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REVIEW

Cost efficiency of ERAS protocols *versus* conventional method in urologic oncology: A systematic review of economic evaluations

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Summary *Background: Urologic oncology procedures are resource-intensive and contribute substantially to healthcare expenditure. Enhanced Recovery After Surgery (ERAS) protocols have been proposed to optimize perioperative care, reduce morbidity, and improve economic efficiency. However, the cost impact of ERAS compared with conventional perioperative management in urologic oncology has not been comprehensively synthesized.*

Methods: This systematic review followed PRISMA guidelines. Database searches were performed using PubMed/MEDLINE, Scopus, Cochrane Library, SpringerLink, and Google Scholar for studies published between 2015 and 2025. Search terms included: "ERAS" AND "urologic oncology" AND "cost efficiency" OR "cost savings". Eligible studies including adult patients who underwent oncologic urologic surgery, comparing the ERAS versus the non-ERAS protocol, and reporting cost outcomes. Data were extracted for study characteristics, ERAS components, and cost results. Risk of bias was assessed using the Newcastle-Ottawa Scale.

Results: A total of 472 articles were identified, and seven studies (n = 1,247 patients) met the inclusion criteria. ERAS shows cost-saving effects in six studies (85.7%) and cost neutrality in one (14.3%), with no evidence of financial harm. Reported savings ranged from USD 1,444 to USD 4,488 per patient in U.S. cohorts and up to 7,353 Y in Chinese cohorts. Cost reductions were primarily attributed to shorter length of stay, reduced complication-related expenditure, and improved perioperative resource utilization. NOS scores ranged from 6 to 7, indicating satisfactory to good quality.

Conclusions: ERAS protocols provide consistent economic advantages over conventional care in urologic oncology, demonstrating cost savings or cost neutrality across diverse procedures and healthcare systems. Standardization of ERAS components, harmonized cost-reporting methods, and prospective cost-effectiveness analyses are needed to support policy adoption and establish ERAS as a cost-efficient component of value-based urologic cancer care.

KEY WORDS: *Enhanced recovery after surgery; Urologic oncology; Cost efficiency; Hospitalization cost; Economic evaluation.*

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INTRODUCTION

Urologic oncologic diseases represent a major global health burden and remain major contributors to cancer-related morbidity and mortality in aging societies (1). According to recent GLOBOCAN and *Global Burden of Disease* (GBD) estimated 2.25 million new cases and 815,000 deaths were attributed to urological cancers worldwide, with prostate cancer accounting for the greatest proportion of incidence and mortality, followed by bladder and renal malignancies (2, 3). This epidemiologic growth is accompanied by escalating clinical complexity, reflected in increasing *disability-adjusted life years* (DALYs) and heightened healthcare utilization for advanced disease (4). The burden is particularly acute in high-income regions, although trends indicate rising incidence in lower-middle-income setting (5, 6).

Major urologic oncology procedures such as radical cystectomy and radical prostatectomy remain highly complex, and healthcare teams continue to face substantial perioperative and postoperative management challenges despite advances in surgical techniques and perioperative care (7). Radical cystectomy reported postoperative complication rates of 30-64% within 30 days, with readmission rates approaching 25-30%, and a median *length of stay* (LOS) of 7-14 days in most high-volume centers (8, 9). Open, laparoscopic, or robot-assisted radical prostatectomy also shows 20-35% complication rates and variable recovery trajectories, particularly in older patients and those with comorbidities (10, 11). These procedures frequently lead to prolonged hospitalization, elevated postoperative complication rates, and significant perioperative morbidity (12).

Patients experience diminished functional recovery and quality of life, while healthcare systems absorb increased utilization of inpatient services, specialized nursing, and readmission-related expenditures. In high-cost surgeries such as radical cystectomy, total hospitalization expenses may exceed USD $40,000-$100,000 per case, creating disproportionate financial strain compared with other oncologic procedures and intensifying pressure on institutions to optimize perioperative pathways and adopt evidence-based strategies that improve recovery while minimizing cost (7, 13, 14). *Enhanced Recovery After Surgery*

(ERAS) protocols directly address these challenges by restructuring perioperative care into a coordinated, evidence-based, multidisciplinary pathway (15, 16).
ERAS reduces surgical stress, preserves physiological stability, and accelerates postoperative rehabilitation through structured interventions such as shortened fasting, multimodal and opioid-sparing analgesia, goal-directed fluid therapy, early enteral nutrition, and early mobilization(13, 14). These active measures enhance physiological resilience, promote faster return of function, and reduce the burden of postoperative morbidity. Across urologic oncology, ERAS protocols have demonstrated reductions in LOS by 2-5 days, postoperative complication reductions of 15-30%, and readmission reductions of up to 20% compared with conventional care models (15, 16)
Economic evaluation has become increasingly critical as health systems strive to balance high-quality care with sustainable expenditure in the context of rising healthcare costs and constrained resources. Cost efficiency, described as the relationship between the resources invested and the outcomes achieved, plays a pivotal role in healthcare decision-making and policy formulation (16, 17). Large meta-analyses of enhanced recovery protocols demonstrate that ERAS pathways reduce hospital length of stay and postoperative complications, with downstream implications for lowering hospitalization costs and optimizing resource utilization (13, 14) The use of the ERAS protocol in urological procedures, especially minimally invasive radical prostatectomy, has been associated with reductions in hospitalization costs alongside improvements in perioperative recovery metrics (18).
Institutional economic analyses report that adoption of ERAS in radical cystectomy care can reduce 30-day total hospital expenditure by several thousand U.S. dollars per case when compared with conventional management (19, 20). Collectively, these findings highlight the potential for ERAS to improve both clinical and fiscal outcomes in major urologic oncologic surgery. The economic impact of ERAS within urologic oncology has not been comprehensively synthesized, despite these promising trends. Prior reviews have predominantly focused on clinical outcomes or patient-reported quality of life, with relatively few studies rigorously assessing cost, cost-effectiveness, or the methodological quality of economic reporting (21, 22). Furthermore, heterogeneity in study design, cost accounting methods, and healthcare system structure limits direct comparison and generalizability across institutions and countries.
Given the growing global demand for high-value care and the pressure on health systems to optimize resource allocation, a systematic review of economic evaluations comparing ERAS versus conventional perioperative pathways in urologic oncology is both timely and necessary. This study aims to synthesize the existing evidence on the cost efficiency of ERAS protocols across major urologic cancer surgeries. By integrating economic outcomes from diverse clinical settings and procedural types, this review seeks to inform clinicians, hospital administrators, and policymakers regarding the value proposition of ERAS pathways and their potential to enhance both clinical performance and economic sustainability in urologic oncology care.

Methods

Search strategy

The methodological approach of this systematic review was guided by the principles outlined in the Cochrane Handbook for Systematic Reviews of Interventions, and its reporting structure adheres to the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) statement.
A comprehensive electronic search was performed across PubMed/MEDLINE, Scopus, the Cochrane Library, SpringerLink, and Google Scholar using controlled vocabulary and free keywords. The primary search terms were based on three domains: ERAS protocols, urologic oncology, and economic outcomes. Search strings were constructed using Boolean operators (AND/OR), including the following terms: "*Enhanced Recovery After Surgery*" OR "*ERAS*", "*urologic oncology*" OR "*urologic cancer*", and "*cost efficiency*" OR "*cost savings*" OR "*direct medical cost*". No filters for currency or costing method were applied. The search was limited to articles published within the last ten years (2015-2025) and to studies written in English or Indonesian.

Table 1.
Keywords for search strategy.

Database	Keywords/search terms used
PubMed/MEDLINE	"Enhanced Recovery After Surgery" OR ERAS AND "urologic oncology" OR "urologic cancer" AND "cost efficiency" OR "cost savings" OR "direct medical cost" AND "conventional care"
Google Scholar	ERAS "urologic oncology" "cost savings" OR "direct medical cost" comparison "conventional care"
SpringerLink	ERAS AND urologic cancer AND cost efficiency OR cost savings
Cochrane Library	Enhanced Recovery Surgery AND urologic malignancy AND cost OR economic OR financial OR "direct cost"

Study selection

All retrieved records were exported into a reference management program to remove duplicates, and the resulting records were then independently screened by two reviewers. Full-text screening was subsequently performed to determine eligibility based on predefined inclusion and exclusion criteria. Only cohort and case-control studies were included. Eligible studies met the following criteria: (1) involved adult patients undergoing urologic oncology surgery such as cystectomy, nephrectomy, or prostatectomy; (2) compared ERAS protocols with conventional perioperative management; and (3) reported at least one economic outcome, including cost efficiency, cost savings, total direct medical costs, or hospitalization-related cost comparisons. Studies were excluded if they were literature reviews, systematic reviews, meta-analyses, editorials, expert commentaries, case reports, pilot descriptive studies without comparative analysis, pediatric studies, non-oncologic urology, or animal and laboratory investigations.
The study selection process was illustrated using a PRISMA flow diagram.

Table 2.
PICO Framework.

Population (P)	Intervention (I)	Comparison (C)	Outcome (O)
Adults undergoing urologic oncology surgery (cystectomy, prostatectomy, nephrectomy for malignancy)	Enhanced Recovery After Surgery (ERAS) protocols	Non-ERAS: conventional, standard, or usual perioperative care	Economic outcomes: cost efficiency, cost savings, total direct medical cost, or hospitalization cost difference

Data extraction

Data extraction was conducted independently by two reviewers using a standardized form. Extracted variables included authors, year of publication, study location, sample size, cancer type, surgical procedure examined, definition and components of the ERAS protocol, comparator intervention, and all reported economic data. Cost variables included total direct medical costs, hospitalization expenditures, readmission and complication-related cost differences, resource utilization, and the financial impact of ERAS implementation on perioperative management. When necessary, cost values were interpreted narratively due to differences in currency or costing methodology across studies. Results were synthesized descriptively without meta-analysis due to methodological heterogeneity in cost reporting and study design.

Methodologic quality assessment

Two reviewers independently evaluated the methodological quality of the included studies. Cohort and case-control studies were appraised using the *Newcastle-Ottawa Scale* (NOS) to assess internal validity and risk of bias based on selection, comparability, and outcome domains. Assessment results will be summarized narratively in accordance with PRISMA guidance.

RESULTS

The database search identified a total of 472 records. After removing 19 duplicates, 453 studies were screened by title and abstract, of which 56 full-text articles were assessed for eligibility. Seven studies met the inclusion criteria and were included in the review. Of these, six studies (85.7%) reported a cost reduction associated with ERAS implementation, while one study (14.3%) demonstrated a cost-neutral effect without evidence of increased financial burden.

Overall, trends across studies consistently favored ERAS over standard perioperative pathways in terms of economic outcomes.

A total of seven studies met the inclusion criteria, comprising 1,247 patients, with 582 individuals treated under ERAS protocols and 665 managed with conventional perioperative care. All studies were retrospective cohort designs published between 2016 and 2025, and were conducted in the United States (n = 3) and China (n = 4). The surgical procedures examined included *radical cystectomy* (RC), *radical prostatectomy* (RP), *radical nephrectomy* (RN), and *radical nephroureterectomy* (RNU). Most RC procedures were performed using an open surgical approach, whereas prostate and renal surgeries were predominantly conducted via minimally invasive techniques, including laparo-

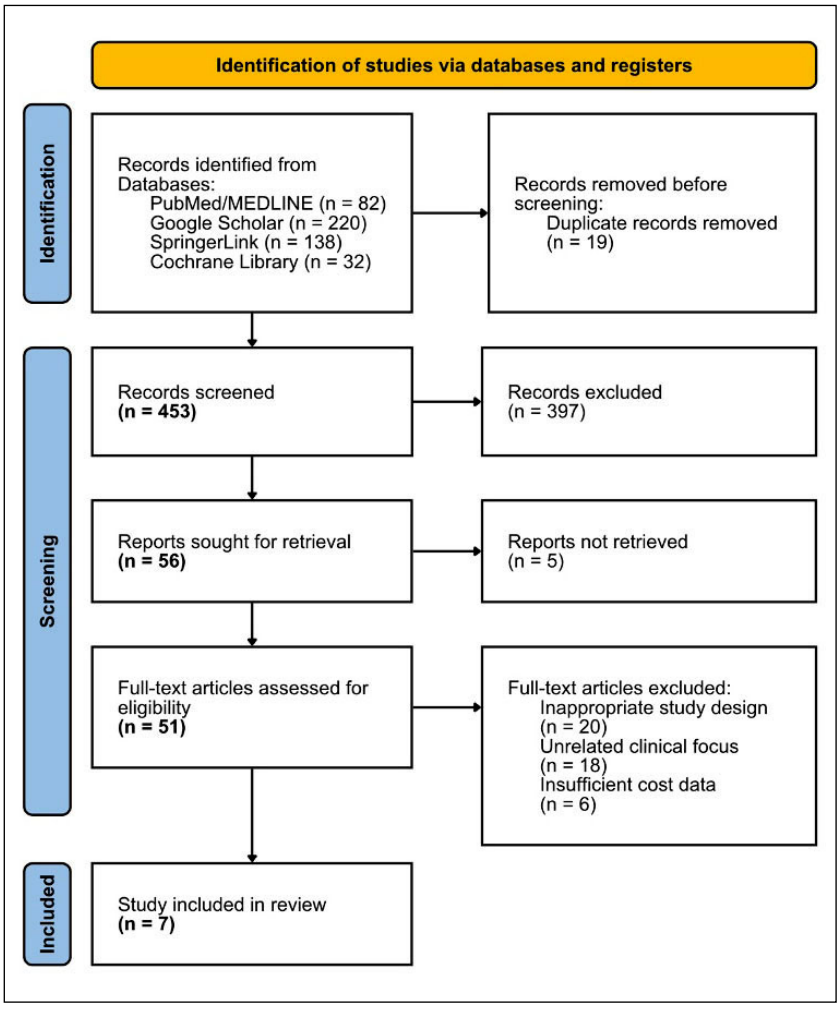

Figure 1.
PRISMA flowchart

Table 3.
Characteristics of included study.

Author, Year	Country	Procedure	Sample (ERAS vs Control)	Study design	Surgical approach
Nabhani, 2016 (23)	USA	RC	102 *vs* 99	Retrospective Cohort	Open
Chipollini, 2017 (24)	USA	RC	112 *vs* 145	Retrospective Cohort	Open
Semerjian, 2017 (25)	USA	RC	56 *vs* 54	Retrospective Cohort	Mixed (Open + Robotic)
Wei, 2018 (19)	China	RC and urinary reconstruction	91*vs* 101	Retrospective Cohort	Open
Xu, 2020 (18)	China	RP (LRP/RALRP)	138 *vs* 163	Retrospective Cohort	Minimally invasive (Laparoscopic & Robot-assisted)
Chen, 2022 (20)	China	RN	40 *vs* 49	Retrospective Cohort	Laparoscopic
Shi, 2025 (26)	China	RNU	43 *vs* 47	Retrospective Cohort	Laparoscopic

RC = Radical cystectomy; RP = Radical prostatectomy; LRP = Laparoscopic radical prostatectomy; RALRP = Robot-assisted laparoscopic radical prostatectomy; RN = Radical nephrectomy; RNU = Radical nephroureterectomy.

Table 4.
PICO and ERAS protocol definition.

Study	Population (P)	Intervention (I)	Comparison (C)	Outcome (O)	ERAS elements
Nabhani, 2016 (23)	Bladder Ca	ERAS	Non-ERAS	30-day direct cost	Carbohydrate loading, LMWH prophylaxis, epidural analgesia, opioid-sparing analgesia, fluid restriction, early oral intake, early ambulation
Chipollini, 2017 (24)	Bladder Ca	ERAS	Pre-ERAS care	Hospital charges	NG tube avoidance, multimodal/epidural analgesia, goal-directed fluid therapy, early oral intake
Semerjian, 2017 (25)	Bladder Ca	ERAS	Pre-ERAS care	Hospital charges	NG tube avoidance, no parenteral nutrition, early oral intake, early mobilization, standardized perioperative pathway
Wei, 2018 (19)	Bladder Ca	ERAS	Non-ERAS	Hospital cost	Carbohydrate loading, thromboprophylaxis (LMWH), epidural analgesia, goal-directed fluid therapy, minimally invasive approach, rectus sheath block, early oral intake
Xu, 2020 (18)	Prostate Ca	ERAS	Non-ERAS	Hospital cost	Pre-op education, shortened fasting, selective bowel prep, goal-directed fluid therapy, minimally invasive approach, early oral intake, early ambulation, early drain removal
Chen, 2022 (20)	RCC	ERAS	Non-ERAS	Hospital expenses	Pre-op education, short fasting/no enema, thermal warming, fluid restriction, early oral intake, early ambulation, early catheter removal
Shi, 2025 (26)	UTUC	ERAS	Non-ERAS	Hospital cost	Pre-op counseling, carbohydrate loading, short fasting/no enema, no NG tube, thermal management, opioid-sparing analgesia, early oral intake, gradual diet advancement, early ambulation, pneumatic compression

RC = Radical cystectomy; RCC = Renal cell carcinoma; UTUC = Upper tract urothelial carcinoma; Ca = Carcinoma; ERAS = Enhanced Recovery After Surgery; NG = Nasogastric.

scopic and robot-assisted approaches. Study characteristics are summarized in Table 3.

Across included studies, ERAS protocols consistently incorporated multimodal perioperative interventions encompassing preoperative, intraoperative, and postoperative components, although implementation varied between centers. Preoperative measures frequently included patient education, shortened fasting intervals, and carbohydrate loading. Intraoperatively, goal-directed fluid therapy, opioid-sparing analgesia, and avoidance of nasogastric tubes were the most consistently reported elements.

Postoperative care emphasized early oral intake, early mobilization, and early removal of drains or catheters to facilitate accelerated recovery. While individual protocol components differed, there was substantial overlap in fluid optimization, nutritional strategy, and mobilization targets, indicating a shared framework of enhanced recovery principles across clinical settings (Table 4).

Economic outcomes demonstrated a predominantly favorable cost profile for ERAS implementation. Six of seven studies reported meaningful reductions in hospitalization costs, with savings ranging from USD 1,444 to USD 41,510 per patient, particularly in RC and RP cohorts. In Chinese cohorts evaluating laparoscopic nephrectomy and nephroureterectomy, ERAS was also associated with significantly lower hospitalization expenses ($p < 0.05$), underscoring the potential value of ERAS beyond bladder cancer surgery. Only one study (*Chipollini et al.*, 2017) reported a cost-neutral outcome (+USD 516; $p = 0.175$), though reduced cost variability was observed, suggesting improved predictability of inpatient expenditure. Collectively, these findings indicate that ERAS is either cost-saving or cost-equivalent when compared with standard perioperative management, without evidence of financial detriment (Table 5).

Methodological quality appraisal using the *Newcastle-Ottawa Scale* (NOS) indicated that three studies met criteria for good quality (7 of 9), while the remaining four were

Table 5.
Economy evaluation.

Study	Cost Perspective	Currency	ERAS Cost	Non-ERAS Cost	Effect Size (Δ)	Interpretation
Nabhani, 2016 (23)	Hospital/provider	USD	$26,650	$31,139	−$4,488	Cost-saving; ERAS significantly lowers 30-day inpatient expenditure ($p < 0.0001$)
Chipollini, 2017 (24)	Hospital charges	USD	$60,655	$59,539	+$516	Cost-equivalent; ERAS shows lower variance in expenses ($p = 0.175$)
Semerjian, 2017 (25)	Hospital charges	USD	$31,090	$35,489	−$4,399	Cost-saving; ERAS significantly reduces hospitalization charges ($p = 0.036$)
Wei, 2018 (19)	Hospital cost	USD	NR	NR	−$41,510	Cost-saving; ERAS reduces inpatient expenditure ($p < 0.05$)
Xu, 2020 (18)	Hospital/provider	USD	$4,086	$5,530	−$1,444	Cost-saving; ERAS significantly reduces hospitalization cost ($p < 0.05$)
Chen, 2022 (20)	Hospital/provider	CNY	NR	NR	Lower hospitalization expenses	Cost-saving; ERAS significantly lowers hospitalization expenses ($p = 0.023$)
Shi, 2025 (26)	Hospital	CNY	¥56,896	¥64,249	−¥7,353	Cost-saving; ERAS significantly reduces hospitalization expenditures ($p = 0.010$)

NR = Not reported numerically (only cost difference provided by study); ERAS = Enhanced Recovery After Surgery; USD = US Dollar; CNY = Chinese Yuan.

Table 6.
Newcastle-Ottawa Scale (NOS) assessment of included studies.

Study	Selection			Comparability		Outcome			Total
	Representativeness	Selection of cohort	Ascertainment of exposure	Result not present at start	Confounder comparability	Assessment of outcome	Follow-up duration	Adequacy of follow-up	
Nabhani, 2016 (23)	*	*	*	*	*	*	-	*	7
Chipollini, 2017 (24)	*	*	*	*	-	*	-	*	6
Semerjian, 2017 (25)	*	*	*	*	*	*	-	-	6
Wei, 2018 (19)	*	*	*	*	-	*	-	-	6
Xu, 2020 (18)	*	*	*	*	*	*	-	-	7
Chen, 2022 (20)	*	*	*	*	-	*	-	-	6
Shi, 2025 (26)	*	*	*	*	*	*	-	-	7

** Newcastle-Ottawa Scale for cohort studies. A maximum of one star can be awarded for each item in the Selection and Outcome domains, and a maximum of two stars can be awarded for Comparability.*
Total scores reflect overall methodological quality: 7–9 = Good; 5–6 = Satisfactory; < 5 = Unsatisfactory. A dash (-) indicates the criterion was not met or not reported in the article.

classified as satisfactory (6 of 9). None of the included studies scored below six points, reflecting an overall satisfactory level of internal validity. However, several methodological limitations were identified, including incomplete documentation of postoperative follow-up and limited adjustment for potential confounders (Table 6).

The available evidence implies ERAS protocols in urologic oncology are generally associated with reductions in inpatient expenditure and improved perioperative efficiency across multiple surgical procedures. Although heterogeneity in ERAS implementation and methodological limitations temper the strength of conclusions, the consistency of economic benefit across diverse clinical environments supports wider adoption and structured evaluation of ERAS within urologic oncology practice.

Discussion

This systematic review demonstrates that ERAS protocols in urologic oncology are consistently associated with superior cost efficiency compared with conventional perioperative care and across seven retrospective cohort studies comprising 1,247 patients. ERAS implementation resulted in reduced hospitalization costs in six studies and a cost-neutral effect in one, with no evidence of increased financial burden. These benefits were observed across multiple cancer types, such as bladder, prostate, renal cell carcinoma, and upper tract urothelial carcinoma within healthcare systems in both North America and Asia, indicating that the economic advantage of ERAS is not geographically or contextually restricted.

The magnitude of cost savings varied, ranging from USD 1,444 to USD 4,488 and CNY 7,353 per patient, suggesting that cost reductions are primarily driven by decreased length of stay, reduced complication incidence, and optimized resource utilization, rather than reductions in operative costs alone. These findings align with international evidence indicating that ERAS mitigates surgical stress, accelerates recovery, and lowers postoperative morbidity (22, 27). This is particularly relevant in radical cystectomy, where complication rates may reach 30-64% and readmission rates 25-30% under conventional pathways (28). ERAS elements such as carbohydrate loading, multimodal/opioid-sparing analgesia, and goal-directed

fluid therapy directly target cost-intensive drivers of postoperative instability (18).

Cost reductions in cystectomy cohorts showed USD 4,488 saved per patient (23), USD 4,399 (29), and USD 1,444 (18), were predominantly attributable to shortened hospitalization and reduced complication management costs. *Chipollini et al.* observed a cost-neutral outcome, but with significantly reduced cost variability, suggesting more predictable hospital expenditure, which is beneficial for health system budgeting and value-based reimbursement models (24). These trends highlight ERAS as a strategic mechanism to enhance care value, consistent with global shifts toward value-based healthcare and bundled payments (30, 31).

As a modern approach to surgical care, ERAS integrates coordinated efforts from surgical, anesthetic, nutritional, and nursing teams to redesign perioperative pathways using evidence-based strategies. This approach reduces stress responses to surgery, enabling faster recovery, fewer complications, shorter hospitalization, and improved economic outcomes (32). A randomized trial found similar results that conventional care significantly increased treatment costs (USD 2,879 ± 1,806 *vs.* USD 2,168.2 ± 933) compared with ERAS. Cost reductions in the ERAS cohort were primarily driven by shorter hospitalization and fewer intestinal complications, including postoperative ileus (16).

Despite encouraging findings, methodological heterogeneity limits comparability across studies. Variation in ERAS protocol components, cost calculation methods, and reimbursement models complicates pooled economic interpretation. Importantly, none of the included studies conducted formal cost-effectiveness analyses, restricting conclusions to direct cost comparison rather than value generation. Newcastle-Ottawa Scale evaluation indicated satisfactory to good methodological quality, though susceptibility to bias remains due to retrospective design and inconsistent confounder adjustment (10-16).

To strengthen future evidence, prospective or randomized ERAS economic evaluations should adopt standardized costing frameworks, incorporate long-term and post-discharge cost data, and examine integration with emerging digital perioperative systems such as remote monitoring and tele-ERAS. The current body of evidence supports ERAS as a clinically beneficial and economically advantageous perioperative approach in urologic oncology. Nonetheless, further high-quality research is warranted to validate its system-wide financial impact, particularly in low- and middle-income settings and value-based funding environments.

Conclusions

ERAS protocols demonstrate consistent economic advantages over conventional perioperative care in urologic oncology, with most included studies reporting meaningful reductions in hospitalization costs and no evidence of increased financial burden. Studies suggest that structured, multimodal ERAS pathways can enhance perioperative value by improving recovery efficiency, reducing postoperative morbidity, and optimizing resource utilization across diverse surgical contexts. However, current evidence is limited by differences in study design, lack of standard cost reporting, and absence of cost-effectiveness analysis. More standardized and prospective research is needed to confirm long-term financial benefits and guide policy decisions. Strengthening the evidence base in this manner will be essential to establish ERAS as a cost-efficient cornerstone within value-based urologic cancer care.

Declarations

Ethical approval and consent for participate: *Ethical approval was not required, as this study is a systematic review and does not involve direct patient data or human subject intervention.*

Competing interests: *The authors declare that there is no conflict of interest related to the publication of this study.*

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