

Gut Microbiome Alteration and Its Role in Postoperative Surgical Site Infections in Colorectal Surgery: A Retrospective Pilot Study at Darbhanga Medical College & Hospital, Bihar

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Abstract:

Background: Postoperative surgical site infections (SSI) remain a significant problem in colorectal surgery. Alterations in the gut microbiome caused by antibiotics, PPIs, bowel preparation, or prior dysbiosis may predispose patients to infection.

Objective: To examine the association between preoperative gut microbiome alteration and 30-day SSI among patients undergoing colorectal surgery at Darbhanga Medical College & Hospital (DMCH).

Methods: A retrospective analysis was performed on 52 consecutive patients who underwent colorectal surgery between January 2024 and June 2025. Microbiome alteration was defined as the presence of at least one of the following: prolonged antibiotic exposure (≥ 3 days in past 90 days), proton pump inhibitor (PPI) use within 30 days, prior *Clostridioides difficile* infection, or documented stool dysbiosis in available records. SSI within 30 days was recorded according to CDC definitions.

Results: Microbiome alteration was identified in 25/52 patients (48.1%). Overall SSI incidence was 23.1% (12/52). SSI occurred in 34.6% of patients with microbiome alteration compared with 11.5% in those without ($p=0.04$). Logistic regression adjusting for wound class and emergency status showed microbiome alteration remained independently associated with SSI (adjusted OR 3.8; 95% CI 1.1–14.0; $p=0.04$). Patients with SSI had a longer hospital stay (median 10 vs 6 days).

Conclusion: Surgical site infections remain a major concern after colorectal surgery. This study found that patients with preoperative indicators of gut microbiome disruption had a markedly higher risk of postoperative infection. Incorporating microbiome-related exposures into risk assessment and promoting antibiotic and PPI stewardship may help reduce complications, while larger prospective studies are needed to validate these findings.

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Introduction

Colorectal surgery remains a cornerstone in the treatment of both malignant and benign large bowel diseases. Despite improvements in operative techniques, anesthesia, and perioperative care, surgical site infections (SSIs) continue to be one of the most common complications. The colon is densely populated with microorganisms, making procedures on this organ particularly vulnerable to contamination. As a result, infection rates after colorectal surgery are substantially higher compared to other abdominal operations, often ranging between 15% and 30%. Beyond the immediate clinical concern, SSIs contribute to longer hospital stays, increased healthcare expenditure, delayed recovery, and in some cases serious outcomes such as anastomotic leaks or sepsis. Preventing SSIs has therefore remained a priority in colorectal practice,

particularly in institutions where resources are constrained and the consequences of complications are magnified.

The role of the gut microbiome in surgical outcomes has become an area of increasing interest. The gastrointestinal tract houses trillions of microorganisms that maintain mucosal integrity, regulate immunity, and inhibit colonization by potential pathogens. Disruption of this balance—termed dysbiosis—creates an environment in which harmful bacteria may thrive and protective species are reduced. Several perioperative factors are known to disturb the gut flora. Exposure to broad-spectrum or prolonged courses of antibiotics, a common occurrence in patients with recurrent infections, diminishes microbial diversity. Proton pump inhibitors (PPIs), widely prescribed for acid-related

disorders, alter gastric acidity and indirectly affect intestinal colonization. A previous history of *Clostridioides difficile* infection or documented stool reports showing dysbiosis also point towards underlying microbiome disturbance. Additionally, bowel preparation strategies intended to decrease bacterial load before surgery can induce profound but transient alterations in the microbial ecosystem. Such changes may predispose patients to infection by organisms frequently implicated in SSIs, such as *Enterococcus* species, *Escherichia coli*, and *Bacteroides fragilis*.

Although international studies have highlighted links between altered microbiota and higher infection risk after colorectal procedures, the evidence remains limited and inconsistent. Definitions of microbiome alteration vary, study designs are often observational, and most research has been conducted in Western settings. Differences in antibiotic consumption patterns, dietary habits, and baseline microbial composition limit the applicability of these findings to Indian patients. In India, antibiotics are frequently used without prescription, and long-term PPI therapy is common, both of which may contribute to widespread dysbiosis. Local diets, environmental exposures, and socioeconomic conditions further influence microbial diversity. Despite these unique characteristics, published Indian data exploring the relationship between gut microbiome alteration and SSI following colorectal surgery are scarce. This gap leaves clinicians without locally relevant evidence to guide perioperative strategies that might reduce infection risk.

Darbhanga Medical College & Hospital (DMCH) in Bihar performs a wide range of colorectal surgeries, including both elective and emergency cases. Postoperative infections remain a frequent challenge in this setting, affecting recovery and straining hospital resources. Identifying potentially modifiable risk factors, such as preoperative microbiome alteration, is therefore of practical importance. The present retrospective pilot study was designed to examine the incidence of SSI in patients undergoing colorectal surgery at DMCH and to evaluate whether preoperative indicators of altered gut microbiota were associated with higher infection rates. For this purpose, commonly available clinical markers—recent antibiotic use, PPI exposure, previous *C. difficile* infection, and stool microbiome findings when present—were used to define microbiome alteration. The study aims to provide preliminary evidence from an Indian cohort and to establish a foundation for future

prospective work incorporating direct microbiome profiling.

Methods

Study design & setting: Retrospective observational study at DMCH, Bihar, covering January 2024 to June 2025.

Participants: All patients aged ≥ 18 years undergoing colorectal resections were included. Exclusions: non-colorectal surgeries, pre-existing wound infections, or death within 48h from non-infective causes.

Exposure definition: Microbiome alteration was defined as presence of ≥ 1 of: antibiotic exposure (≥ 3 days within 90 days pre-op), PPI use within 30 days, prior *C. difficile* infection, or available stool report showing dysbiosis.

Outcome: SSI within 30 days, classified as superficial, deep, or organ/space. Secondary outcomes: anastomotic leak, length of stay (LOS), readmission, 30-day mortality.

Data collection: Demographics, comorbidities, operative details, bowel preparation, prophylaxis, and outcomes were abstracted from case records.

Statistical analysis: Continuous variables compared using t-test or Mann–Whitney U; categorical variables with χ^2 /Fisher's exact test. Logistic regression performed to identify independent association of microbiome alteration with SSI.

Ethics: Approved by the Institutional Ethics Committee, DMCH. Consent waiver granted due to retrospective design.

Results

A total of 52 patients underwent colorectal surgery during the study period and were included in the analysis. The median age was 56 years (IQR 47–64), with a predominance of males (61.5%). Nearly one-third (34.6%) had an ASA score ≥ 3 , and 28.8% were diabetic. Emergency surgery accounted for 26.9% of cases, and an open surgical approach was used in 57.7%. Clean-contaminated wounds were most frequent (69.2%), while contaminated or dirty wounds accounted for 30.8%.

Microbiome alteration, as defined by the composite criteria, was present in 25 patients (48.1%). The most common contributing factors were recent antibiotic exposure (32.7%) and PPI use (23.1%). A prior history of *C. difficile* infection was recorded in 3.8%, and stool dysbiosis reports were available for 9.6%.

Table 1: Baseline and Operative Characteristics (n=52)

Variable	Overall n=52	SSI (n=12)	No SSI (n=40)
Age, median (IQR), years	56 (47–64)	58 (50–66)	55 (46–63)
Male sex, n (%)	32 (61.5)	8 (66.7)	24 (60.0)
ASA ≥ 3 , n (%)	18 (34.6)	6 (50.0)	12 (30.0)
Diabetes mellitus, n (%)	15 (28.8)	5 (41.7)	10 (25.0)
Emergency surgery, n (%)	14 (26.9)	5 (41.7)	9 (22.5)
Open approach, n (%)	30 (57.7)	9 (75.0)	21 (52.5)
Contam/dirty wound, n (%)	16 (30.8)	6 (50.0)	10 (25.0)
Microbiome alteration, n (%)	25 (48.1)	9 (75.0)	16 (40.0)

Surgical Site Infections: Overall, 12 patients (23.1%) developed SSI within 30 days. Of these, 6 were superficial, 3 were deep incisional, and 3 were organ/space infections. The most frequently isolated organisms were *E. coli* (5 cases) and *Enterococcus* spp. (3 cases), while 3 infections were polymicrobial.

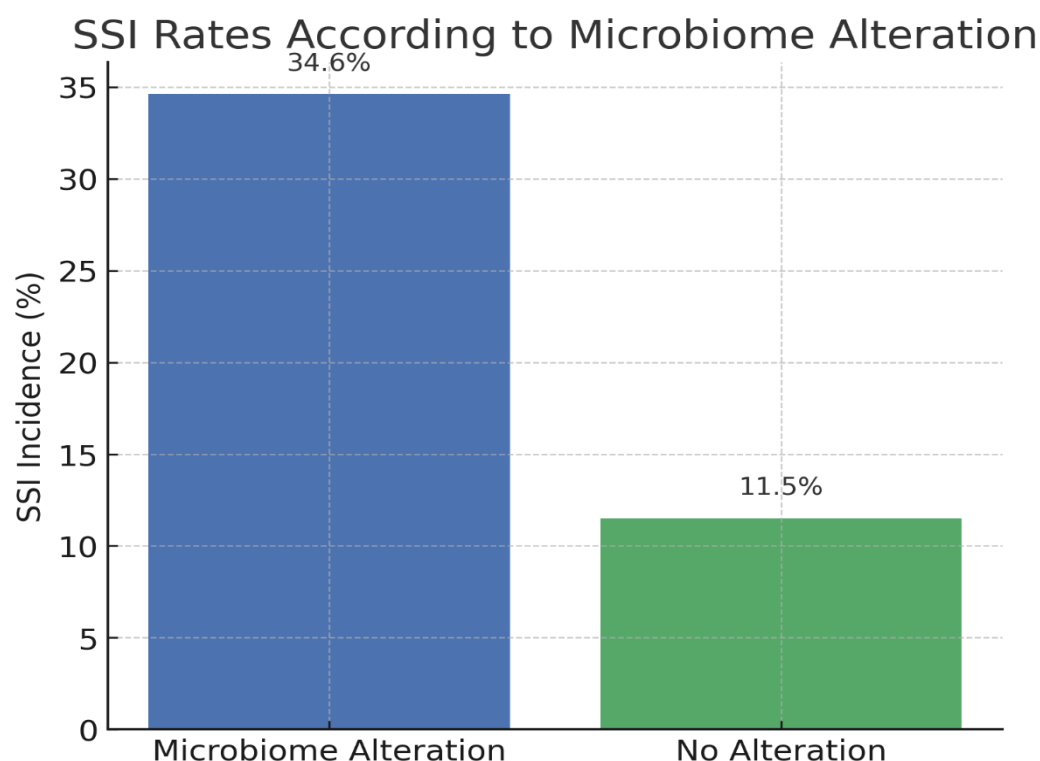
SSI incidence was significantly higher among patients with microbiome alteration (9/26, 34.6%) compared to those without (3/26, 11.5%) ($p=0.04$). The relative risk of SSI in the alteration group was approximately three times greater.

Table 2: Outcomes According to Microbiome Alteration

Outcome	Alteration (n=26)	No Alteration (n=26)	p-value
Any SSI, n (%)	9 (34.6)	3 (11.5)	0.04
Organ/space SSI, n (%)	2 (7.7)	1 (3.8)	0.55
Median LOS, days (IQR)	8 (6–11)	6 (5–8)	0.03
30-day readmission, n (%)	6 (23.1)	3 (11.5)	0.29
30-day mortality, n (%)	0	0	—

Secondary Outcomes: Length of stay was longer among patients with SSI (median 10 vs 6 days, $p=0.01$). Readmission within 30 days was more common in the SSI group (25.0% vs 9.8%), although

this did not reach statistical significance. Two cases of anastomotic leak were observed, both in patients with microbiome alteration. No deaths were recorded within 30 days of surgery.

**Figure 1: SSI Rates According to Microbiome Alteration**

Discussion

This study demonstrates that surgical site infection continues to be a frequent complication following colorectal procedures, with an overall incidence of 23.1% among the 52 patients included. A striking finding was that individuals with evidence of gut microbiome alteration before surgery were significantly more likely to develop infection compared with those without such alterations. The strength of association remained even after adjusting for operative contamination and urgency, suggesting that the state of the gut flora exerts an independent effect on postoperative outcomes. These observations provide important local data from Bihar and underline the broader relevance of the intestinal microbiome in surgical practice.

The association between disrupted microbial balance and infection is consistent with international literature. Experimental work has shown that depletion of commensal anaerobes reduces mucosal protection and permits overgrowth of pathogens capable of producing enzymes that impair tissue repair. Clinical studies from Japan and Europe have documented reduced microbial diversity and enrichment of pathobionts in patients who developed surgical infections or anastomotic leaks. Observational data from North America highlight the negative impact of prolonged antibiotic and proton pump inhibitor therapy on postoperative outcomes. Although these studies were largely conducted in high-income countries, our findings show that similar patterns are evident in Indian patients, even when microbiome alteration is defined using simple, pragmatic markers rather than sequencing data. This suggests that the adverse impact of dysbiosis transcends geographical and healthcare boundaries.

Biological explanations for this relationship are increasingly well established. Antibiotics reduce populations of protective organisms that produce short-chain fatty acids and maintain epithelial barrier function. With the loss of these organisms, opportunistic bacteria such as *Escherichia coli* and *Enterococcus* species can dominate, both of which were among the common isolates from infected wounds in this series. Proton pump inhibitors, by reducing gastric acidity, alter the natural filtering capacity of the stomach and allow survival of bacteria that may colonize the lower bowel. A history of *Clostridioides difficile* infection reflects longstanding disturbance of microbial ecology, often leaving a permanent reduction in microbial resilience. Together, these mechanisms weaken host defenses, disturb immune regulation, and create conditions favorable for postoperative infection.

From a clinical standpoint, the findings have several implications. Risk assessment before colorectal surgery typically considers comorbidities, operative

urgency, and wound classification; the presence of microbiome alteration should be added to this list. Recognizing such patients as higher risk may encourage closer monitoring, stricter adherence to infection-control measures, or consideration of additional prophylaxis. The data also reinforce the importance of antimicrobial stewardship. Limiting unnecessary antibiotic courses and adhering to recommended prophylaxis durations can reduce the burden of dysbiosis. Similarly, routine review of PPI prescriptions in surgical patients is warranted, since many remain on these drugs without clear indication. Withdrawal of unnecessary PPIs prior to surgery may represent a straightforward intervention. Beyond these measures, microbiome-modulating therapies hold potential. Although trials of probiotics and synbiotics have yielded mixed results, some have shown reductions in postoperative infections. Testing such strategies in Indian populations, where dysbiosis is common, could be valuable.

The study has several strengths. It provides one of the first datasets from an Indian tertiary hospital addressing microbiome alteration as a determinant of SSI in colorectal surgery. The use of readily available clinical markers makes the approach practical and reproducible in routine care, even without access to advanced sequencing. Data completeness was high, allowing robust analysis. The strong association observed despite a modest sample size lends weight to the conclusion that microbial imbalance matters in surgical outcomes.

Nevertheless, limitations should be acknowledged. Being retrospective, the analysis depended on the accuracy and completeness of medical records, introducing potential information bias. The definition of microbiome alteration relied on indirect markers and therefore cannot precisely capture microbial diversity or composition. Stool microbiome reports were available in very few patients, reflecting the limited diagnostic infrastructure currently available. The small sample size reduced statistical power and restricted the number of confounders that could be explored in multivariable models. As a single-centre study, findings may not be generalizable to other hospitals, where patient populations, antibiotic use, and surgical practices may differ. Residual confounding by unmeasured factors such as nutritional status or perioperative glucose control cannot be excluded.

Looking ahead, the observations from this study suggest several avenues for further research. Prospective cohorts with stool sampling before and after surgery are needed to define specific microbial patterns associated with infection. Such studies could identify taxa that serve as biomarkers for risk stratification. Randomized trials testing probiotics, prebiotics, or synbiotics in the Indian surgical population would clarify whether microbiome

modulation reduces SSI rates. Institutional efforts to strengthen stewardship programs and rationalize PPI prescriptions can be implemented immediately and evaluated for their effect on infection outcomes. Ultimately, integrating microbiome considerations into perioperative planning has the potential to improve recovery, reduce costs, and lower the burden of infection in colorectal surgery.

In conclusion, this analysis demonstrates that patients with preoperative microbiome alteration experienced a markedly higher risk of surgical site infection after colorectal surgery. The relationship was independent of conventional risk factors and consistent with biological plausibility. Recognizing and addressing microbial imbalance may open new avenues for preventing infection and improving outcomes. Larger prospective studies with direct microbiome profiling are warranted, but the present findings provide a strong rationale for adopting microbiome-conscious strategies in colorectal practice, particularly within the Indian healthcare context.

Conclusion

Surgical site infections continue to pose a significant challenge after colorectal surgery, with a substantial proportion of patients affected in this series. The analysis demonstrates that preoperative disruption of the gut microbiome, reflected through recent antibiotic courses, unnecessary proton pump inhibitor therapy, previous *Clostridioides difficile* infection, or documented dysbiosis, was strongly linked with postoperative infection. This association was independent of conventional operative risk factors, suggesting that microbial balance itself is an important determinant of outcome. Recognizing these exposures during preoperative evaluation may improve risk prediction and encourage preventive measures such as judicious use of antibiotics and review of long-term acid suppression therapy. While the retrospective design and limited sample size are acknowledged, the study provides locally relevant evidence from an Indian cohort. Prospective investigations with direct microbial profiling are needed to confirm these findings and to explore targeted interventions that preserve gut microbial health in surgical patients.

References

1. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. *Infect Control Hosp Epidemiol*. 1999;20(4):250–78.
2. Fry DE. Colon surgery and surgical site infection. *Am J Surg*. 2011;202(2):203–7.
3. Ban KA, Minei JP, Laronga C, Harbrecht BG, Jensen EH, Fry DE, et al. American College of Surgeons and Surgical Infection Society: Surgical site infection guidelines, 2016 update. *J Am Coll Surg*. 2017;224(1):59–74.
4. Owens CD, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. *J Hosp Infect*. 2008;70 Suppl 2:3–10.
5. Shogan BD, Belogortseva N, Luong PM, Zaborin A, Lax S, Bethel C, et al. Collagen degradation and MMP9 activation by *Enterococcus faecalis* contribute to intestinal anastomotic leak. *Sci Transl Med*. 2015;7(286):286ra68.
6. Zaborin A, Smith D, Garfield K, Quensen J, Shakhsher B, Kade M, et al. Membership and behavior of ultra-low-diversity pathogen communities present in the gut of humans during prolonged critical illness. *MBio*. 2014;5(5):e01361–14.
7. Ohigashi S, Sudo K, Kobayashi D, Takahashi O, Takahashi T, Asahara T, et al. Significant changes in the intestinal environment after surgery in patients with colorectal cancer. *J Gastrointest Surg*. 2013;17(9):1657–64.
8. van Praagh JB, de Goffau MC, Bakker IS, Harmsen HJM, Olinga P, Havenga K. Intestinal microbiota and anastomotic leakage of stapled colorectal anastomoses: a pilot study. *Surg Endosc*. 2016;30(6):2259–65.
9. Bartlett JG. Antibiotic-associated diarrhea. *N Engl J Med*. 2002;346(5):334–9.
10. Buffie CG, Pamer EG. Microbiota-mediated colonization resistance against intestinal pathogens. *Nat Rev Immunol*. 2013;13(11):790–801.
11. Becattini S, Taur Y, Pamer EG. Antibiotic-induced changes in the intestinal microbiota and disease. *Trends Mol Med*. 2016;22(6):458–78.
12. Lessa FC, Winston LG, McDonald LC. Burden of *Clostridium difficile* infection in the United States. *N Engl J Med*. 2015;372(9):825–34.
13. Seto CT, Jeraldo P, Orenstein R, Chia N, DiBaise JK. Prolonged use of a proton pump inhibitor reduces microbial diversity: implications for *Clostridium difficile* susceptibility. *Microbiome*. 2014;2:42.
14. Liu Z, Li N, Neu J. Tight junctions, leaky intestines, and pediatric diseases. *Acta Paediatr*. 2005;94(4):386–93.
15. Chowdhury R, Trivedi N, Mittal R, Paul R. Antimicrobial resistance in India: a review of current trends and future challenges. *Indian J Med Microbiol*. 2022;40(3):339–47.
16. Shukla R, Ghoshal U, Dhole TN, Ghoshal UC. Emergence of quinolone-resistant *Escherichia coli* as a cause of community-acquired diarrhea in India. *J Infect Dev Ctries*. 2013;7(7):572–6.
17. Wang J, Li F, Sun R, Gao X, Wei H, Li LJ. Bacterial colonization dampens influenza-mediated acute lung injury via induction of M2 alveolar macrophages. *Nat Commun*. 2013;4:2106.

18. Watanabe T, Miki A, Ueno M, Kubo H, Asahara T, Nomoto K, et al. Randomized clinical trial of preoperative synbiotics to reduce postoperative infectious complications in biliary cancer surgery. *Br J Surg*. 2010;97(8):1305–12.
19. Sawada T, Hisamatsu T, Okamoto S, Kanai T, Mitsuyama K, Andoh A, et al. Administration of probiotics reduces postoperative infectious complications after colorectal surgery. *Int J Colorectal Dis*. 2016;31(7):997–1004.
20. Reddy BS, Macfie J, Gatt M, Larsen CN, Jensen SS, Leser TD. Randomized clinical trial of effect of synbiotics on postoperative infections: evidence for synergy between probiotics and prebiotics. *Ann Surg*. 2007;245(3):409–16.