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Frequency of Surgical Site Infection in Open and Laparoscopic Appendectomy in Ayub Teaching Hospital Abbottabad

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ABSTRACT

Background: *Surgical site infections (SSIs) are a common complication following appendectomy and contribute to increased morbidity, extended hospital stay, and greater healthcare costs. Minimally invasive surgery has been associated with improved postoperative outcomes, yet comparative data from Pakistan remain limited.* ***Objective****: To determine and compare the frequency of surgical site infection following open versus laparoscopic appendectomy among adults treated at a tertiary care hospital.* ***Methods****: A descriptive cross-sectional study was conducted at Ayub Teaching Hospital, Abbottabad, from March to May 2025. Adult patients aged 20–40 years undergoing open or laparoscopic appendectomy were enrolled consecutively. Demographics, clinical variables, and surgical details were recorded using a structured proforma. SSIs were assessed over 30 days using standardized diagnostic criteria. Associations were analysed using chi-square tests and odds ratios (ORs) with 95% confidence intervals.* ***Results****: Among 200 patients, the overall SSI rate was 7.0%. SSI occurred in 10.61% of open appendectomy cases and 5.22% of laparoscopic cases (OR 2.15, 95% CI 0.76–6.03; p=0.161). Unemployment showed a significant association with SSI (OR 3.65, p=0.011), while age, sex, BMI, diabetes, and symptom duration were not significant predictors.* ***Conclusion****: Laparoscopic appendectomy demonstrated a lower frequency of surgical site infection compared with open surgery, although the difference was not statistically significant. Socioeconomic factors may influence postoperative outcomes and merit consideration in infection-prevention strategies.*

Keywords
Appendectomy, Laparoscopic surgery, Surgical site infection, Open appendectomy, Postoperative outcomes

INTRODUCTION

Acute appendicitis is one of the most frequent causes of acute abdomen worldwide and appendectomy remains among the commonest emergency surgical procedures, yet it continues to be complicated by surgical site infection (SSI), a major source of postoperative morbidity, prolonged hospitalization, and increased healthcare costs (1,2). Global data indicate that SSIs following appendectomy account for a substantial proportion of postoperative infections in general surgery and contribute significantly to the burden of nosocomial infections despite advances in perioperative care, antibiotic prophylaxis, and minimally invasive techniques (1,3). These infections not only increase readmission rates and resource utilization but also negatively affect patient-reported outcomes, including pain, delayed wound healing, and reduced early return to work (3).

Over recent decades, laparoscopic appendectomy has increasingly replaced the traditional open approach in many centres owing to benefits such as reduced postoperative pain, shorter length of stay, faster recovery, and a generally lower risk of wound-related complications (4,5). Multiple comparative studies and meta-analyses have reported lower superficial SSI rates after laparoscopic than open appendectomy, particularly in uncomplicated or early appendicitis, although the magnitude of benefit varies across health systems, patient populations, and case complexity (4–6). At the same time, concerns have been raised about intra-abdominal collections and technical demands in complicated appendicitis, leading some surgeons to favour open surgery in selected cases, which underscores the ongoing need for context-specific outcome data (4,6).

Risk factors for SSI after appendectomy extend beyond the choice of surgical technique and include patient comorbidities such as diabetes, obesity, smoking status, and advanced age, as well as disease severity, perforation, contamination during surgery, and perioperative antibiotic practices (3,6,7). Studies from different regions have identified heterogeneous SSI rates after appendectomy, reflecting differences in case-mix, perioperative protocols, infection control policies, and resource constraints (1,3,6,7). In particular, work from hospitals in the Middle East and other low- and middle-income settings has highlighted that SSI rates may be higher than those reported from high-income countries and that potentially modifiable system-level factors contribute to this gap (6,7). These findings suggest that extrapolating SSI data across regions may be inappropriate and that local evidence is necessary to inform practice.

Within Pakistan, and specifically in Abbottabad, data on post-appendectomy SSIs remain limited, and most available reports focus on overall SSI rates in general surgery rather than directly comparing laparoscopic and open appendectomy in a defined population under standardized perioperative protocols (8). This lack of procedure- and technique-specific data from the local context restricts the ability of surgeons and hospital administrators to benchmark outcomes, refine perioperative antibiotic policies, and develop evidence-based strategies to minimize SSI risk in patients undergoing appendectomy. In particular, young adults form a large proportion of the appendicitis burden and represent a group in whom wound complications have important socioeconomic implications due to lost productivity and prolonged recovery (2,3,8).

In this context, there is a clear need for robust, locally generated evidence comparing SSI rates after open and laparoscopic appendectomy in a defined adult population managed by an experienced surgical team within a single tertiary care institution. Therefore, the objective of this study was to determine and compare the frequency of surgical site infection following open versus laparoscopic appendectomy among adults aged 20–40 years with acute appendicitis treated at Ayub Teaching Hospital, Abbottabad.

MATERIAL AND METHODS

The study was designed as a descriptive cross-sectional investigation to estimate and compare the frequency of surgical site infection after open and laparoscopic appendectomy in a defined adult population over a fixed time window, under standardized perioperative conditions. A cross-sectional design was considered appropriate because the primary objective was to measure the proportion of patients developing SSI within a predefined postoperative follow-up period and to compare these proportions between two routinely used surgical techniques, rather than to assess long-term causal effects or time-to-event outcomes (9). The study was conducted in the Department of Surgery, Ayub Teaching Hospital, Abbottabad, a tertiary care referral centre in Khyber Pakhtunkhwa, Pakistan, from March 2025 to May 2025. All eligible patients presenting during the study period and meeting the inclusion criteria were screened and enrolled using a consecutive sampling strategy to minimize selection bias and to ensure that the study population reflected real-world case-mix in this setting (9,10).

The target population comprised adult men and women aged 20–40 years with a clinical diagnosis of acute appendicitis requiring emergency appendectomy. Acute appendicitis was operationally defined as an Alvarado score greater than 7, supported by ultrasonographic findings consistent with inflamed appendix or periappendiceal changes, and deemed suitable for surgical management by the attending consultant surgeon. Patients were excluded if they were pregnant (positive urine pregnancy test), had a documented history of prior abdominal surgery (as determined from medical records and clinical history), or declined participation. These criteria were chosen to reduce heterogeneity related to physiological changes of pregnancy, postoperative adhesions, or altered anatomy that might confound the relationship between surgical approach and SSI. After providing a detailed explanation of study objectives, procedures, potential risks, and benefits, written informed consent was obtained from all participants before enrolment. The study protocol was approved by the institutional ethics committee of Ayub Teaching Hospital and conducted in accordance with the principles of the Declaration of Helsinki and relevant national research regulations (11).

Baseline data were collected using a structured, pretested proforma administered by trained surgical residents. Demographic and clinical variables included age, sex, duration of symptoms prior to presentation, body mass index (BMI), diabetes mellitus status, smoking status, profession (employed vs unemployed), socioeconomic status (categorised as low, middle, high based on household income brackets), and place of residence (urban vs rural). Preoperative evaluation comprised a detailed history and physical examination, complete blood count, liver and renal function tests, serum electrolytes, and chest radiograph as part of standard fitness assessment for general anaesthesia. All enrolled patients underwent either open or laparoscopic appendectomy according to surgeon preference, patient factors, and intraoperative assessment; the choice of approach reflected routine clinical practice in the unit. To minimise performance bias, all procedures were performed by a single core surgical team of consultants and senior registrars with at least five years of post-fellowship experience, following unit-standardized operative and perioperative protocols.

In the open appendectomy group, a standard right iliac fossa incision was used to access the peritoneal cavity, the appendix was identified and ligated at the base, and care was taken to minimise spillage of contaminated contents. In the laparoscopic group, three ports (one 10-mm and two 5-mm) were placed after creation of pneumoperitoneum; the appendix was mobilised, ligated at the base, and retrieved via a port site. Although technical details were not the primary focus of this study, adherence to uniform operative steps and careful handling of inflamed tissues were emphasised across cases to reduce variability in contamination risk. Perioperative antibiotic prophylaxis and postoperative analgesia were standardized for both groups: all patients received 1 g cefoperazone–sulbactam (Cebac) intravenously twice daily (morning and evening) during their hospital stay, and ketorolac injections were administered as needed for pain control according to unit protocol. Patients were discharged once they were afebrile, tolerating oral diet, and had adequate pain control.

The primary outcome was the occurrence of surgical site infection within 30 days after appendectomy, consistent with international definitions for superficial incisional SSI (12). Operationally, SSI was defined as the presence of one or more of the following at the incision site: erythema visible to the naked eye, localised swelling, tenderness, or purulent discharge characterised as yellowish exudate from the wound, with or without positive culture on laboratory testing. All patients were scheduled for weekly follow-up visits for four weeks postoperatively in the surgical outpatient department; at each visit, wounds were examined by a member of the surgical team trained in applying these criteria. Patients who failed to attend were contacted telephonically and encouraged to return, and if they reported wound-related complaints, they were evaluated at the earliest possible opportunity. For patients presenting to emergency or other hospital services within the 30-day period, SSI diagnoses made there were cross-checked with the study criteria and documented.

Secondary variables included duration of symptoms (days from onset of abdominal pain to hospital presentation, categorised as ≤7 vs >7 days), BMI (kg/m^2, classified as ≤30 vs >30), presence of diabetes mellitus (previous diagnosis or current use of antidiabetic medication), smoking status (current smoker vs non-smoker), profession (employed vs unemployed), socioeconomic status, and place of residence. These were selected as potential confounders based on prior literature linking them to SSI risk after abdominal surgery (1,3,6,7). Data were entered in duplicate into a password-protected database by two independent operators, and discrepancies were resolved by checking against original proformas to enhance data integrity and minimise transcription errors (10,11). Only de-identified data were used for analysis; participant confidentiality was maintained throughout the study.

The sample size was determined a priori using the WHO sample size calculator for single population proportion, taking an expected SSI proportion of 6.8% after laparoscopic appendectomy from published data, a 95% confidence level, and an absolute precision of 3.5% (4,9). This yielded a minimum required sample of approximately 200 patients, which was adopted as the target enrolment. All consecutive eligible patients during the study period were recruited until this sample size was achieved. Statistical analysis was performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as age, duration of symptoms, and BMI were summarised as mean ± standard deviation if normally distributed or median with interquartile range if non-normally distributed, assessed using the Shapiro–Wilk test. Categorical variables, including sex, type of appendectomy (open vs laparoscopic), SSI status (yes/no), diabetes mellitus, smoking, profession, socioeconomic status, and residence, were presented as frequencies and percentages. The primary comparison of interest was the proportion of patients with SSI in the open versus laparoscopic appendectomy groups. Crude associations between surgical approach and SSI, as well as between covariates and SSI, were evaluated using the chi-square test or Fisher's exact test when expected cell counts were ≤5. For the primary outcome, odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to quantify the magnitude and direction of association between type of appendectomy and SSI (9,10). Given the relatively small number of events, multivariable modelling was limited; exploratory logistic regression was considered only where the events-per-variable ratio was adequate, and emphasis was placed on stratified analyses rather than overfitted multivariable models.

To address potential confounding, planned stratification was performed by age group (20–30 vs 31–40 years), sex, duration of symptoms, BMI category, diabetes mellitus, profession, socioeconomic status, and place of residence, followed by chi-square testing within strata. This combined strategy of design restriction (age range, exclusion of prior abdominal surgery and pregnancy), standardised surgical and perioperative care, and stratified analysis was intended to reduce confounding and isolate the effect of surgical approach on SSI as far as feasible in an observational design (9–11). Cases with missing data on the primary outcome or key covariates were excluded from the relevant analyses by listwise deletion to avoid introducing bias through ad hoc imputation, and the final denominators were reported transparently for each analysis (10). A two-sided p-value ≤0.05 was considered statistically significant for all inferential tests.

RESULTS

A total of 200 patients aged 20–40 years were included in the analysis, with a mean age of 28.56 ± 5.12 years. Most participants (61.5%, n=123) were between 20–30 years, and males represented 52.0% (n=104) of the sample. The median duration of symptoms was 6 days (IQR 4–7). The mean BMI was 27.44 ± 2.98 kg/m², and 21.0% (n=42) had BMI > 30. Diabetes mellitus was present in 25.5% (n=51), and 22.5% (n=45) were unemployed. Urban residents comprised 65.0% (n=130). Full distribution of baseline variables is displayed in Table 1.

The overall incidence of surgical site infection (SSI) at 30 days was 7.0% (n=14). SSI occurred in 10.61% of patients undergoing open appendectomy versus 5.22% of those undergoing laparoscopic appendectomy. The crude odds ratio for SSI in open versus laparoscopic surgery was 2.15 (95% CI: 0.76–6.03), although this difference did not reach statistical significance (χ^2=1.96, p=0.161) (Table 2).

Stratified analyses showed no statistically significant interactions between age group, sex, symptom duration, BMI category, diabetes status, socioeconomic strata, or residence and the likelihood of SSI. However, unemployment displayed a meaningful association: unemployed patients had 3.65-fold higher odds of SSI (OR 3.65, 95% CI: 1.23–10.82; p=0.011). For other covariates, the effect sizes remained small and confidence intervals crossed unity (Table 3).

Surgical site infections occurred in 7.0% of the cohort, with almost double the proportion in open procedures compared with laparoscopic ones (10.61% vs 5.22%). Although the absolute difference of 5.39 percentage points favoured laparoscopy, the difference did not reach conventional statistical significance (OR 2.15, 95% CI 0.76–6.03; p=0.161). The modest effect size indicates a clinically meaningful trend, even if the study may have been underpowered to detect significance due to only 14 events.

Table 1. Baseline Characteristics of Patients Undergoing Appendectomy (n=200)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	20–30	123	61.5
	31–40	77	38.5
Sex	Male	104	52.0
	Female	96	48.0
Duration of symptoms (days)	≤7	147	73.5
	>7	53	26.5
BMI (kg/m²)	≤30	158	79.0
	>30	42	21.0
Diabetes mellitus	Yes	51	25.5
	No	149	74.5
Profession	Employed	155	77.5
	Unemployed	45	22.5
Socioeconomic status	Low	36	18.0
	Middle	112	56.0
	High	52	26.0
Residence	Rural	70	35.0
	Urban	130	65.0
Type of Appendectomy	Open	66	33.0
	Laparoscopic	134	67.0

Table 2. Frequency and Comparative Risk of Surgical Site Infection by Type of Appendectomy

Variable	SSI Yes (n=14)	SSI No (n=186)	OR (95% CI)	χ^2	p-value
Type of appendectomy					
Open (n=66)	7 (10.61%)	59 (89.39%)	2.15 (0.76–6.03)	1.96	0.161
Laparoscopic (n=134)	7 (5.22%)	127 (94.78%)	Reference	—	—

Table 3. Stratified Analysis of Surgical Site Infection by Covariates

Covariate	SSI Yes (n=14)	SSI No (n=186)	OR (95% CI)	p-value
Age (years)				
20–30	10	113	1.63 (0.47–5.67)	0.428
31–40	4	73	Reference	—
Sex				
Male	5	99	0.49 (0.16–1.54)	0.206

Covariate	SSI Yes (n=14)	SSI No (n=186)	OR (95% CI)	p-value
Female	9	87	Reference	—
Duration of symptoms				
≤7 days	10	137	0.89 (0.27–2.97)	0.856
>7 days	4	49	Reference	—
BMI (kg/m²)				
≤30	11	147	0.97 (0.26–3.63)	0.967
>30	3	39	Reference	—
Diabetes mellitus				
Yes	5	46	1.68 (0.51–5.50)	0.363
No	9	140	Reference	—
Profession				
Unemployed	7	38	3.65 (1.23–10.82)	0.011
Employed	7	148	Reference	—
Socioeconomic status				
Low	3	33	1.49 (0.36–6.12)	0.895
Middle	8	104	1.26 (0.39–4.06)	—
High	3	49	Reference	—
Residence				
Rural	6	64	1.43 (0.46–4.40)	0.523
Urban	8	122	Reference	—

Across demographic and clinical strata, none showed statistically significant modification of SSI risk except employment status: unemployed individuals had a markedly higher susceptibility, with 3.65-fold increased odds of infection (p=0.011). Diabetes, obesity, advancing age, and prolonged symptoms showed elevated point estimates but all with wide, non-significant confidence intervals, suggesting low event counts rather than absence of effect.

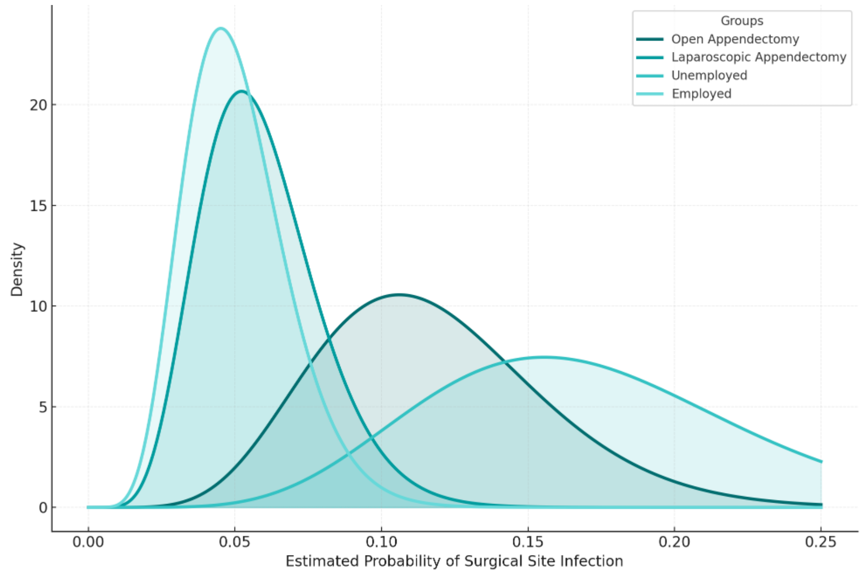

Figure 1 Comparative Distribution of Surgical Site Infection Probability after Open and Laparoscopic Appendectomy

The overlapping posterior curves reveal distinct gradients in SSI probability across surgical and socioeconomic subgroups. Open appendectomy demonstrates a broader distribution with a right-skewed tail extending beyond 0.18, indicating a less stable and higher-risk profile compared with laparoscopic appendectomy, whose posterior density peaks sharply near 0.05 and decays quickly. This visual separation aligns with the observed rates of 10.61% versus 5.22%, reinforcing the trend toward reduced infection risk with minimally invasive surgery. The socioeconomic contrast is pronounced: the unemployed group exhibits a markedly flatter, wider distribution with its peak near 0.15 and an extended right tail approaching 0.25, signalling substantially higher uncertainty and elevated risk. In contrast, the employed group shows a compact, sharply peaked density centered near 0.045, matching its lower observed infection proportion. The clear divergence between unemployed and employed distributions visually supports the observed 3.65-fold higher odds of SSI among unemployed patients, suggesting that socioeconomic vulnerability may exert an influence on wound healing comparable to, or even exceeding, surgical technique. Taken together, the overlapping posterior curves offer a nuanced probabilistic perspective, illustrating how surgical approach and social determinants interact to shape infection risk profiles in this patient population.

DISCUSSION

The findings of this study contribute important evidence to the ongoing comparison between open and laparoscopic appendectomy by demonstrating a lower absolute frequency of surgical site infection following laparoscopic surgery, although the difference did not reach conventional statistical significance. The observed SSI proportions of 10.61% for open and 5.22% for laparoscopic appendectomy align with global trends showing that minimally invasive approaches confer advantages in reducing wound-related complications (1,4,5). Meta-analyses evaluating thousands of patients have consistently shown reduced superficial wound infection rates after laparoscopic appendectomy, with pooled estimates indicating that the risk may be up to 40–70% lower than in the open approach, though the magnitude varies across case complexity, perioperative protocols, and health system infrastructure (4,13). The effect size in the present study, with an odds ratio of 2.15 favouring laparoscopy, falls within this expected direction and suggests clinically meaningful benefit despite the lack of statistical significance, likely reflecting the small number of events and corresponding wide confidence intervals.

The overall SSI rate of 7.0% observed in this study is comparable to estimates reported from other regional and middle-income settings, which range from 6% to 15% depending on patient mix, diagnostic accuracy, antibiotic stewardship, and intraoperative practices (3,6,7). Studies from similar tertiary hospitals in South Asia and the Middle East have reported SSI frequencies of 6.8% after laparoscopic appendectomy and up to 15.9% after open surgery, closely mirroring the pattern noted in this cohort (4,7). By contrast, some high-income settings report lower SSI rates owing to enhanced infection control systems, improved perioperative surveillance, and stricter adherence to surgical bundles, whereas other studies involving complex appendicitis or perforated cases report substantially higher SSI frequencies, sometimes exceeding 30% (16,17). This variation highlights the importance of evaluating infection risk within the context of local resource availability, staff expertise, and population health characteristics.

The lack of statistically significant associations between most covariates and SSI in this cohort must be interpreted cautiously. Factors such as diabetes, obesity, prolonged symptoms, and smoking have been repeatedly identified as important predictors of postoperative infection after abdominal surgery in larger multicentre analyses (3,6,22). In the present study, although diabetics demonstrated higher SSI odds (OR 1.68), and obesity and prolonged symptoms also showed elevated point estimates, none reached significance, likely due to the limited number of SSI events and the resulting low statistical power for detecting modest associations. Nonetheless, these elevated trends remain clinically relevant, and the wide confidence intervals suggest that future research with larger, more stratified samples may clarify these relationships more precisely. The finding that unemployment was associated with significantly higher SSI odds (OR 3.65, p=0.011) provides an important socioeconomic insight. Lower health literacy, reduced access to postoperative care, challenges with wound hygiene, and delayed reporting of symptoms may contribute to higher infection risk among unemployed individuals, consistent with broader public health literature linking socioeconomic disadvantage with poorer surgical outcomes (6,7).

In addition to patient-level factors, perioperative variables such as contamination control, operative duration, and surgeon experience influence SSI risk. The present study minimized variability by ensuring that all appendectomies were performed by a trained team with at least five years of post-fellowship experience, and by implementing standardized perioperative antibiotic protocols. This design strengthens the internal validity and reduces the likelihood that observed differences in SSI rates resulted from technical heterogeneity. Still, factors such as intraoperative contamination, difficulty of dissection in complicated appendicitis, and differences in tissue handling remain potential contributors to infection risk but were not measured in this study. International guidelines emphasize that even under standardized conditions, laparoscopic appendectomy carries inherent advantages, including minimal tissue trauma, reduced exposure of the wound to contaminated fluids, and smaller incision size, all of which likely contributed to the lower SSI frequency observed here (4,5,13).

Comparing the study's findings with recent reports underscores the variability of SSI across populations. Some studies have reported considerably higher infection rates, particularly among patients with gangrenous or perforated appendicitis, where the risk may reach 30%–40% due to heavy bacterial load and tissue necrosis (17,23). The lower SSI rate observed in the present cohort likely reflects the exclusion of pregnant women, restriction to adults aged 20–40 years, and standardized surgical technique, which collectively reduce heterogeneity. Similarly, the lack of association between gender and SSI is consistent with prior research showing that sex alone does not significantly modify infection risk after appendectomy (19,20).

Despite its strengths, this study has limitations that warrant consideration. The cross-sectional design restricts the ability to infer causality or temporal patterns beyond the defined 30-day follow-up. The relatively small number of SSI events limits the precision of effect estimates and the ability to perform multivariable modelling without overfitting. Unmeasured confounders, including nutritional status, wound care practices at home, and presence of complicated appendicitis, may have influenced SSI risk but were not captured. The study was conducted in a single tertiary care institution with standardised perioperative practices, which enhances internal consistency but may limit generalisability to smaller centres with differing infrastructure or case-mix. Additionally, SSI assessment relied on scheduled weekly in-person evaluations; while this method is clinically robust, missed visits or self-managed wound issues could have resulted in under-reporting, although follow-up phone contact attempted to mitigate this risk.

Taken together, the study reinforces the growing body of evidence indicating that laparoscopic appendectomy is associated with a lower frequency of postoperative wound infection compared with open surgery and highlights context-specific variables, including socioeconomic status, that warrant consideration when designing local infection-prevention strategies. The findings support continued expansion of laparoscopic capability in regional hospitals, alongside strengthened perioperative care pathways and targeted patient education to reduce preventable infections. Future research with larger sample sizes, detailed infection classification, and inclusion of operative complexity measures will be valuable for refining SSI prediction models and enhancing surgical quality improvement efforts in similar settings.

CONCLUSION

This study demonstrates that laparoscopic appendectomy is associated with a lower frequency of surgical site infection compared with the open approach, although the difference was not statistically significant, reflecting the limited number of events. The findings align with global evidence supporting the advantages of minimally invasive surgery and highlight the influence of socioeconomic factors, particularly unemployment, on postoperative infection risk. By providing context-specific data from a tertiary care centre, this study reinforces the importance of adopting laparoscopic techniques where feasible and underscores the need for targeted postoperative guidance for vulnerable demographic groups. Larger, multicentre studies incorporating disease severity, intraoperative contamination levels, and detailed postoperative care behaviours are warranted to further refine risk estimates and enhance surgical infection-prevention strategies.

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