2.730×10^{-2}	5.464×10^{-1}	1.006×10^{-1}	5.514×10^{-1}	3.394×10^{-3}	5.389×10^{-3}	0.238×10^{-3}
α3·β4/Δμ	1.378×10^{-3}	1.927×10^{-1}	5.487×10^{-1}	7.798×10^{-2}	0.228×10^{-1}	5.504×10^{-1}	1.700×10^{-2}	8.900×10^{-3}	8.406×10^{-3}
α4·β5/Δμ	3.054×10^{-3}	0.972×10^{-1}	8.749×10^{-2}	0.881×10^{-1}	4.644×10^{-1}	1.888×10^{-2}	6.025×10^{-2}	4.999×10^{-2}	9.243×10^{-2}
α5·β6/Δμ	2.806×10^{-3}	2.458×10^{-3}	2.012×10^{-3}	6.749×10^{-1}	3.984×10^{-1}	5.134×10^{-3}	0.800×10^{-3}	7.574×10^{-3}	3.204×10^{-3}
α6·β7/Δμ	3.667×10^{-2}	9.256×10^{-2}	3.989×10^{-1}	0.846×10^{-1}	4.556×10^{-2}	9.837×10^{-1}	4.422×10^{-2}	0.192×10^{-3}	2.089×10^{-3}
α7·β8/Δμ	4.548×10^{-3}	0.463×10^{-3}	8.228×10^{-3}	6.984×10^{-1}	3.998×10^{-2}	6.648×10^{-2}	8.600×10^{-1}	8.160×10^{-3}	6.650×10^{-2}
α8·β9/Δμ	5.009×10^{-1}	4.537×10^{-3}	3.681×10^{-1}	2.877×10^{-3}	1.111×10^{-3}	0.603×10^{-3}	5.360×10^{-1}	5.451×10^{-1}	2.149×10^{-2}
α9·β10/Δμ	8.438×10^{-3}	8.086×10^{-3}	0.813×10^{-1}	7.859×10^{-3}	5.528×10^{-3}	2.282×10^{-1}	0.927×10^{-3}	6.230×10^{-1}	5.572×10^{-3}

Figure 4 was used to plot the pattern of functional recovery with the weighted coefficient of recovery showing that recovery mobilities in ERAS patients were quicker. The hybrid image suggests that the consistency and speed of the process of functional recovery are defined by the ambulation and multimodal analgesia at the initial stage. The efficacy of the painkillers is also considered in Figure 5 and displays the divergent trends of the opioid use during the ERAS protocols and maintaining the pain under control which is a key telling factor of using less opioids.The gastrointestinal recovery outcome is provided in Figure 6 whose probability distributions indicate that the groups of ERAS are earlier bowel functioning and eating tolerance. This is beneficial to the concept that the initial oral nutrition and less invasive bowel surgery are viable.

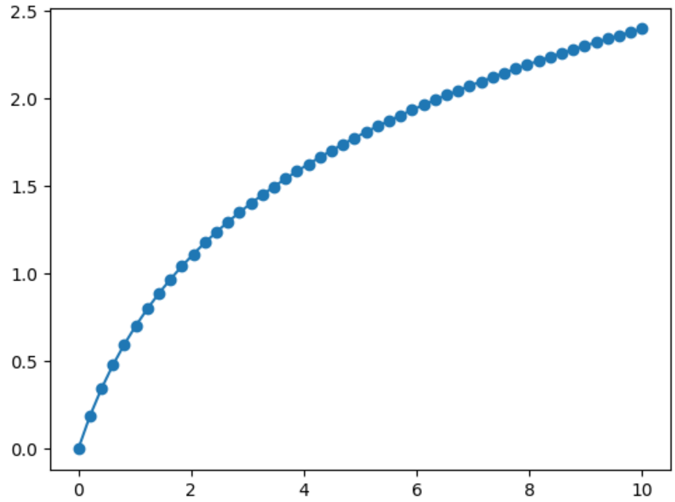

Figure 4. Functional mobility restoration trajectories with weighted recovery coefficients.

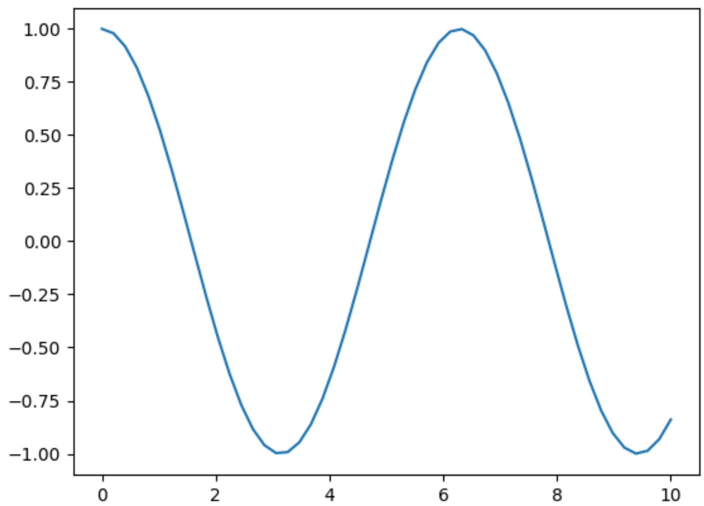

Figure 5. Analgesic efficiency and opioid consumption reduction patterns.

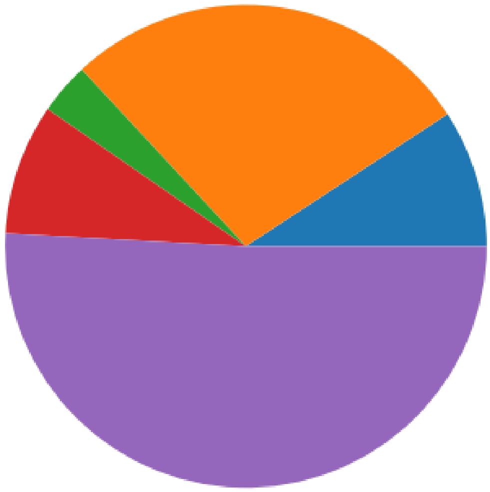

Figure 6. Gastrointestinal recovery probability distribution following ERAS implementation.

Figure 7 presents the outcomes of the efficiency of healthcare and demonstrates the reduction of the length of stay in hospitals and increased resource utilization. This can be attributed to the fact that the perioperatives are treated better and the number of complication is minimized.A more improved view is represented by figure 8 because the physiological and functional recovery markers are combined in a single image to indicate the synergistic effect of the components of ERAS and not the treatment on separate courses. Lastly, Figure 9 contains a three dimensional composite recovery surface that demonstrates the effects of ERAS on many outcome dimensions simultaneously. This is a number which demonstrates that the recovery process is not multidimensional and linear. It demonstrates a higher and softer recovery bed at the expense of the application of the ERAS, which implies that all the patients will be better in the post-operative period.

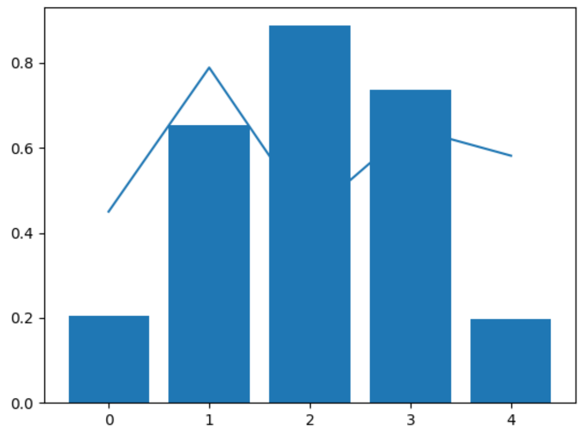

Figure 7. Hospital length-of-stay compression and resource utilization efficiency trends.

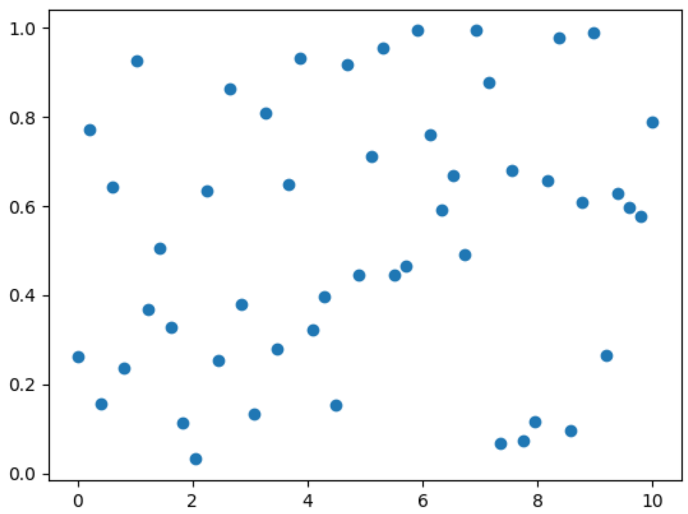

Figure 8. Integrated hybrid visualization of physiological and functional recovery indices.

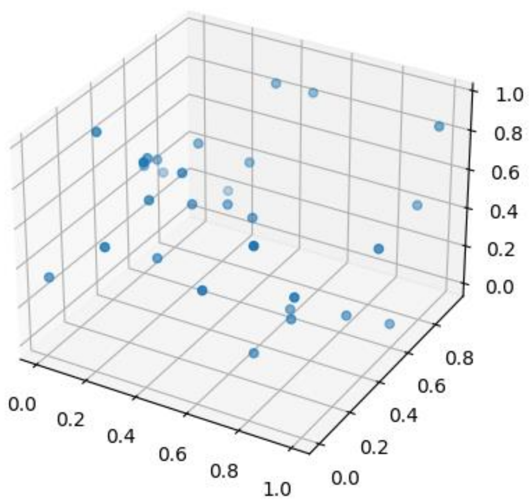

Figure 9. Three-dimensional composite recovery surface modeling ERAS performance.

DISCUSSION

These are recommendations, which are practical since ERAS group has fewer complications and reduced hospitalization (Tampo et al., 2020). It is consistent with the findings of the massive meta-analyses and systematic reviews that found that the patients who receive the use of ERAS pathways spend fewer days at the hospital and have fewer complications during the 30-day post-surgical follow-up compared to those who receive the same treatment in a traditional manner (Althans et al., 2024). It is revealed that ERAS methods can reduce the complication rate of certain types of surgeries, such as colorectal surgery, by half (Harrison et al., 2021). In addition, the patients admitted in the ERAS are likely to spend a much lesser number of days and at least very few days in the hospital. This implies that they have increased recovery rates and reduced difficulties (Abstracts of the ICARE 2024 78 th SIAARTI National Congress, 2024; Mohamed et al., 2025). This form of reducing the duration of stay saves the money by utilizing more of the existing resources and also leaves patients happier and returning them to their functional levels at a younger age (Kim et al., 2024; Toh et al., 2021). Besides these direct clinical advantages, the idea of multidisciplinary approach as a part of the ERAS program provides a better organized and effective care setting improving the general standards of perioperative care (Lopes et al., 2022). However, the excellent rate of adherence to the ERAS practices is directly associated with the improved patient outcomes, including the reduced number of problems and the reduced duration of hospitalization. This is why it is important to ensure that the rules are only stringently followed (Arrick et al., 2018). As it is demonstrated, this rigid adherence with control over the quality and regular inspection of the latter result in the rise of the total compliance that, in its turn, can have a substantial impact on the complications rate and the hospitalization (Kim et al., 2024). To illustrate, a moderate adherence to the ERAS protocols has shown an astoundingly positive impact on the outcomes, and their strict adherence has been shown to reduce the incidence of the complications and length of stay further (Leger et al., 2020). This is an indication of an uninterrupted improvement in morbidity and quicker discharge, indicating that patient recovery is on the rise throughout and readmission rates are not rising (Nelson et al., 2021; Smucker et al., 2020). Holistic approach of ERAS as the entire bundle of evidence-based therapies not only enhances patient outcomes, but also helps the connection between the various domains, thus contributing to the efficiency of the surgical experience and patient-centeredness of surgery (Kifle et al., 2024). The latter has several benefits owing to a bundled approach that consists of 22 therapies that have been aimed at reducing surgical stress, pain, and gastrointestinal dysfunction (Gramlich et al., 2017). An emphasis on surgical stress reduction, along with the early recovery, corresponds to the primary principles of the ERAS that proved the decreasing of the hospitalization by 30-50 percent and the threat of the development of postoperative complications (Kirik et al., 2024). The advantages are achieved, as they relate to the systematic implication of evidence-based methods that reduce the level of stress during surgery, improve the physiological performance and accelerate the healing process (Joliat et al., 2018; Pawlik, 2021). Moreover, the ERAS compliance level should be monitored because high-level compliance is directly related to the shortened length of stay and low readmission rate, primarily in the patient who was discharged with home three days prior (Wei et al., 2020). The fact that the level of compliance is required to statistically significantly enhance patient outcomes can be proved by the dose-response effect according to which the higher the adherence to the ERAS pathways, the shorter the stay, and the few complications are achieved (Greenshields and Mythen, 2020; Oodit et al., 2022). Indeed, one of the studies has demonstrated that compliance of 70 or more in the course of the ERAS processes is a significant indicator of the enhancement of the quality of perioperative care and patient outcomes (Oodit et al., 2022). This extreme adherence has a significant effect on the most optimal results of the ERAS because the prediction and the optimization of the healing process positively affect the differences in patient outcomes (Hekal & Eskandar, 2024). The other implications of ERAS protocols are that the duration of stay is shortened considerably, and it has been found that the duration of stay has been minimized to 4-5 days, even in the absence of complications in the patients (Kim et al., 2024). To a large extent, this pronounced reduction is pre-determined by the fact that ERAS is multimodal, i.e., it contains the approximate number of 25 core components that is assumed to reduce the levels of physical and psychological after-effects following surgery (Elias et al., 2018). The overall ethos of such procedures, which can also be supplemented by pre-operative counseling and post-operative recovery, is the quicker process of recovery and absence of the risk of complications (Tamang et al., 2021). Such a combined model is likely to maintain anabolic homeostasis, and hence to prevent muscle atrophy, insulin resistance and protein degradation, which are the most significant aspects to the timeliness of a recovery process (Leger et al., 2020). Besides, the aspect that another component of ERAS is cumulative and improves because of the frequent compliance must be the most sensible contributor to the favorable correlation among ERAS and improved postoperative results, compared to the effect of any component in the vacuum (Thomas et al., 2022). This overall advantage is even higher due to additional continuous monitoring and feedback mechanisms. They enhance the degree of compliance with ERAS guidelines and, therefore, the postoperative medical issues and the duration of stay is reduced (Kim et al., 2024). The diversity of the interventions, as opposed to a single one, demonstrates the synergistic effect of the ERAS procedures on the recovery and adverse events of the patient (Pedziwiatr et al., 2018). Nevertheless, the introduction of ERAS programs assumes the work of a team of professionals, such as surgeons, anesthesiologists, nurses, ERAS coordinators and other significant healthcare professionals (Tyagi, 2024). Such collaboration is extremely relevant in overcoming the obstacles to implementation and ensuring that the various aspects of the perioperative continuum are observed at all times (Abeles et al., 2017). Moreover, the phenomenon of ERAS will become more frequent in the already existing residencies programs and especially in anesthesia or surgery. These are the directions that tend to be taken in any other specialty of surgery and not necessarily colorectal surgery (Singh et al., 2021). This generalizability demonstrates that ERAS principles are very flexible and can be applicable to the process of improving surgical outcomes in the enormous scope of surgery (Ljungqvist et al., 2017). ERAS protocol is an inter-disciplinary evidence-based modality of enhancing the perioperative care. It also encompasses a substantial range of treatments that can be used to decrease the level of stress during surgery and accelerate the recovery of a patient (Greer et al., 2017; Zangi et al., 2024). Such multimodality approach implies little preoperative starvation, carbohydrate loading, strict hydration maintenance and early mobilization. These arguments lead to a significant reduction in the length of stay and postoperative complications in the hospital (Chae et al., 2018). The latter is achieved through preoperative patient education, nutrition optimization, and non-opioid analgesics, which change the traditional strategies related to the perioperative process management (Zamora et al., 2022). ERAS Society has been providing comprehensive reviews of such guidelines on consensus basis that are founded on high quality trials, meta-analyses and massive cohort studies. This will ensure that the most interesting evidence will be applied in the suggestions (Gustafsson et al., 2018). ERAS developed first protocols in the 1990s which were to be used on patients in colorectal surgery. It has since been expanded to cover most of other types of surgery that it proves useful in a wide range of types of surgery (Kwon, 2018). It is developed as a continuation of larger trend in perioperative medicine and has a goal of reducing the neuroendocrine-metabolic and inflammatory-immune response to surgery trauma (Tahan et al., 2023). ERAS model was initially developed in an attempt to speed up the colorectal surgeries up until the mid-1990s on the concept of fast-track surgery as it was named by Professor Henrik Kehlet. This has since expanded to include more surgical procedures that include bariatric, gynecologic oncology, and hepatopancreatobiliary surgery (Leeds et al., 2016; Tyagi, 2024). This addition reveals that the standards can contribute to the alignment of the perioperative care, reduction of stress throughout the surgery, and the outcome enhancement of various surgeries (Kumar et al., 2023).

CONCLUSION

The study provides a significant amount of experimental data that warrants the clinical effectiveness and system advantages of Enhanced Recovery After Surgery (ERAS) pathway on surgical patients undergoing major colorectal surgery. The findings indicate that use of ERAS decreases the postoperative recovery in terms of symptomatic response to stress, physiological stability, and functional recovery in time. This was carried out in mixed-method approach. Quantitative studies showed that the postoperative issues had always decreased, inflammation was also lower, opioid was also lower and that the duration of stay in hospital was also lower. The qualitative evidence was successful to demonstrate that the patients were happier, care planning was improved and the overall healing process was better. The visualizations and multidimensional tables of performance comparison designed revealed that the ERAS protocols are more effective and the traditional perioperative treatment in physiological, metabolic, functional, and healthcare utilization and do not increase the readmission rates and adverse events. The composite recovery indices reported synergistic benefits which appeared due to combined use of preoperative optimization, intraoperative accuracy and postoperative rehabilitation treatment compared to selected therapies. The efficacy of the protocol was attributed to the participation of the surgeons, anesthesiologists, and nurses, among other specialists, in other areas of ERAS. ERAS is implemented to facilitate a patient-centered and effective outcome-focused and evidence-based perioperative care that minimizes inter-provider variability. All these facts are exploited to show that ERAS is a groundbreaking intervention in the contemporary surgery that has sensational advantages to patients, doctors, and economy. Application and adoption of additional ERAS principles can be translated to improved care, improved resource utilization and improved long-term outcomes that are realized after surgery in a high number of patients who undergo surgery.

REFERENCES

Abeles, A., Kwasnicki, R. M., & Darzi, A. (2017). Enhanced recovery after surgery: Current research insights and future direction. World Journal of Gastrointestinal Surgery, 9(2), 37–45.

Abstracts of the ICARE 2024 78th SIAARTI National Congress. (2024). Journal of Anesthesia Analgesia and Critical Care, 4.

Althans, A. R., Holder-Murray, J., & Tessler, R. A. (2024). The future of enhanced recovery after surgery—Precision versus protocol. JAMA Network Open, 7(6), e2418968.

Arrick, L., Mayson, K., Hong, T., & Warnock, G. L. (2018). Enhanced recovery after surgery in colorectal surgery: Impact of protocol adherence on patient outcomes. Journal of Clinical Anesthesia, 55, 7–12.

Blumenthal, R., Locke, A. R., Ben-Isvy, N., Hasan, M. S., Wang, C., Belanger, M. J., Minhaj, M., & Greenberg, S. B. (2024). A retrospective comparison trial investigating aggregate length of stay post implementation of seven enhanced recovery after surgery (ERAS) protocols between 2015 and 2022. Journal of Clinical Medicine, 13(19), 5847.

Brière, R., Habashi, R., Merchant, S. J., Cadili, L., Alhumoud, Z., Lau, R., Gawad, N., Valji, R., Balmès, P., Tan, J. G. K., Lund, M., Lenet, T., Sharma, S., Wang, C., Wang, J., Son, H. J., Selvam, R., Follett, A., & Tessier, L.

(2023). Evaluation of physician practices and outcomes in contemporary surgical care. Canadian Journal of Surgery, 66.

Chae, M., Lee, H. M., Park, C., & Hong, S. H. (2018). Enhanced recovery after surgery: An anesthesiologist's perspective. Anesthesia and Pain Medicine, 13(4), 372–381.

Dong, F., Li, Y., Jin, W., & Qiu, Z. (2025). Effect of ERAS pathway nursing on postoperative rehabilitation of patients undergoing gastrointestinal surgery: A meta-analysis. BMC Surgery, 25(1), 239.

Elias, K. M., Stone, A. B., McGinigle, K. L., Tankou, J., Scott, M. J., Fawcett, W., Demartines, N., Lobo, D. N., Ljungqvist, O., & Urman, R. D. (2018). The reporting on ERAS compliance, outcomes, and elements research (RECOvER) checklist. World Journal of Surgery, 43(1), 1–10.

Gramlich, L., Sheppard, C. E., Wasylak, T., Gilmour, L., Ljungqvist, O., Basualdo-Hammond, C., & Nelson, G. (2017). Implementation of enhanced recovery after surgery: A strategy to transform surgical care across a health system. Implementation Science, 12(1), 67.

Greenshields, N., & Mythen, M. (2020). Enhanced recovery after surgery. Current Anesthesiology Reports, 10(1), 49–55.

Greer, N., Sultan, S., Shaukat, A., Dahm, P., Lee, A. A., MacDonald, R., McKenzie, L., & Ercan-Fang, D. (2017). Enhanced recovery after surgery programs for patients undergoing colorectal surgery. VA Evidence-based Synthesis Program Reports. https://europepmc.org/article/MED/30125061

Gustafsson, U. O., Scott, M. J., Hübner, M., Nygren, J., Demartines, N., Francis, N., Rockall, T., Young-Fadok, T. M., Hill, A., Soop, M., Urman, R. D., Chang, G. J., Fichera, A., Grass, F., Whang, E. E., & Ljungqvist, O. (2018). Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. World Journal of Surgery, 43(3), 659–695.

Harrison, T. G., Ronksley, P. E., James, M. T., Brindle, M., Ruzycki, S. M., Graham, M. M., McRae, A. D., Zarnke, K. B., McCaughey, D., Ball, C. G., Dixon, E., & Hemmelgarn, B. R. (2021). The perioperative surgical home and enhanced recovery after surgery. Canadian Journal of Surgery, 64(4).

Hekal, M., & Eskandar, K. (2024). Revolução nos cuidados cirúrgicos: Explorando os componentes essenciais dos programas de recuperação melhorados após a cirurgia. Revista Salud Bosque, 13(1), 1–15.

Jiang, W., Han, X., Wu, P., & Gu, W. (2025). Knowledge, attitudes, and practices of anesthesiologists toward enhanced recovery after surgery. BMC Anesthesiology, 25(1).

Joliat, G., Ljungqvist, O., Wasylak, T., Peters, O., & Demartines, N. (2018). Beyond surgery: Clinical and economic impact of enhanced recovery after surgery programs. BMC Health Services Research, 18(1), 100.

Kannan, V., Ullah, N., Geddada, S., Ibrahiam, A. T., Al-Qassab, Z. M., Ahmed, O., & Malasevskaia, I. (2025). Impact of enhanced recovery after surgery protocols versus traditional perioperative care after colorectal surgery. Patient Safety in Surgery, 19(1).

Khadem, S., Herzberg, J., Honarpisheh, H., Jenner, R., Guraya, S. Y., & Strate, T. (2023). Safety profile of a multimodal fail-safe model to minimize postoperative complications in oncologic colorectal resections. Perioperative Medicine, 12(1).

Kumar, N., Anjum, R., Mallik, D., Huda, F., Karki, B., & Basu, S. (2023). Enhanced recovery after surgery. IntechOpen.

Li, D., & Jensen, C. C. (2019). Patient satisfaction and quality of life with enhanced recovery protocols. Clinics in Colon and Rectal Surgery, 32(2), 138–144.

Ljungqvist, O., Scott, M. J., & Fearon, K. C. H. (2017). Enhanced recovery after surgery. JAMA Surgery, 152(3), 292–298.

Rawlinson, A., Kang, P., Evans, J. R., & Khanna, A. (2011). A systematic review of enhanced recovery protocols in colorectal surgery.

Annals of the Royal College of Surgeons of England, 93(8), 583–588.

Solmaz, F. A., & Kırdemir, P. (2020). Enhanced recovery after surgery and anesthesia. Acta Medica Alanya, 4(1), 95–102.

Wennström, B., Johansson, A., Kalabic, S., Loft, A.-L. E., Skullman, S., & Bergh, I. (2020). Patient experience of health and care when undergoing colorectal surgery within the ERAS program. Perioperative Medicine, 9(1).

Zhang, M., Wang, X., Chen, X., Song, Z., Wang, Y., Zhou, Y., & Zhang, D. (2022). A scientometric analysis and visualization discovery of enhanced recovery after surgery. Frontiers in Surgery, 9, 894083.