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ROBOTIC-ASSISTED SURGERY IN MODERN HEALTHCARE: CLINICAL EFFECTIVENESS, ECONOMIC ACCESSIBILITY, AND SOCIETAL IMPLICATIONS OF THE DA VINCI SURGICAL SYSTEM

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ABSTRACT

Background: Robotic-assisted surgery has become an increasingly prominent component of modern healthcare, with the da Vinci Surgical System representing one of the most widely adopted platforms. Despite its technological advantages, including enhanced instrument articulation, three-dimensional visualization, and improved surgical ergonomics, questions remain regarding its comparative clinical effectiveness, economic accessibility, and broader implications for healthcare systems.
Aim: This review critically examines the available evidence concerning the clinical outcomes and economic implications of da Vinci-assisted procedures compared with conventional laparoscopic and open surgery.
Materials and Methods: Particular attention is given to operative time, postoperative complications, hospital stay, surgical conversion rates, and healthcare expenditure. The review also considers the influence of institutional resources, surgical expertise, and technological accessibility on the implementation of robotic-assisted procedures.
Results: Recent comparative studies indicate that robotic surgery may offer advantages in selected surgical settings; however, these benefits are not consistently demonstrated across all procedures and patient populations. Furthermore, substantial financial requirements and methodological limitations in existing economic evaluations complicate conclusions regarding cost-effectiveness.
Conclusions: The findings highlight the importance of procedure-specific evidence and balanced healthcare investment decisions. Robotic-assisted surgery should therefore be evaluated not solely as a technological innovation but as a healthcare intervention whose clinical value, affordability, and accessibility must be assessed together.

KEYWORDS

Robotic-Assisted Surgery, da Vinci Surgical System, Surgical Outcomes, Healthcare Economics, Minimally Invasive Surgery, Healthcare Accessibility

CITATION

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Introduction

Over recent decades, the development of minimally invasive surgical techniques has significantly transformed modern healthcare. Traditional open surgery, which generally requires relatively large incisions and extensive tissue manipulation, has increasingly been complemented or replaced by laparoscopic procedures, contributing to reduced operative trauma and shorter postoperative recovery. More recently, robotic-assisted surgery has emerged as an additional technological development intended to expand the capabilities of minimally invasive interventions.

Among established robotic platforms, the da Vinci Surgical System, developed by Intuitive Surgical, has become particularly prominent, combining robotic instrument control, three-dimensional visualization, and a surgeon-operated console. The system allows surgeons to manipulate specialized instruments through robotic arms while maintaining direct control, as the platform does not independently perform procedures (Barbash & Glied, 2010; Turchetti et al., 2012). These technological characteristics have driven its adoption across multiple medical specialties, including urology, gynecology, general surgery, colorectal surgery, and thoracic surgery (Pal & Gamage, 2024; Weinberg et al., 2011). However, the rising implementation of advanced systems has also introduced substantial capital investment requirements, maintenance expenditures, and institutional costs (Barbash & Glied, 2010; Turchetti et al., 2012).

Despite technological sophistication, advanced equipment does not automatically guarantee superior patient outcomes, prompting detailed critical evaluation of its actual clinical value (Barbash & Glied, 2010). A systematic review of randomized controlled trials found that robotic and conventional laparoscopic surgery generally demonstrated comparable outcomes regarding mortality, postoperative complications, and hospital stay, though robotic procedures were frequently associated with longer operative times and higher costs (Kawka et al., 2023). Similarly, the COMPARE study—a comprehensive systematic review and meta-analysis

evaluating millions of surgical cases across oncological procedures—identified favorable perioperative outcomes for da Vinci-assisted surgery compared to conventional approaches, while noting longer operative durations and substantial study heterogeneity (Ricciardi et al., 2025). Corresponding platform evaluations and specialty-specific meta-analyses further emphasize that clinical advantages vary significantly across procedures, ranging from radical prostatectomies and hysterectomies to colorectal, gynecological, and pediatric applications (Di Fabrizio et al., 2026; Ma et al., 2023; Mirza et al., 2026; Mohammed et al., 2026; Zhang & Zhang, 2025).

Furthermore, evaluating the clinical safety and efficacy of robotic interventions requires addressing complex intraoperative parameters, such as the risk of conversion from minimally invasive approaches to open laparotomy. Seminal randomized clinical trials, including the ROLARR trial for rectal cancer resection, demonstrated that despite the advanced ergonomics of robotic systems, conversion rates to open surgery remained statistically comparable between robotic-assisted and conventional laparoscopic techniques (Jayne et al., 2017). This indicates that intraoperative technical challenges and anatomical complexities are dictated more by disease stage and surgical proficiency than by the robotic platform alone, emphasizing the critical role of structured training and accumulated experience.

In addition to baseline technical proficiency, the proficiency-gain trajectory and learning curves associated with surgical robotics significantly impact both operating room efficiency and perioperative outcomes. Mastering the console interface, managing multi-arm coordination, and overcoming the absence of haptic feedback require dedicated training programs and standardized proctoring for surgical teams (Soomro et al., 2020). Institutional variations in achieving surgical competency can introduce performance variability during early adoption phases, highlighting that technological innovation must be supported by rigorous institutional credentialing and continuous competency assessment.

Beyond clinical outcomes, the economic dimension remains a central challenge. Comprehensive economic evaluations indicate that robotic-assisted surgery is frequently more expensive than alternative approaches, though existing cost analyses often exhibit methodological limitations and inconsistent reporting standards (Bosscha et al., 2025; Husereau et al., 2022; Lai et al., 2025; Sadri et al., 2023). These financial requirements directly affect healthcare accessibility and institutional resource allocation, as well-funded hospitals are better positioned to adopt advanced platforms, potentially exacerbating regional disparities in care (Logan et al., 2023; Morocho et al., 2026). Furthermore, the continuous evolution of the market—marked by the emergence of alternative multiport and next-generation robotic platforms—requires rigorous comparative evidence to determine whether newer systems offer true clinical equivalence or economic superiority (Bruno et al., 2026; Lisondra et al., 2026; Wen et al., 2024).

Furthermore, the expansion of surgical robotics has fundamentally influenced specialized clinical domains, extending far beyond initial applications. In gynecological care and general surgery, emerging evidence highlights the intricate balance between technological innovation and patient safety, where platforms are evaluated for their capacity to minimize invasiveness while optimizing functional and oncological parameters (Bruno et al., 2026; Mohan et al., 2021). Concurrently, technological adaptations in pediatric and thoracic interventions demonstrate how multi-platform diversification aims to address anatomical constraints previously deemed prohibitive for conventional robotic approaches (Di Fabrizio et al., 2026; Syrigos et al., 2025).

Finally, evaluating the sustainability of surgical robotics requires a comprehensive understanding of institutional resource allocation and long-term economic forecasting. Disparities in technology adoption rates between urban medical centers and regional facilities highlight ongoing challenges regarding equitable patient access and optimal capital distribution (Logan et al., 2023; Morocho et al., 2026). Addressing these structural imbalances remains a critical prerequisite for aligning technological advancement with broader public health objectives and universal healthcare equity.

The aim of this review Is to critically examine the clinical effectiveness, economic accessibility, and broader healthcare implications of the da Vinci Surgical System and emerging platforms in comparison with conventional laparoscopic and open surgical approaches. By evaluating technological development, measurable patient outcomes, healthcare expenditure, and equitable access together, the article seeks to contribute to a more balanced assessment of robotic-assisted surgery in contemporary healthcare.

Methodology

This article adopts a critical literature review approach to examine the clinical effectiveness, economic implications, and healthcare accessibility associated with robotic-assisted surgery, with particular emphasis on the da Vinci Surgical System. To capture and critically evaluate the complex interplay between clinical effectiveness, surgical outcomes, economic evaluations, and healthcare delivery systems, this narrative review employed a multidisciplinary literature synthesis across surgical disciplines, healthcare economics, and medical technology adoption. The investigative timeline was strategically bounded between 2016 and 2026 to ensure that synthesized empirical evidence captures contemporary robotic platforms, comparative clinical data, and long-term economic assessment frameworks. Early foundational publications were selectively retained only when they provided essential theoretical concepts necessary for interpreting the evolution of minimally invasive surgery and the technological shift toward robotic systems.

Search Strategy and Information Sources

Scientific publications were identified through searches of PubMed and available publisher-indexed scientific literature. Particular attention was given to systematic reviews, meta-analyses, randomized controlled trials, and comparative observational studies. Publications concerning robotic-assisted surgery, conventional laparoscopy, open surgery, and the da Vinci platform were considered relevant.

The search strategy used combinations of the following terms:

- “da Vinci Surgical System”;
- “robot-assisted surgery”;
- “robotic-assisted surgery”;
- “laparoscopic surgery”;
- “open surgery”;
- “clinical outcomes”;
- “cost-effectiveness”;
- “healthcare accessibility”;
- “surgical complications”.

Inclusion and Exclusion Criteria

o Retrieved publications were screened and deemed eligible for inclusion if they satisfied at least one of the following operational inclusion criteria:

- Evaluated clinical effectiveness, postoperative outcomes, operative times, complication rates, blood loss, or conversion rates specifically in patients undergoing robotic-assisted procedures compared with conventional laparoscopic or open surgery;
- Examined economic evaluations, health care expenditures, system acquisition costs, maintenance expenses, or cost-effectiveness analyses of robotic surgical platforms (such as the da Vinci system);
- Investigated healthcare accessibility, institutional resource distribution, surgical training curves, and the influence of technological adoption on healthcare equity;
- Documented comparative outcomes across diverse surgical specialties, including urology, gynecology, colorectal surgery, general surgery, and oncological surgery.

o Conversely, publications were systematically excluded if they met any of the following criteria:

- Did not directly address robotic-assisted surgery, surgical outcomes, or healthcare economic evaluations;
- Examined technical device specifications or engineering characteristics of robotic equipment without relevant clinical, economic, or healthcare implications;
- Consisted of commercial product marketing materials, non-refereed web articles, popular media publications, or opinion-based commentaries lacking structured empirical data;
- Manuscripts without available full English text.

Evidence Evaluation and Synthesis

The literature selection emphasized publications providing comparative information on patient outcomes, operative characteristics, healthcare expenditure, or institutional implementation. Particular attention was given to the methodological quality of the available evidence, recognizing the potential susceptibility to selection bias, differences in patient characteristics, and institutional variation.

The selected evidence was evaluated according to the following analytical criteria:

- clinical effectiveness, including postoperative complications, blood loss, conversion rates, and hospital stay;
- operative efficiency, including procedure duration and surgical workflow;
- economic implications, including equipment acquisition, maintenance, instruments, and hospital expenditure;
- accessibility, including institutional resources and the distribution of robotic surgical services;
- methodological reliability, including study design, sample characteristics, heterogeneity, and potential conflicts of interest.

Results

The available literature demonstrates that robotic-assisted surgery can provide favorable clinical outcomes in selected surgical procedures (Kawka et al., 2023; Ricciardi et al., 2025). However, its advantages are not consistently observed across all clinical settings (Kawka et al., 2023).

One of the most relevant comparative analyses is the systematic review by Kawka et al. (2023), which examined 45 randomized controlled trials involving 7,364 patients undergoing abdominal and pelvic surgery. The review compared robotic-assisted and conventional laparoscopic procedures across 13 surgical indications. The findings indicated that mortality outcomes were generally comparable between the two approaches. Most included studies also reported no statistically significant differences in postoperative complications, length of hospital stay, and conversion rates. Nevertheless, robotic-assisted surgery was frequently associated with longer operative times and higher total costs. These findings are particularly important because they challenge the assumption that the introduction of robotic technology necessarily results in improved clinical outcomes (Barbash & Glied, 2010; Kawka et al., 2023).

A more recent analysis by Ricciardi et al. (2025) examined robotic-assisted surgery in oncological procedures. The study included 230 publications and more than 3.9 million surgical cases. Compared with conventional minimally invasive approaches, robotic-assisted surgery was associated with lower conversion rates and modest reductions in certain postoperative outcomes. However, the investigators also identified substantial differences between surgical procedures and study populations. Consequently, the reported advantages should not be interpreted as evidence of universal superiority.

The relationship between surgical approach and patient outcomes is therefore more complex than a simple comparison of technological capabilities (Kawka et al., 2023; Ricciardi et al., 2025). Clinical benefits may depend on anatomical complexity, surgical indication, patient characteristics, and the experience of the operating team (Soomro et al., 2020).

Operative time and surgical efficiency

Operative duration represents an important indicator when evaluating robotic-assisted surgery (Kawka et al., 2023; Ricciardi et al., 2025).

Although robotic platforms offer improved instrument articulation and three-dimensional visualization, these characteristics do not necessarily translate into shorter procedures (Kawka et al., 2023). Robotic surgery involves additional procedural stages, including system preparation, robotic docking, instrument installation, and coordination between surgical personnel. Furthermore, the learning curve can influence operative efficiency. Surgeons and operating room teams require appropriate training and experience before achieving consistent performance with robotic systems (Soomro et al., 2020).

The findings of Kawka et al. (2023) indicate that conventional laparoscopic procedures frequently require less operative time than robotic-assisted procedures. Similarly, Ricciardi et al. (2025) reported longer operative durations for robotic-assisted procedures compared with laparoscopic or video-assisted thoracoscopic approaches (Ricciardi et al., 2025; Syrigos et al., 2025). These findings suggest that the evaluation of robotic surgery should include not only the duration of the surgical intervention itself but also the organizational requirements associated with the technology (Bosscha et al., 2025; Kawka et al., 2023).

At the same time, longer operative time should not automatically be interpreted as an unfavorable clinical outcome (Jayne et al., 2017). In technically complex procedures, additional operating time may be associated with improved surgical access or reduced conversion rates (Jayne et al., 2017; Ricciardi et al., 2025). Therefore, operative efficiency should be considered alongside patient outcomes rather than as an isolated indicator (Kawka et al., 2023; Ricciardi et al., 2025).

Postoperative recovery and complications

Postoperative recovery is another important area in which robotic-assisted surgery has demonstrated potential advantages (Ricciardi et al., 2025).

Compared with open surgery, minimally invasive procedures generally reduce the extent of surgical trauma (Ricciardi et al., 2025). Robotic-assisted procedures may further support precise instrument manipulation in anatomically restricted areas (Pal & Gamage, 2024; Ricciardi et al., 2025). The COMPARE study identified several favorable outcomes associated with da Vinci-assisted oncological surgery compared with open surgery, including reduced blood loss, fewer postoperative complications, and shorter hospital stays (Ricciardi et al., 2025). However, the comparison between robotic and conventional laparoscopic surgery produces a more nuanced picture (Kawka et al., 2023). The differences in clinical outcomes are generally smaller, and several indicators demonstrate comparable results (Kawka et al., 2023). This distinction is important because the clinical advantages of robotic surgery may be more apparent when the alternative is open surgery rather than an already established minimally invasive technique (Kawka et al., 2023; Ricciardi et al., 2025). Accordingly, the value of robotic-assisted surgery should be evaluated against the most appropriate available alternative for each individual surgical indication (Kawka et al., 2023; Ricciardi et al., 2025).

Economic implications and healthcare expenditure

Economic considerations represent one of the most significant challenges associated with the implementation of robotic-assisted surgery (Barbash & Glied, 2010; Bosscha et al., 2025).

Unlike conventional laparoscopic equipment, robotic surgical platforms require substantial initial investment (Barbash & Glied, 2010; Turchetti et al., 2012). In addition to purchasing the system, hospitals must account for installation, maintenance, specialized instruments, disposable components, staff training, and technical support (Barbash & Glied, 2010; Bosscha et al., 2025). These expenses may influence institutional decisions regarding the introduction and continued use of robotic technology (Barbash & Glied, 2010; Morocho et al., 2026).

A particularly important contribution to this discussion is the systematic review by Bosscha et al. (2025), which evaluated economic analyses from randomized controlled trials. The authors found that robotic-assisted surgery was more expensive than alternative approaches in the vast majority of comparative cost evaluations. Furthermore, only a portion of studies included important structural expenses such as robotic system acquisition and maintenance. The review also identified considerable methodological weaknesses in the economic evaluations, noting that included studies often fell short of optimal ECOBIAS and CHEERS reporting standards (Husereau et al., 2022). These findings suggest that the economic disadvantages of robotic surgery are frequently reported, while the actual magnitude of its additional financial burden may remain incompletely measured (Lai et al., 2025). Importantly, higher expenditure does not necessarily mean that a medical intervention is economically unjustified (Barbash & Glied, 2010; Lai et al., 2025). A more expensive procedure may still provide value if it produces meaningful improvements in patient outcomes, reduces subsequent healthcare utilization, or generates long-term benefits (Bosscha et al., 2025; Lai et al., 2025). However, such conclusions require comprehensive economic evaluations rather than comparisons based exclusively on the immediate cost of surgery (Bosscha et al., 2025; Husereau et al., 2022; Lai et al., 2025).

Accessibility and institutional differences

The financial requirements of robotic-assisted surgery may also influence the accessibility of advanced surgical services. Hospitals with greater financial resources are generally better positioned to purchase and maintain robotic platforms, develop specialized surgical teams, and provide continuous professional training. Conversely, institutions operating under financial constraints may experience difficulties introducing and sustaining such technologies (Logan et al., 2023; Morocho et al., 2026). This creates an important distinction between technological availability and equitable access to healthcare (Logan et al., 2023). The presence of robotic equipment in a healthcare system does not necessarily mean that all patients can benefit from it. Access

may depend on geographical location, institutional capacity, insurance coverage, public reimbursement policies, and the availability of appropriately trained specialists (Logan et al., 2023; Morocho et al., 2026).

In publicly funded healthcare systems, these considerations are particularly important because investments in expensive surgical technologies must be balanced against competing healthcare priorities (Barbash & Glied, 2010; Bosscha et al., 2025).

The decision to introduce robotic surgery should therefore consider not only its potential clinical advantages but also the opportunity costs associated with purchasing and maintaining the equipment (Barbash & Glied, 2010; Bosscha et al., 2025; Morocho et al., 2026).

Development of alternative robotic platforms

The market for robotic-assisted surgery is gradually evolving as additional manufacturers introduce competing platforms (Bruno et al., 2026; Di Fabrizio et al., 2026; Picozzi et al., 2024). The emergence of alternative systems may influence procurement strategies, equipment pricing, technological development, and competition within the medical technology sector (Bruno et al., 2026; Lisondra et al., 2026). For example, alternative and next-generation surgical systems, such as the KangDuo robotic system, have been investigated as alternatives to the da Vinci platform in urological and gastrointestinal procedures (Wen et al., 2024).

Systematic reviews and meta-analyses comparing these emerging systems with established platforms have evaluated parameters such as estimated blood loss, operative time, and postoperative complication rates. While preliminary results indicate comparable periometric safety and short-term efficacy profiles for certain alternative platforms, specific metrics like operative duration may vary, and available evidence often remains limited by sample size and study number. The authors emphasized that the available evidence remained limited (Wen et al., 2024). These findings illustrate the importance of distinguishing between technological competition and demonstrated clinical equivalence. The introduction of alternative robotic platforms may create opportunities for healthcare institutions to reconsider equipment costs and procurement arrangements (Bruno et al., 2026; Wen et al., 2024). Nevertheless, long-term clinical outcomes, safety, maintenance requirements, and training demands must also be considered before alternative technologies can be regarded as equivalent substitutes (Bruno et al., 2026; Soomro et al., 2020; Wen et al., 2024).

Discussion

The findings of this review indicate that robotic-assisted surgery occupies an increasingly important position in modern healthcare. However, its clinical and economic value cannot be assessed through technological innovation alone (Barbash & Glied, 2010). The available evidence demonstrates that the da Vinci Surgical System may provide advantages in selected surgical procedures, particularly where anatomical complexity and the technical requirements of minimally invasive surgery create challenges for conventional approaches (Pal & Gamage, 2024; Ricciardi et al., 2025). Nevertheless, the comparative evidence does not establish universal superiority over laparoscopic surgery. This distinction is central to understanding the current position of robotic-assisted surgery, as the technology remains clinically relevant, but its value appears to be procedure-specific rather than universal (Kawka et al., 2023; Ricciardi et al., 2025).

One of the main issues identified in the literature is the difference between technological capability and measurable clinical benefit (Barbash & Glied, 2010; Kawka et al., 2023). The da Vinci platform provides several technical advantages, including three-dimensional visualization, articulated instruments, and improved ergonomic conditions for surgeons, which may facilitate particular surgical procedures, especially those involving anatomically restricted operating spaces (Pal & Gamage, 2024). However, improved instrument control does not automatically translate into lower complication rates, reduced mortality, or improved long-term patient outcomes (Kawka et al., 2023). The findings of Kawka et al. (2023) are particularly relevant in this context, as their systematic review of randomized controlled trials demonstrated that robotic and laparoscopic approaches frequently produced comparable clinical outcomes. This suggests that the technological advantages of robotic surgery should be interpreted as potential facilitators of surgical performance rather than direct evidence of improved patient outcomes. At the same time, the findings should not be interpreted as evidence that robotic surgery lacks clinical value, given that selected procedures may benefit from robotic assistance, particularly when conventional laparoscopic techniques are technically demanding. Therefore, the most appropriate approach is to evaluate robotic surgery according to specific clinical indications rather than treating it as a universally superior surgical method (Kawka et al., 2023; Ricciardi et al., 2025).

The economic dimension raises additional questions regarding the sustainability of robotic-assisted surgery (Barbash & Glied, 2010; Bosscha et al., 2025). The findings reported by Bosscha et al. (2025) indicate that robotic procedures are frequently associated with higher costs than alternative surgical approaches. However, the same review highlights an important methodological problem, noting that economic evaluations often fail to include all relevant expenses, exhibiting limitations in meeting standard reporting criteria (Husereau et al., 2022; Lai et al., 2025). A comprehensive assessment should consider the acquisition and maintenance of robotic systems, the cost of instruments, operating room utilization, staff training, and postoperative healthcare requirements, alongside potential savings associated with shorter hospitalization, reduced complications, and faster recovery where these outcomes are demonstrated (Barbash & Glied, 2010; Bosscha et al., 2025). Without such a comprehensive perspective, economic comparisons may provide an incomplete picture of the actual value of robotic surgery (Bosscha et al., 2025; Lai et al., 2025). Another important consideration is the difference between institutional and societal perspectives, where a hospital may experience higher expenditure when introducing robotic surgery, while patients or society may potentially benefit from reduced recovery time or earlier return to normal activities (Barbash & Glied, 2010; Bosscha et al., 2025; Lai et al., 2025). Nevertheless, these potential benefits should be supported by procedure-specific evidence and should not be assumed to occur in every clinical setting (Kawka et al., 2023; Ricciardi et al., 2025). The economic justification of robotic surgery therefore requires a balanced assessment of costs, clinical outcomes, and broader healthcare consequences (Barbash & Glied, 2010; Bosscha et al., 2025).

The introduction of expensive medical technologies can also influence the distribution of healthcare resources. Robotic surgical systems require not only financial investment but also specialized infrastructure and trained professionals, meaning that the availability of robotic surgery may differ considerably between hospitals and geographical regions. This issue has broader implications for healthcare equity, as patients may experience differences in available treatment options depending on where they live if access to technologically advanced surgical procedures is concentrated in a limited number of institutions (Logan et al., 2023; Morocho et al., 2026). From a healthcare policy perspective, technological innovation should therefore be accompanied by consideration of accessibility and resource distribution, ensuring that the implementation of robotic surgery is evaluated within the context of the overall healthcare system rather than exclusively from the perspective of individual hospitals or manufacturers (Barbash & Glied, 2010; Logan et al., 2023; Morocho et al., 2026).

The development of alternative robotic platforms may influence the future economic position of the da Vinci Surgical System (Bruno et al., 2026; Di Fabrizio et al., 2026; Wen et al., 2024). Competition between manufacturers has the potential to encourage technological innovation and provide healthcare institutions with additional procurement options (Bruno et al., 2026; Lisondra et al., 2026). However, lower acquisition prices alone do not establish better overall value, and healthcare institutions must also consider instrument compatibility, reliability, maintenance, surgical training, clinical evidence, and long-term operational expenses (Bruno et al., 2026; Soomro et al., 2020; Wen et al., 2024). The limited comparative evidence currently available for newer platforms further emphasizes the need for cautious evaluation, indicating that the future development of robotic surgery will depend not only on improvements in equipment design but also on the ability of manufacturers and healthcare institutions to demonstrate measurable clinical and economic benefits (Bruno et al., 2026; Wen et al., 2024).

Several limitations affect the interpretation of the current literature. Firstly, clinical studies frequently examine different surgical procedures, patient populations, and outcome measures, making direct comparisons difficult. Secondly, many studies focus on short-term postoperative outcomes, while long-term clinical and patient-reported outcomes remain less consistently documented (Kawka et al., 2023; Ricciardi et al., 2025). Thirdly, differences in surgeon experience and institutional expertise may influence the results of robotic procedures (Soomro et al., 2020). Fourthly, economic evaluations frequently use different methods of calculating costs, making comparisons between healthcare institutions and countries difficult (Bosscha et al., 2025; Husereau et al., 2022; Lai et al., 2025). Finally, potential conflicts of interest should be considered when interpreting studies involving manufacturers of robotic surgical systems; for example, several authors of the COMPARE study reported employment with Intuitive Surgical (Ricciardi et al., 2025). While this does not invalidate the findings, it reinforces the importance of independent research and transparent declarations (Ricciardi et al., 2025). Taken together, these limitations indicate that further high-quality comparative research is required to establish the circumstances in which robotic-assisted surgery provides meaningful additional value (Kawka et al., 2023; Ricciardi et al., 2025).

Conclusions

Robotic-assisted surgery has become an important component of technological development in modern healthcare. The da Vinci Surgical System has contributed to the expansion of minimally invasive surgical procedures by providing improved instrument articulation, three-dimensional visualization, and enhanced ergonomic conditions for surgeons. However, the findings of this review demonstrate that technological advancement does not necessarily correspond to universal clinical superiority.

Comparative studies indicate that robotic-assisted surgery may provide advantages in selected surgical procedures, particularly when compared with open surgery. These advantages may include reduced blood loss, fewer postoperative complications, shorter hospitalization, and lower conversion rates. Nevertheless, comparisons with conventional laparoscopic surgery frequently demonstrate more limited differences in clinical outcomes.

Economic considerations remain a significant challenge. Robotic surgical systems require substantial investment, including equipment acquisition, maintenance, specialized instruments, and professional training. Available randomized evidence indicates that robotic procedures are frequently more expensive than conventional alternatives, although the quality and completeness of economic evaluations remain insufficient in many studies.

The development of competing robotic platforms may create opportunities for greater technological diversity and potentially improved economic accessibility. Nevertheless, additional independent clinical and economic research is necessary to establish whether alternative systems provide comparable long-term outcomes. Future research should prioritize long-term patient outcomes, independent comparative studies, standardized economic evaluations, and investigations into the relationship between surgical expertise and clinical effectiveness.

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