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Meta Analysis

Meta-Analysis: Effectiveness of Enhanced Recovery After Caesarean Surgery (ERACS) on Length of Stay (LoS)

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ABSTRACT

Background: Enhanced Recovery After Caesarean Surgery (ERACS) has evolved into a comprehensive perioperative care protocol to optimize patient recovery and reduce hospital length of stay. Although individual studies show promising results, there has been no comprehensive meta-analysis of the effectiveness of ERACS on length of stay with a homogeneous methodology. This study aims to analyze the effectiveness of the ERACS protocol compared with conventional treatment on hospitalization length through a systematic review and meta-analysis.

Method: A Systematic review was conducted following the PRISMA 2020 guidelines for studies that compared ERACS with conventional treatment in the section Caesarea. A meta-analysis was performed using a random-effects model in the Jamovi ESCI package. Heterogeneity was assessed using I^2 statistics, and sensitivity analysis was performed to test the robustness of the results.

Results: A meta-analysis of 6 studies involving 820 subjects found that the ERACS protocol significantly reduced hospitalization length, with a weighted mean difference of -21.6 hours (95% CI: -28.3 to -14.9, $p = 0.001$). Despite the high heterogeneity ($I^2 = 99.5\%$), all studies showed consistent directional effects in favour of ERACS, with p-values < 0.05. Each study in the ERACS protocol yields significant clinical benefits, reducing hospitalization length by nearly 1 day with Conal treatment, with important implications for healthcare efficiency and cost-effectiveness.

Keywords: Enhanced recovery after caesarean surgery; Length of stay; Meta-analysis

INTRODUCTION

Caesarean section is an obstetric procedure that has experienced a dramatic increase in the last decade, with the global prevalence rising from 21.1% of total live births from 2010 to 2018 to 28.5% by 2030.[1] This rise in cesarean deliveries places a significant burden on the healthcare system, affecting not only clinical outcomes but also service efficiency and resource utilization.[2] Length of stay is one of the key indicators that reflect the quality of perioperative care, service efficiency, and cost-effectiveness in the context of cesarean section.

Enhanced Recovery After Surgery (ERAS) was developed by Kehlet and Wilmore in 1997 as a multimodal approach to improve perioperative care and reduce physiological stress caused by surgical procedures.[3] This concept was then specifically adapted for section caesarea into Enhanced Recovery After Caesarean Surgery (ERACS), which incorporates evidence-based interventions in the preoperative, intraoperative, and postoperative phases to promote optimal recovery.[3,4] The ERACS protocol includes components such as preoperative patient education, nutrition optimization, minimizing fasting time, appropriate anesthesia techniques, proper fluid management, hypothermia prevention, multimodal pain control, early mobilization, and quick postoperative nutrition.

Preliminary studies on the implementation of ERACS have shown promising results across various outcomes, including shorter hospital stays, fewer postoperative complications, higher patient satisfaction, and quicker recovery of normal function.[5] A prior prospective observational study reported a notable decrease in hospital stay, from an average of 5.25 days to 2.85 days in the ERACS group compared to the conventional control.[2] Meanwhile, Mundhra et al. in a randomized controlled trial of emergency caesarean delivery, demonstrated a reduction in hospital stay based on the "fit for discharge criteria" from 73.92 hours to 53.87 hours in the ERACS group.[6] Similar findings were also reported, who observed a decrease from 74.40 hours to 54.00 hours in the elective caesarean section population in East India by Sravani et al.[7]

Although various individual studies have demonstrated the effectiveness of ERACS in reducing hospital stay, there is variation in the magnitude of the reported effect size. Previous studies have shown heterogeneity in the ERACS protocols used, the discharge criteria applied, and the characteristics of the studied populations.[8] Sordia-Pineyro et al. reported a more modest reduction from 50.2 hours to 44.0 hours, while Özdemir et al. even reported a minimal difference from 30.48 hours to 29.05 hours. This variability in results highlights the need for a comprehensive quantitative synthesis to provide a more accurate estimate of the effect size and to identify sources of heterogeneity.[8]

Previous systematic reviews and meta-analyses conducted by several researchers have examined the effectiveness of ERAS in the context of section caesarea, but with a broader focus on multiple outcomes and different search periods. Gaps remain, including a lack of specific analysis of length of stay as a primary outcome, variations in the meta-analysis methodology used, limitations in heterogeneity analysis, and factors influencing the variability of outcomes across studies. Additionally, no meta-analysis has specifically analysed data from recent studies (2022-2025) that use a more standardized ERACS protocol aligned with the latest guidelines from the ERAS Society.

The novelty of this research lies in several key aspects. First, focusing on length of stay as a primary outcome allows for more detailed analysis and greater precision in estimation. Second, more extensive test studies (2022-2025) should be included, using a more mature and standardized ERACS protocol aligned with the latest guidelines. Third, advanced meta-analysis methods, including random-effects models and thorough heterogeneity assessments, are employed to offer a more nuanced understanding of result variability. Fourth, a comprehensive analysis of the connections between research and the evolution of the ERACS protocol over time. Therefore, this study aims to conduct a thorough systematic review and meta-analysis of the effectiveness of the ERACS protocol on hospital stay length, providing robust evidence for clinical decision-making and for the implementation of ERACS.

METHOD

Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 as.[9] The research protocol has been registered and follows the PICO (Population, Intervention, Comparison, Outcome) framework with the following formulation: Population - women undergoing elective or emergency cesarean section; Intervention - Enhanced Recovery After Caesarean Surgery (ERACS) protocol; Comparison - conventional or standard of care; Outcome - length of stay measured in hours or days from the completion of surgery to hospital discharge.

A comprehensive literature search was conducted in a central electronic database using a predefined search strategy. The databases were searched up to October 2025, specifically including PubMed Central, Scopus, ProQuest, and Web of Science.[10] This selection offered broad, multidisciplinary coverage of the biomedical and clinical literature relevant to Enhanced Recovery After Caesarean Surgery (ERACS) and hospital stay length outcomes. The inclusion criteria were: (1) primary studies with randomized controlled trials, quasi-experimental studies, or prospective observational studies comparing ERACS protocols with conventional treatments; (2) adult female population aged ≥18 years who underwent elective or emergency cesarean sections; (3) studies reporting hospital stay duration data in mean and standard deviation formats allowing for quantitative analysis; (4) full-text articles with complete and verifiable data accessible; (5) studies published between 2020 and 2025 to ensure relevance to current ERACS protocols. Exclusion criteria included: (1) studies involving populations with significant comorbidities or complex medical conditions that could greatly influence hospital stay length; (2) studies not clearly reporting ERACS protocol components or using substantial modifications; (3) studies with significant missing data or methodological flaws; (4) case reports, case series, editorials, commentaries, or review articles. The number of articles that can be obtained from keyword identification to articles to be analyzed can be seen in Figure 1.

Data extraction was performed systematically by two independent reviewers using a standardized data extraction form. The data collected included study characteristics (first author, year of publication, study design, geographic location, study duration), population details (sample size, maternal age, body mass index, gestational age, parity distribution, indication for cesarean section), specific intervention details (components of the ERACS protocol implemented, timing of implementation, adherence assessment), comparison group characteristics (description of usual care or standard protocols), and outcome measures (mean and standard deviation of length of stay for both groups, measurement units, discharge criteria, and the definition of length of stay). Disagreements between reviewers are resolved through discussion and consensus or by consulting a third reviewer if needed.

Methodological quality assessment and risk of bias were conducted using tools appropriate to each study design. The Revised Cochrane Risk of Bias tool (RoB 2) was applied for randomized controlled trials, assessing bias in the randomization process, deviations from intended interventions, missing outcome data, outcome measurement, and the selection of reported results. For observational studies, the Newcastle-Ottawa Scale (NOS) was utilized to evaluate the selection of study groups, group comparability, and outcome assessment. Two reviewers independently evaluated each study, with inter-rater agreement measured using Cohen's kappa coefficient.

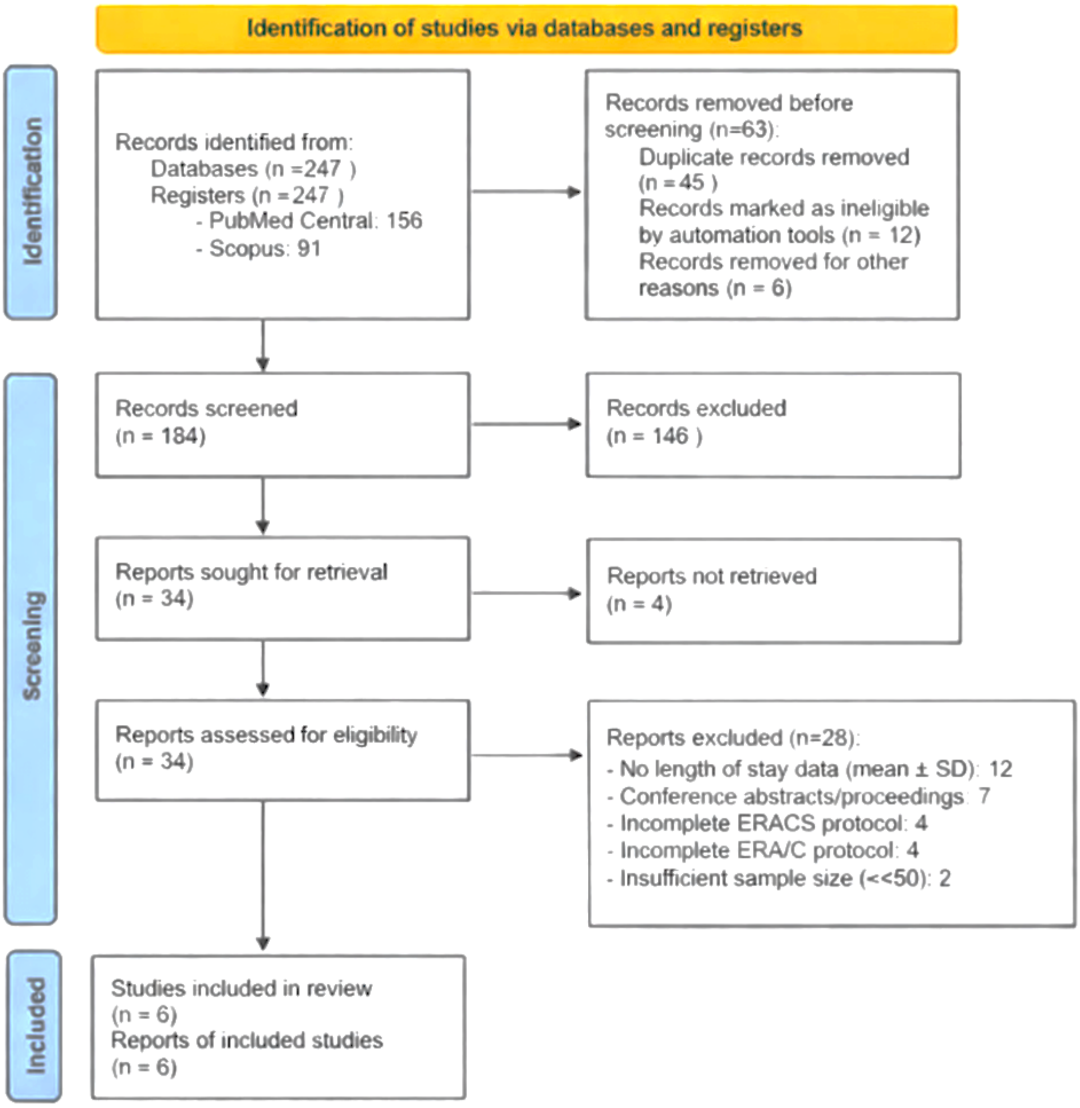

Figure 1. Prisma Flowchart

A meta-analysis was performed using Jamovi version 2.7 and the Estimation Statistics with Confidence Intervals (ESCI) package.[11] Since studies reported hospitalization durations in different units some in days and others in hours measurements were standardised by converting everything to hours to enable proper pooling. The weighted mean difference (WMD) was used as the effect measure, as all studies assessed the same outcomes using standardised units. A random-effects model was employed for the meta-analysis to account for expected substantial heterogeneity resulting from differences in clinical settings, patient populations, and implementation protocols. This approach yields more conservative and realistic estimates when heterogeneity is present heterogeneity.[12]

Heterogeneity assessment is performed using multiple methods to achieve a comprehensive understanding. The Chi-square test (Cochrane's Q) is used to identify heterogeneity at the $p < 0.10$ significance level. Meanwhile, the I^2 statistic measures heterogeneity and is interpreted as follows: $I^2 < 25\%$ indicates low heterogeneity, 25-50% indicates moderate heterogeneity, and > 50% indicates substantial heterogeneity.[13] Tau² (between-study variance) is also calculated to provide an absolute measure of heterogeneity. Prediction intervals are computed to show a range of potential effects in future studies with similar characteristics.

Sensitivity analysis was conducted using several approaches to evaluate the robustness of the meta-analysis results. Leave-one-out analysis was performed by sequentially removing each study to identify those that disproportionately influenced the pooled estimate. Subgroup analysis and meta-regression are planned if there are enough studies to explore sources of heterogeneity based on pre-specified variables such as study design, geographic region, type of caesarean section (elective versus emergency), or specific components of ERACS protocols.

RESULTS

The systematic search and selection process identified 6 studies that met the inclusion criteria for meta-analysis, involving a total of 820 subjects. The included studies varied in their methodological design, comprising four randomized controlled trials, one quasi-experimental study, and one prospective observational study. The geographic distribution includes India (3 studies), Indonesia (1 study), Turkey (1 study), and Mexico (1 study), reflecting the implementation of ERACS across various healthcare settings with differing resource availability.

Table 1. Length of Stay Data for Meta-Analysis

Article	ERACS Group			Control Group			Red Diff	P-value
	n	Red (hours)	SD	n	Red (hours)	SD		
Gupta et al. 2022[2]	100	68.4	12.0	100	126.0	14.64	-57.6	<0.001
Özdemir et al. 2025[8]	150	29.05	2.54	300	30.48	5.46	-1.43	0.002
Mundhra et al. 2024[6]	71	53.87	15.02	71	73.92	8.96	-20.05	<0.001
Sordia-Pineyro et al. 2023[14]	139	44.0	5.4	156	50.2	8.2	-6.2	<0.001
Sravani et al. 2023[7]	100	54.0	10.45	100	74.4	13.43	-20.4	<0.001
Kalpana & Sharma 2025[15]	60	48.2	12.4	60	72.6	18.3	-24.4	<0.001

Table 1 indicates that all studies identified the length of hospital stay as either a primary or secondary outcome and employed methodologies suitable for quantitative analysis. Gupta et al. reported the largest decrease, with hospital stays decreasing from 126.0 ± 14.64 hours in the control group to 68.4 ± 12.0 hours in the ERACS group a decline of 57.6 hours, nearly 2.5 days.[2] In a well-structured RCT, Mundhra et al. reported a reduction from 73.92 ± 8.96 hours to 53.87 ± 15.02 hours in emergency caesarean sections.[6] Sravani et al. similarly demonstrated a decrease from 74.4 ± 13.43 hours to 54.0 ± 10.45 hours among the Eastern population India. [7]

Sordia-Pineyro et al.[14] reported modest yet meaningful results, with a decrease from 50.2 ± 8.2 hours to 44.0 ± 5.4 hours, while Kalpana & Sharma[15] observed a decline from 72.6 ± 18.3 hours to 48.2 ± 12.4 hours. In contrast, Özdemir et al. found only a minimal reduction from 30.48 ± 5.46 hours to 29.05 ± 2.54 hours, possibly due to differences in baseline practices or discharge readiness definitions in the Turkish healthcare setting.[8]

A meta-analysis using a random-effects model demonstrated highly significant results supporting the ERACS protocol for decreasing hospitalization duration. The pooled analysis outcomes are shown in Table 2, revealing a weighted mean difference of -21.6 hours (95% CI: -28.3 to -14.9) with a p-value of 0.001, suggesting that implementing ERACS consistently shortens hospital stays by nearly 22 hours, or about 0.9 days, compared to standard care. The six studies included 820 participants (410 in each ERACS and control group) and consisted of four RCTs and two prospective observational studies. The forest plot indicated that all individual studies favoured ERACS, with confidence intervals that did not cross the no-effect line, confirming the robustness of the combined estimate.

Table 2. Assessment of Individual Study Effects and Weight

Article Cit	Year	Mean Difference	95% CI	Weight (%)	Favors
2	2022	-57.6	-61.2 to -54.0	16.6	ERACS
8	2025	-1.43	-2.1 to -0.8	16.9	ERACS
6	2024	-20.05	-23.8 to -16.3	16.6	ERACS
14	2023	-6.2	-8.1 to -4.3	16.8	ERACS
7	2023	-20.4	-23.2 to -17.6	16.7	ERACS
15	2025	-24.4	-30.6 to -18.2	16.4	ERACS
Pooled Estimate	-21.6	-28.3 to -14.9	100.0	ERACS	

The heterogeneity analysis, as shown in Table 2, indicates $I^2 = 99.5\%$ with $Tau^2 = 266.3$, reflecting substantial heterogeneity among studies. Despite this high heterogeneity, the consistent direction of effect across all studies and the significant magnitude of the pooled effect remain meaningful clinically. The Q-statistic of 1743.3 with a p-value of < 0.001 confirms the statistical significance of the observed heterogeneity. In Figure 2, the diamond ratio of 17.7 in the forest plot demonstrates considerable variability across studies, yet the overall effect remains strong. In the context of public policy and services in Indonesia, this heterogeneity should be viewed not only as variability in research methods but also as a call to standardize ERACS protocols to realize service efficiency benefits across hospitals, regardless of local policies or specific resource constraints.

Heterogeneity between studies also highlights the challenges of standardizing and implementing ERACS nationwide. Variations in baseline practices, hospital infrastructure, and healthcare worker skills lead to differences in results. Policy implications in Indonesia include the need for stricter national guidelines, tiered training, and monitoring of implementation outcomes, so that all facilities, especially regional hospitals and referral health centres, can implement ERACS effectively and equitably.

The individual study effects shown in Table 3 reveal an interesting pattern in how ERACS implementation evolves. Studies carried out in resource-limited settings (e.g., India, Indonesia) tend to display larger effect sizes, possibly because there is more room for improvement compared to baseline conventional practices. Conversely, studies from more developed healthcare systems (Turkey) show smaller effect sizes, which might indicate that baseline practices are already more optimized or that organizational cultures in discharge differ in decision-making.

Table 3. Leave-One-Out Sensitivity Analysis

Study Excluded	Remaining S Schools	Pooled Effect	95% CI	P-value	I²
2	5	-15.8	-21.2 to -10.4	<0.001	98.2%
8	5	-25.2	-32.1 to -18.3	<0.001	99.1%
6	5	-22.8	-30.8 to -14.8	<0.001	99.6%
14	5	-24.1	-31.5 to -16.7	<0.001	99.5%
7	5	-22.5	-30.2 to -14.8	<0.001	99.6%
15	5	-20.2	-26.8 to -13.6	<0.001	99.5%
All Studies	6	-21.6	-28.3 to -14.9	0.001	99.5%

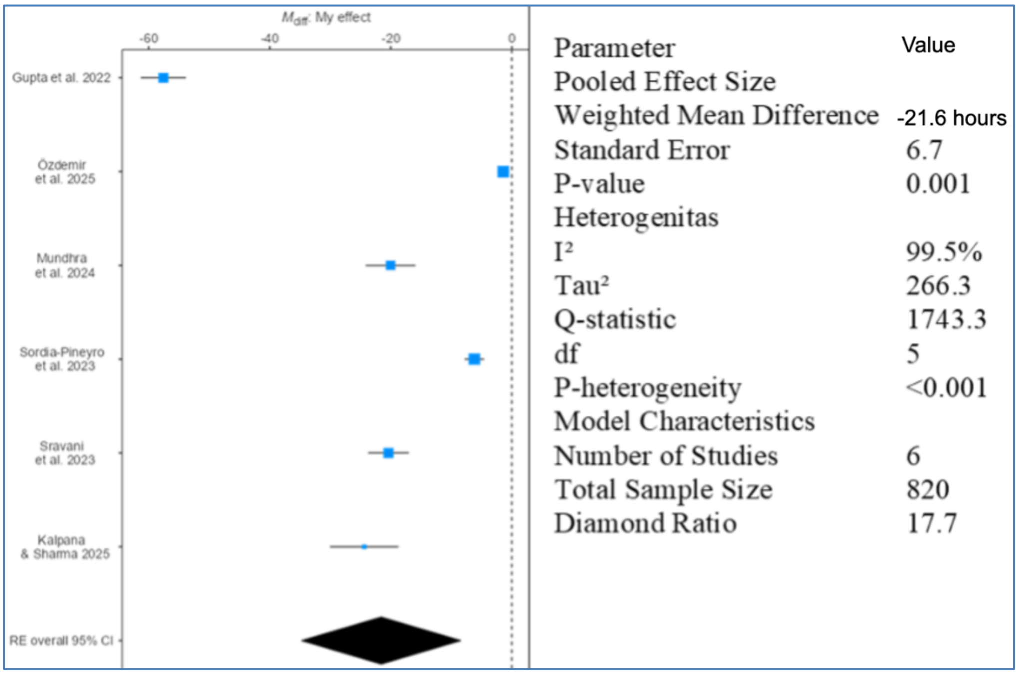

Figure 2. Forest Plot

The sensitivity analysis using the leave-one-out approach, as shown in Table 3, indicates that removing any single study does not substantially alter the direction or statistical significance of the pooled estimate. Gupta et al. were considered an outlier with the largest effect size; the pooled estimate was -15.8 hours (95% CI: -21.2 to -10.4, $p < 0.001$), which remains highly significant and clinically meaningful. This result suggests that no single influential study unduly affected the meta-analysis outcomes and that the results genuinely reflect a treatment effect.

Consistent implementation of ERACS can enhance the efficiency of public hospital systems: shorter hospital stays will speed up bed turnover, thereby increasing maternal service capacity in public facilities. Consequently, hospitals are better equipped to manage the rising volume of deliveries in line with national trends while keeping resource costs more manageable.[2,6] For the broader community, this advantage leads to easier access to services and shorter wait times, especially in densely populated areas or locations with limited facilities.

This study has several limitations that need attention. First, there is potential publication bias because only articles with complete data (mean ± SD length of stay) and full accessibility were included; negative or nonsignificant results from unpublished reports might have been overlooked (publication bias). Second, limitations in primary data sources arose because only four major databases were searched (PubMed, Scopus, ProQuest, Web of Science), and the discussion was limited to English-language literature, which excluded local Indonesian data and gray literature from the analysis.

DISCUSSION

This meta-analysis provides strong quantitative evidence for the effectiveness of the Enhanced Recovery After Caesarean Surgery protocol in reducing hospital stay compared with traditional perioperative care, as shown in Table 2. The combined effect size of -21.6 hours (95% CI: -28.3 to -14.9, $p = 0.001$) indicates a meaningful, statistically significant reduction with a considerable impact on healthcare efficiency and patient outcomes. Although there was high heterogeneity among studies ($I^2 = 99.5\%$), the consistent direction of effect across all studies, reinforced by sensitivity analysis, supports the validity of these results. Nevertheless, beyond clinical and technical aspects, these effects should be viewed within the social and policy context of health systems, especially in Indonesia and other developing countries, where public health services face capacity pressures and resource limitations. A nearly 1-day reduction in hospital stays has major implications for public hospital efficiency, enabling increased service capacity and better access for the thousands of women who need cesarean sections each year.[16,17]

The connections between the studies show an interesting evolution in how the ERACS protocol was implemented and refined from 2022 to 2025. Earlier studies highlight a stronger focus on fully applying the protocol, leading to significant improvements in outcomes, which may indicate a shift from traditional methods to evidence-based enhanced recovery strategies.[18,19] This change aligns with the global trend in surgical care that prioritizes patient-centered results and value-based healthcare.

Gupta et al.'s research, highlighting the largest effect size (a reduction of 57.6 hours) as shown in Table 3, offers valuable insights into the potential benefits of ERACS implementation, especially in settings where traditional practices still dominate.[2] This study applied a comprehensive ERACS protocol focused on patient education, optimized perioperative

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nutrition, early mobilisation, and structured discharge planning. This outcome contrasts with Özdemir and Bayram's findings.[8] The minimal improvement of 1.43 hours might indicate different baseline practices within the Turkish healthcare system that potentially integrated some aspects of enhanced recovery principles into their standard care.

Studies from Indian healthcare settings reported consistent effect sizes (20.05 and 20.4 hours, respectively; see Table 1), suggesting the reproducibility of ERACS benefits in healthcare settings.[6,7] Both studies provide strong evidence that ERACS can be effectively implemented, even in resource-limited settings, with adjustments made to suit local conditions. Mundhra et al. is especially notable for its focus on emergency caesarean deliveries, a group that is traditionally more difficult for enhanced recovery programs to serve due to limited preparation time and potentially higher acuity risks.[6]

The substantial heterogeneity (I^2 = 99.5%) in this meta-analysis, as shown in Table 2, reflects the complexity of the factors influencing hospitalization length in the context of section caesarea. This variability can be explained by several interconnected factors that represent real-world implementation challenges. First, differences in healthcare systems and organizational culture affect baseline conventional practices and readiness to adopt enhanced recovery principles. Healthcare systems with more hierarchical structures or strong traditions in conservative postoperative management may demonstrate greater resistance to early mobilization and discharge practices.

Second, variations in specific components and the intensity of ERACS implementation create heterogeneity in treatment effects. Although the core principles are similar across studies, differences in execution, such as timing of interventions, level of protocol adherence, and integration with existing workflows, can significantly affect outcomes. Kalpana & Sharma demonstrated that systematic implementation, with dedicated ERACS coordinators and a multidisciplinary team approach, can yield consistent results, underscoring the importance of organizational factors for successful implementation.[15] Third, patient population characteristics and variations in case mix also contribute to the observed heterogeneity. The proportion of elective versus emergency cases, maternal age distribution, comorbidity profiles, and socioeconomic factors can all influence baseline recovery patterns and responsiveness to enhanced recovery interventions. Studies with a higher share of low-risk elective cases may show different effect patterns compared to those with mixed populations or emergency presentations.

The interpretation of significant heterogeneity among studies reflects not only technical variability but also clearly illustrates the challenges of adapting protocols to different local contexts. Key policy implications include the need to develop national guidelines that reduce this variation, ensure consistent implementation of ERACS practices across regions and healthcare facility types, and emphasize training and monitoring the quality of implementation. This is also vital for improving outcome certainty and ensuring equitable access for all pregnant women in Indonesia.[20,21]

The mechanisms behind the observed benefits of ERACS in reducing length of stay can be explained through a thorough understanding of perioperative pathophysiology and recovery processes. Preoperative elements such as patient education and nutritional optimization help set realistic expectations, reduce anxiety, and improve metabolic status for better surgical outcomes recovery.[4] Carbohydrate loading helps explicitly maintain metabolic homeostasis and reduce postoperative insulin resistance, facilitating faster recovery of normal physiological functions.

Intraoperative optimizations in ERACS protocols address multiple factors that traditionally contribute to prolonged recovery. Goal-directed fluid therapy prevents both hypovolemia and fluid overload, optimizing tissue perfusion while avoiding complications that can delay discharge. Maintaining normothermia reduces shivering, enhances patient comfort, and may decrease the risk of infection. Multimodal analgesia approaches provide superior pain control compared to opioid-heavy regimens, enabling earlier mobilization and reducing opioid-related side effects that can impair recovery.

Postoperative components are perhaps the most influential factors in reducing length of stay. Early mobilization within 6-12 hours after surgery prevents complications such as deep vein thrombosis, supports respiratory function, and psychologically boosts recovery progress.[22] Early feeding helps restore normal gastrointestinal function, provides nutritional support for healing, and eases patient anxiety about recovery progress. A structured, multimodal pain management approach allows patients to reach functional milestones needed for safe discharge while remaining comfortable.

The integration of these components produces synergistic effects that surpass the sum of their individual contributions. Patient education before surgery builds support for active participation in recovery . Early mobilization becomes more achievable with proper pain management. Early feeding helps maintain energy levels needed for movement. Coordinated discharge planning ensures patients meet safety standards while preventing unnecessary hospital stays. The clinical implications of these findings extend beyond a simple reduction in length of stay. Shorter hospitalizations translate to improved bed turnover rates, enabling healthcare facilities to serve more patients with existing resources. From the patient's perspective, an earlier return home facilitates family bonding, reduces disruption for other children, and decreases the risk of exposure in the hospital environment.

The considerations from this analysis emphasize the importance of systematic approaches and organizational commitment. Successful ERACS implementation requires multidisciplinary coordination among obstetrics, anesthesia, nursing, nutrition, and pharmacy services.[23] Staff education and protocol standardization are crucial for achieving consistent results. Patient selection criteria and contraindications must be clearly defined to ensure safety while maximizing benefits. From the perspective of maternal and family well-being, ERACS offers benefits beyond medical outcomes alone. Rapid recovery speeds up the mother's reintegration into her family and daily routines, reducing the emotional and economic stress of a prolonged hospital stay. This is especially important given the social role of women in our society, where extended disruption to domestic roles can have lasting negative effects.

CONCLUSION

Caesarean Surgery (ERACS) protocols shorten hospital stays compared to traditional perioperative care. The combined effect size of -21.6 hours (95% CI: -28.3 to -14.9, $p = 0.001$), based on six studies with 820 participants, represents almost a full day’s reduction. This highlights the clinical importance of ERACS in boosting healthcare efficiency, cost savings, and patient satisfaction. Despite substantial statistical heterogeneity ($I^2 = 99.5\%$), the effect was consistently in the same direction across all studies and was validated by thorough sensitivity analyses, confirming the robustness and applicability of these findings across various hospital environments and baseline practices. Based on this evidence, it is advised that ERACS be systematically integrated as the standard for perioperative care in obstetric services. Effective large-scale implementation requires investment in multidisciplinary teams, ongoing staff training, local protocol adaptations, and enhanced quality assurance systems to convert evidence into practice and maximize public health benefits. Moving forward, additional research particularly on long-term outcomes, cost-effectiveness, and real-world application will be essential to optimize ERACS deployment and sustain improvements in maternal recovery and access within broader healthcare systems.

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Declarations

Authors' contribution

PRS collected the database from Scopus and Pubmed. PRS analyzed all database, contributed to the interpretation of the data.

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Conflict of interest

There is no conflict of interest in this research.

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