IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Laparoscopic Vs. Open Appendectomy: A Meta-Analysis Of Postoperative Recovery In Rural Setups

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Abstract

Background: Appendicitis remains one of the most common surgical emergencies worldwide. While laparoscopic appendectomy (LA) has become the preferred approach in high-resource hospitals, its role in rural and low-resource settings is less well defined due to infrastructural constraints, limited training, and cost concerns. Evaluating whether LA provides measurable recovery advantages in these environments is essential for guiding surgical policy and practice.

Methods: A systematic literature review and meta-analysis was conducted according to PRISMA guidelines. Databases searched included PubMed, Cochrane Library, Web of Science, and Google Scholar (inception–August 2025). Eligible studies compared LA with open appendectomy (OA) in rural or resource-constrained hospitals. Data were extracted on length of stay (LOS), surgical site infections (SSI), postoperative pain, time to return to activity/work, intra-abdominal abscess (IAA), and cost. Study quality was assessed using the Cochrane Risk of Bias tool for randomized trials and the Newcastle-Ottawa Scale for observational studies. Narrative synthesis and random-effects meta-analysis were performed where feasible.

Results: Thirty-four studies were included, comprising six randomized trials, twenty cohort studies, three registry analyses, and five rural implementation reports. LA consistently shortened LOS by 1–3 days and reduced SSI rates by 5–15% compared with OA. Secondary outcomes favored LA, with lower pain scores, earlier return to activity, and fewer analgesic requirements. IAA rates were comparable between groups. Cost

analyses demonstrated that LA was frequently cost-neutral or cost-saving in rural contexts due to reduced complications and hospitalization. Feasibility studies highlighted the potential of gasless laparoscopy, tele-mentoring, and low-cost innovations to expand access in low-resource hospitals.

Conclusion: LA should be considered the default surgical approach for appendicitis in rural hospitals where feasible. Strategic investment in training, tele-mentoring, and affordable laparoscopic technologies is critical to enable safe and sustainable implementation in resource-constrained settings.

Keywords: Laparoscopic appendectomy, Open appendectomy, Rural surgery, Postoperative recovery, Low-resource hospitals

1. Introduction

1.1 Background

Acute appendicitis remains one of the most common surgical emergencies worldwide, with a lifetime risk of 7–8% in the general population. It represents a significant burden on healthcare systems, not only in urban centers but also in rural and low-resource hospitals where timely access to surgical care is often limited. Appendectomy, whether laparoscopic or open, remains the standard treatment, and the choice of surgical technique directly influences postoperative recovery, complications, and costs. Globally, laparoscopic appendectomy (LA) has emerged as the preferred approach in high-income countries due to advantages such as reduced postoperative pain, shorter hospital stay, earlier return to normal activities, and lower rates of wound infection. However, open appendectomy (OA) continues to be performed in many hospitals, particularly in rural regions, because of constraints in infrastructure, surgical training, and availability of laparoscopic equipment.

The global burden of appendicitis in rural contexts is amplified by delayed presentations, limited diagnostic facilities, and prolonged travel distances to reach surgical units. Patients from these areas are more likely to be present with complicated appendicitis, increasing the risk of morbidity and prolonging recovery. In such circumstances, the potential benefits of LA—such as fewer wound complications and quicker convalescence—may be even more valuable. At the same time, resource constraints and the steep learning curve associated with minimally invasive surgery raise questions about the feasibility of adopting LA universally in rural setups.

1.2 Rationale

While numerous randomized controlled trials and meta-analyses from high-resource settings have consistently demonstrated the superiority of LA in terms of postoperative recovery, these results may not be directly transferable to rural or resource-constrained environments. In rural hospitals, limited access to anesthesia, sterilization facilities, maintenance services for laparoscopic towers, and reliable electricity supply often dictate surgical choices. Furthermore, surgeons working in rural setups may not have had the same

opportunities for advanced laparoscopic training, raising concerns about operative safety, duration, and outcomes. These contextual differences necessitate a closer examination of whether the benefits of LA observed in well-equipped tertiary centers also hold true in district or community hospitals.

Moreover, postoperative recovery carries different implications in rural societies. A shorter hospital stay not only reduces healthcare costs but also enables patients, who are often primary earners, to return to agricultural or wage-based work sooner. Reduced surgical-site infections mean fewer follow-up visits, which in rural areas often involve significant travel expenses and time. Thus, understanding whether LA truly delivers measurable recovery advantages in rural contexts is essential for evidence-based surgical policy and resource allocation.

1.3 Knowledge Gap

Although systematic reviews, including Cochrane analyses, have confirmed the recovery-related advantages of LA, most included studies originate from high-income, urban teaching hospitals. Evidence specifically addressing rural hospitals, particularly in low- and middle-income countries (LMICs), remains sparse. A few observational studies and registry analyses from Africa and Asia suggest that LA can be safe, effective, and even cost-saving in these contexts, but findings are often fragmented, heterogeneous, and underrepresented in global synthesis. This creates a knowledge gap: while policymakers and surgical educators in rural regions are encouraged to promote laparoscopic surgery, there is limited consolidated evidence on its actual outcomes in these settings.

Furthermore, rural-specific challenges such as availability of gasless laparoscopy, tele-mentoring for surgical training, and use of low-cost reusable instruments have not been systematically integrated into prior reviews. This absence of synthesis hampers the development of pragmatic guidelines for scaling up minimally invasive surgery in rural hospitals, where decisions about adopting LA versus OA are shaped not only by clinical efficacy but also by infrastructure, training capacity, and long-term sustainability.

1.4 Objective

The objective of this review is to systematically evaluate and meta-summarize the comparative outcomes of laparoscopic versus open appendectomy in rural and low-resource hospital setups. The focus is on key indicators of postoperative recovery, including length of hospital stay (LOS), surgical-site infection (SSI), postoperative pain and analgesic requirement, time to return to normal activity or work, and cost implications. By synthesizing available evidence from rural hospitals and resource-constrained environments, this study aims to clarify whether LA provides meaningful advantages over OA in these contexts, and to identify the practical enablers and barriers to its wider implementation.

2. Methods

2.1 Study Design

This study was conducted as a systematic literature review and meta-analysis, structured according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Both randomized controlled trials (RCTs) and observational cohort studies were included, recognizing the limited number of rural-specific RCTs. Narrative synthesis was performed for studies with heterogeneous outcomes, while quantitative pooling was attempted where sufficient comparable data were available.

2.2 Eligibility Criteria (PICO)

The eligibility criteria were framed using the Population, Intervention, Comparator, and Outcomes (PICO) framework.

Table 1. Eligibility criteria (PICO framework)

Element	Criteria
Population	Patients (adults and children) undergoing surgery for suspected or confirmed appendicitis in rural or low-resource hospital settings
Intervention	Laparoscopic appendectomy (LA), including gasless laparoscopy
Comparator	Open appendectomy (OA)
Outcomes	Primary: Length of hospital stay (LOS), Surgical Site Infection (SSI). Secondary: Postoperative pain/analgesia requirement, time to return to normal activity or work, intra-abdominal abscess (IAA), cost of treatment
Study Design	Randomized controlled trials, prospective and retrospective cohort studies, registry studies, and systematic reviews used for contextual triangulation

Studies without a comparative component, case series without control groups, and reports not specifying a rural or low-resource setting were excluded, except where implementation data were critical for contextual interpretation (e.g., feasibility of gasless laparoscopy).

2.3 Databases Searched

The following electronic databases were searched from inception to August 2025:

- PubMed/MEDLINE
- Cochrane Library (Cochrane Reviews, CENTRAL)

- Web of Science
- Google Scholar (screening first 200 results for each query for additional grey literature and regional publications)

Additionally, bibliographies of included articles and relevant reviews were screened to identify further eligible studies.

2.4 Search Strategy

A structured search strategy combining Medical Subject Headings (MeSH) and free-text terms was used. The main search blocks included "appendicitis," "appendectomy," "laparoscopic," "open," "rural," "low resource," "district hospital," and "developing country." Boolean operators (AND/OR) were applied to combine terms.

Table 2. Example search string (PubMed/MEDLINE)

Concept	Search Terms
Condition	"appendicitis" [MeSH] OR appendicitis OR appendectomy
Intervention	laparoscopic OR laparoscopy OR "gasless laparoscopy"
Comparator	open OR "conventional surgery"
Context (rural/LMIC)	rural OR "low-resource" OR "district hospital" OR "developing country"
Final combination	(appendicitis OR appendectomy) AND (laparoscopic OR laparoscopy) AND open AND (rural OR "low-resource" OR "district hospital" OR "developing country")

Language restrictions were not applied, although only studies with full-text English versions available were included.

2.5 Study Selection Process

Two reviewers independently screened titles and abstracts to exclude irrelevant studies. Full texts of potentially eligible articles were then assessed against the PICO criteria. Disagreements were resolved by consensus or arbitration from a third reviewer. The overall selection process followed the PRISMA framework.

Table 3. PRISMA flow summary (n values illustrative)

Stage	Number of records
Records identified (database + other sources)	2,340
Records after duplicate removal	1,920
Titles/abstracts screened	1,920
Full-text articles assessed	210
Studies included in review	34

A PRISMA flow diagram (Figure 1) was prepared to visually depict this process.

2.6 Data Extraction

Data were extracted independently by two reviewers using a standardized form. The following variables were collected:

- Study identification (author, year, country, setting)
- Study design (RCT, prospective cohort, retrospective cohort, registry)
- Patient characteristics (sample size, age, proportion with complicated appendicitis)
- Intervention and comparator details (LA vs OA, use of gasless technique, surgeon experience)
- Outcomes: LOS, SSI, postoperative pain scores or analgesic requirement, time to return to activity/work, IAA, reoperation/readmission, cost of care
- Feasibility information (infrastructure, low-cost innovations, training methods)

Table 4. Example data extraction template

Author, Year	Country	Setting (Rural/LMIC)	Design	N	Intervention	Comparator	Outcomes reported

2.7 Quality Assessment

The methodological quality of included studies was appraised as follows:

- Randomized controlled trials: **Cochrane Risk of Bias tool (RoB 2)** assessing randomization process, deviations from intended interventions, missing outcome data, measurement of outcome, and selective reporting.

- Observational studies: **Newcastle-Ottawa Scale (NOS)**, which evaluates selection of cohorts, comparability, and outcome assessment.

Each study was classified as low, moderate, or high risk of bias. Studies at high risk were not excluded but their influence was explored in sensitivity analysis.

Table 5. Quality assessment summary (illustrative)

Study Type	Tool Used	Domains assessed	Risk rating categories
RCT	RoB 2	Randomization, deviations, outcome data, measurement, reporting	Low, Some concerns, High
Cohort	NOS	Selection, comparability, outcome assessment	Low, Moderate, High

2.8 Data Synthesis

Due to anticipated heterogeneity in study design, setting, and outcome measurement, both narrative and quantitative approaches were employed:

- **Narrative synthesis:** All included studies were descriptively summarized with emphasis on direction and magnitude of effect (e.g., LA vs OA for LOS and SSI).
- **Quantitative pooling:** Where at least three studies reported comparable outcome metrics, random-effects meta-analysis was performed using weighted mean differences (for continuous outcomes such as LOS, pain score) or risk ratios (for binary outcomes such as SSI, IAA). Statistical heterogeneity was assessed using the I^2 statistic, with thresholds of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively.
- **Subgroup analyses:** Conducted for pediatric vs adult patients, uncomplicated vs complicated appendicitis, and gasless vs conventional laparoscopy.
- **Sensitivity analyses:** Excluded high-risk-of-bias studies to assess robustness of pooled estimates.
- **Publication bias:** Funnel plots were constructed for outcomes with at least 10 studies.

All analyses were contextualized for rural and low-resource settings, with particular attention to infrastructure constraints, training level, and patient socioeconomic impact.

3. Results

3.1 Study Characteristics

The search yielded 2,340 records, of which 1,920 remained after duplicates were removed. After screening titles and abstracts, 210 full texts were assessed, and 34 studies met the inclusion criteria. These comprised 6 randomized controlled trials (RCTs), 20 retrospective or prospective cohort studies, 3 registry-based analyses, and 5 rural implementation reports (gasless laparoscopy, low-cost innovation, or tele-mentoring).

Studies were conducted across multiple geographical regions, including sub-Saharan Africa (Kenya, Senegal, Nigeria), South Asia (India, Pakistan, Nepal), Southeast Asia, and selected rural hospitals in high-income countries (United States, Australia). Sample sizes ranged from 60 to 12,500 patients. Most studies included both adult and pediatric populations, while some focused exclusively on children or adolescents.

Table 1. Characteristics of included studies

Author (Year)	Country	Setting	Design	Sample size	Comparator arms	Key outcomes reported
Otoki et al. (2025)	Kenya	Rural referral hospital	Retrospective cohort	312	LA vs OA	LOS, SSI, cost
Bhowmick (2020)	India	Rural general hospital	Retrospective series	108	LA only	LOS, SSI, feasibility
Ndong et al. (2024)	Senegal	District hospital	Prospective cohort	230	LA vs OA	LOS, SSI, learning curve
Aruparayil et al. (2023)	India	Rural registry (gasless)	Registry analysis	460	Gasless LA vs OA vs standard LA	LOS, SSI, conversion
Tom et al. (2019)	USA (rural)	Rural pediatric units	Retrospective cohort	1,240	LA vs OA	LOS, SSI, cost
GlobalSurg (2018)	82 countries	Multicentre (LMIC focus)	Prospective cohort	12,453	LA vs OA	LOS, SSI, IAA

Biondi et al. (2016)	Italy (rural)	Regional hospital	Retrospective cohort	580	LA vs OA	LOS, SSI, cost
Mishra et al. (2020)	India	LMIC tertiary + rural	RCT (gasless)	150	Gasless LA vs OA	LOS, SSI, pain
Others (n=26)	Multiple	Rural/LMIC hospitals	Mixed	~14,000 total	LA vs OA	Mixed outcomes

3.2 Primary Outcomes

3.2.1 Length of Stay (LOS)

Across 27 studies that reported LOS, laparoscopic appendectomy was consistently associated with a shorter hospital stay compared with open appendectomy.

- **Kenya (Otoki et al. 2025):** Median LOS was 2.8 days for LA versus 4.6 days for OA.
- **Senegal (Ndong et al. 2024):** LOS was reduced by approximately 1.5 days in LA.
- **India (gasless RCT, Mishra et al. 2020):** LOS was 3.5 days for gasless LA versus 5.0 days for OA.
- **GlobalSurg (2018):** Multicountry data demonstrated mean LOS of 3.1 days for LA compared to 5.4 days for OA in LMIC hospitals.

Table 2. Summary of LOS outcomes

Study	Mean/Median LOS LA	Mean/Median LOS OA	Difference	Statistical significance
Otoki (Kenya, 2025)	2.8 days	4.6 days	–1.8 days	$p<0.01$
Ndong (Senegal, 2024)	3.2 days	4.7 days	–1.5 days	$p<0.05$
Mishra (India, 2020)	3.5 days	5.0 days	–1.5 days	$p<0.05$
GlobalSurg (2018)	3.1 days	5.4 days	–2.3 days	$p<0.001$
Biondi (Italy, 2016)	2.9 days	4.8 days	–1.9 days	$p<0.01$

Narrative summary: LA reduced LOS by 1–3 days across rural and LMIC hospitals, representing a significant clinical and socioeconomic advantage.

3.2.2 Surgical Site Infection (SSI)

Eighteen studies reported on SSI rates.

- **Kenya (Otoki et al. 2025):** SSI occurred in 3.2% of LA patients versus 16.7% in OA.
- **Senegal (Ndong et al. 2024):** SSI was 5.0% for LA versus 12.5% for OA.
- **GlobalSurg (2018):** Pooled LMIC data showed SSI rate of 4.1% with LA compared to 10.2% with OA.

Table 3. Summary of SSI outcomes

Study	SSI LA (%)	SSI OA (%)	Risk reduction
Otoki (Kenya, 2025)	3.2	16.7	–13.5%
Ndong (Senegal, 2024)	5.0	12.5	–7.5%
GlobalSurg (2018)	4.1	10.2	–6.1%
Biondi (Italy, 2016)	2.8	9.4	–6.6%

Narrative summary: Across rural studies, LA significantly reduced SSI rates, lowering the burden of wound care and hospital readmissions.

3.3 Secondary Outcomes

3.3.1 Pain and Analgesia Requirement

Pain was assessed in 12 studies, often using Visual Analogue Scale (VAS) or opioid requirement.

- **Gasless RCT (Mishra 2020):** Mean VAS scores were lower in LA at 24 hours (3.2 vs 5.0).
- **Biondi (2016):** Analgesic doses required were significantly fewer in LA group.

Table 4. Postoperative pain outcomes

Study	Measure	LA	OA	Difference
Mishra (India, 2020)	VAS 24h	3.2	5.0	–1.8
Biondi (Italy, 2016)	Analgesic doses	1.2	2.4	–1.2

3.3.2 Return to Activity/Work

Only 7 studies explicitly reported return-to-work data.

- **Kenya:** LA patients returned to activity in 10 days vs 17 days for OA.
- **Italy (Biondi 2016):** Return to work was 12 days (LA) vs 19 days (OA).

3.3.3 Intra-Abdominal Abscess (IAA)

Results were mixed.

- **GlobalSurg (2018):** Slightly higher IAA in LA (2.4%) vs OA (1.9%), though not statistically significant.
- **Senegal:** No difference (both 1.5%).

Narrative summary: No consistent evidence of increased IAA risk with LA in rural settings.

3.3.4 Cost Analysis

Five rural/LMIC studies reported direct and indirect cost outcomes.

- **Kenya (Otoki 2025):** LA reduced total cost (PPP-adjusted) despite longer OR time.
- **India (gasless):** Consumable cost reduced by using reusable trocars and sterilized retrieval bags.
- **USA rural pediatric hospitals (Tom 2019):** No significant difference in total cost, but fewer complications reduced hidden expenses.

Table 5. Cost outcomes

Study	Cost LA (USD/PPP)	Cost OA (USD/PPP)	Direction of effect
Otoki (Kenya, 2025)	$520	$640	Lower with LA
Mishra (India, 2020)	$300	$350	Lower with LA
Tom (USA, 2019)	$5,400	$5,450	Similar

3.4 Feasibility Findings

Gasless Laparoscopy

Registry data from India (Aruparayil 2023) and RCTs (Mishra 2020) confirmed gasless laparoscopy is feasible and safe in rural setups. Conversion to open surgery was <12%, comparable to conventional laparoscopy.

Tele-Mentoring

Two implementation reports documented tele-mentoring programs where rural surgeons received live guidance from tertiary centers. Early evidence showed reduced operative time over successive cases and no increase in complications.

Low-Cost Innovations

Several rural hospitals reported successful adaptations:

- Reusable trocars and ports
- On-table creation of ligature loops
- Sterilized surgical gloves or condom bags for specimen retrieval

Table 6. Feasibility innovations in rural laparoscopy

Innovation	Country	Outcome benefit
Gasless laparoscopy	India	Reduced cost, lower anesthesia requirement
Tele-mentoring	Senegal/India	Improved training, reduced OR time
Reusable trocars	India	Lower consumable cost
Sterilized specimen bag	India	Reduced SSI, affordable replacement

4. Discussion

4.1 Summary of Findings

This systematic review and meta-analysis compared laparoscopic appendectomy (LA) and open appendectomy (OA) with a focus on rural and low-resource hospital contexts. The findings demonstrate that LA provides significant advantages in terms of postoperative recovery. Across multiple studies from sub-Saharan Africa, South Asia, and rural hospitals in high-income countries, LA consistently reduced length of hospital stays (LOS) by 1–3 days and decreased surgical site infection (SSI) rates by 5–15%. Secondary outcomes also favored LA, including lower postoperative pain scores, reduced analgesic requirements, and earlier return to work or normal activities. Cost analyses, though limited, revealed that LA is often cost-neutral or even cost-saving when overall resource use and complication avoidance are considered, despite longer operative times. Intra-abdominal abscess (IAA) rates were comparable between the two techniques, alleviating earlier concerns that LA might increase this risk. Implementation studies further highlighted that innovations such as gasless laparoscopy, tele-mentoring, and low-cost adaptations (e.g., reusable trocars, sterilized retrieval bags) can enable rural hospitals to deliver LA safely and effectively.

4.2 Comparison with Existing Literature

These results align with established evidence from large-scale meta-analyses and Cochrane reviews, which have consistently demonstrated the superiority of LA over OA in terms of postoperative pain, LOS, SSI, and time to return to activity. In high-income, tertiary hospitals, these benefits are well documented and have made LA the global standard of care. However, previous reviews often underrepresent rural and low-resource settings, where contextual factors may alter feasibility and outcomes. The present review adds value by confirming that LA's advantages extend to rural hospitals despite resource constraints, and in some respects, may be even more impactful.

For instance, while a two-day reduction in LOS may appear modest in urban tertiary centers, in rural settings it represents a critical reduction in hospital bed occupancy and patient cost. Similarly, SSI reduction has greater implications in rural communities, where wound care resources are limited and follow-up travel may be prohibitively expensive. These context-specific nuances differentiate the present synthesis from global reviews and underscore the need to interpret surgical outcomes not just in clinical but also in socioeconomic terms.

4.3 Clinical Significance in Rural Setups

The rural implications of these findings are substantial. Shorter LOS directly translates into lower direct healthcare costs for hospitals with limited inpatient capacity and reduces indirect costs for patients, many of whom are primary earners in agrarian economies. Reduced SSI rates mean fewer readmissions and follow-up visits, which is vital in settings where travel to healthcare facilities can involve long distances and financial

hardship. Early return to activity ensures faster resumption of economic productivity, which is critical in subsistence communities. Thus, the clinical benefits of LA align with broader public health and socioeconomic goals in rural regions.

Moreover, hospitals in rural settings often operate with limited surgical capacity and longer stays for one patient can delay treatment for others. By reducing recovery times, LA indirectly increases surgical throughput, allowing hospitals to treat more patients with existing resources. Therefore, LA is not only superior clinically but also enhances system efficiency in low-resource hospitals.

4.4 Safety Concerns

The primary safety concern historically associated with LA has been a potential increase in IAA. While some early studies reported higher IAA rates, particularly in complicated appendicitis, recent data—including those from rural cohorts—show no consistent or statistically significant increase. Standardized intraoperative techniques such as suction-based peritoneal clearance, selective use of drains, and appropriate perioperative antibiotic protocols appear to mitigate this risk.

Another challenge is the learning curve. Inexperienced surgeons may face longer operative times and higher complication rates during the initial phase of adopting LA. Rural hospitals, often staffed by generalists or early-career surgeons, may therefore be disproportionately affected. However, studies using CUSUM analysis in Senegal and tele-mentoring initiatives in India have shown that with structured support, proficiency can be achieved safely and within a relatively short series of cases. Importantly, the learning curve issue emphasizes the need for systemic investment in rural surgical training rather than representing an inherent limitation of LA.

4.5 Implementation Challenges

Despite its advantages, the adoption of LA in rural hospitals faces multiple barriers. Infrastructure remains a critical challenge: laparoscopic towers, reliable electricity, sterilization facilities, and maintenance services are often lacking. Consumable costs, particularly for disposable trocars and specimen retrieval bags, may deter routine use in resource-constrained hospitals. Furthermore, training opportunities in advanced laparoscopy are scarce in rural areas, where surgeons often practice in relative professional isolation.

Several solutions have been proposed and tested. Gasless laparoscopy reduces dependence on CO_2 insufflation and complex anesthesia, making it suitable for hospitals with limited resources. Tele-mentoring enables real-time support from tertiary centers, bridging the training gap and ensuring patient safety during the learning phase. Low-cost innovations, including reusable instruments and improvised specimen retrieval devices, have shown promise in reducing consumable expenses without compromising safety. Collectively, these innovations demonstrate that context-adapted strategies can overcome barriers to implementation and allow rural hospitals to provide laparoscopic care.

4.6 Strengths and Limitations

A major strength of this review is its explicit focus on rural and low-resource hospitals, an area often overlooked in global systematic reviews. By consolidating evidence from LMICs, rural referral hospitals, and implementation studies, it provides a pragmatic understanding of how LA performs outside tertiary centers. Including both clinical and feasibility outcomes also broadens the analysis to incorporate the realities of rural surgical practice.

Nevertheless, several limitations must be acknowledged. First, few randomized controlled trials were conducted specifically in rural settings, meaning that much of the evidence is derived from retrospective cohort studies with inherent risks of bias. Second, heterogeneity across studies was considerable, with variation in case mix (uncomplicated vs complicated appendicitis), surgeon experience, antibiotic protocols, and definitions of outcomes such as SSI. Third, many rural studies had small sample sizes, limiting statistical power. Finally, economic evaluations were sparse and used varying methodologies, making it difficult to draw definitive conclusions about cost-effectiveness across different contexts.

4.7 Future Research

Future work should prioritize well-designed, multicenter RCTs conducted specifically in rural and LMIC contexts to strengthen the evidence base. Cost-effectiveness analyses that incorporate both direct medical costs and indirect socioeconomic costs are essential for informing policy. The role of tele-mentoring and digital surgical education in accelerating the learning curve warrants further evaluation. Additionally, comparative trials of gasless laparoscopy versus conventional laparoscopy could clarify the most scalable approach for rural hospitals. Research should also investigate long-term outcomes such as quality of life and workforce reintegration, which are particularly relevant in rural economies.

4.8 Conclusion of Discussion

Overall, this review confirms that laparoscopic appendectomy offers significant recovery benefits in rural and low-resource hospitals. The clinical advantages—shorter hospital stays, reduced SSI, earlier recovery, and favorable cost implications—are amplified in rural contexts where hospital capacity and patient resources are limited. Safety concerns are manageable with standardized perioperative protocols, and implementation barriers can be addressed through targeted innovations such as gasless laparoscopy, tele-mentoring, and low-cost instruments. Expanding access to LA in rural hospitals is therefore not only clinically justified but also a strategic step toward improving surgical equity and efficiency globally.

5. Conclusion

This systematic review and meta-analysis demonstrate that laparoscopic appendectomy (LA) offers clear and consistent advantages over open appendectomy (OA) in rural and low-resource hospital settings. Across studies from diverse geographic regions, LA was associated with shorter hospital stays, fewer surgical site infections, reduced postoperative pain, and earlier return to normal activity or work. Although operative times were often longer, this drawback was offset by improved recovery profiles and, in many contexts, lower total costs. Importantly, concerns about increased intra-abdominal abscesses were not substantiated when evidence-based intraoperative and perioperative protocols were followed.

Given these findings, LA should be considered the default surgical approach for appendicitis in rural hospitals wherever feasible. Its benefits are not only clinical but also socioeconomic, enabling patients to return to livelihoods sooner and improving hospital efficiency by reducing bed occupancy and complications. The rural context amplifies these advantages, as limited infrastructure, travel burdens, and patient dependence on daily wages make faster recovery particularly valuable.

For policy makers, the implications are clear. Investment is needed in capacity building, including structured laparoscopic training, tele-mentoring systems to support rural surgeons, and deployment of low-cost technologies such as gasless laparoscopy and reusable instruments. These measures can overcome barriers of cost, equipment maintenance, and surgical expertise that have historically limited LA adoption in rural areas.

Practical recommendations include incorporating LA into rural surgical training curricula, prioritizing procurement of adaptable laparoscopic systems, and incentivizing innovation in cost-saving techniques. Supporting rural surgeons in adopting LA as standard practice represents an important step toward equitable, safe, and efficient surgical care delivery.

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