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# IMPLEMENTATION OF A SURGICAL SITE INFECTION (SSI) PREVENTION BUNDLE FOR COLORECTAL SURGERY: EFFECT ON 30-DAY SUPERFICIAL, DEEP AND ORGAN-SPACE SSI RATES

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## ABSTRACT
**Objective:** To determine the effect of implementation of a surgical site infection (SSI) prevention bundle on the frequency of 30-day superficial, deep and organ-space SSI in patients undergoing colorectal surgery.
**Study Design:** Quasi-experimental, before-after (pre- and post-intervention) study.
**Setting:** Department of Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi.
**Period:** September 2025 to March 2026 (Group A reviewed retrospectively, September–December 2025; Group B enrolled prospectively over four months, January–March 2026).
**Material & Methods:** Using non-probability purposive sampling, 160 patients undergoing elective or emergency colorectal resection (with or without anastomosis/stoma) were allocated to two groups of 80: Group A (pre-bundle, retrospective) and Group B (post-bundle, prospective). Group B received a structured six-element bundle comprising combined mechanical bowel preparation with oral antibiotics, pre-operative chlorhexidine bathing, intravenous antibiotic prophylaxis within 60 minutes of incision, 2% chlorhexidine-alcohol skin preparation, intraoperative normothermia, and glove/instrument change before closure. Patients were followed for 30 days for superficial incisional, deep incisional and organ/space SSI per CDC/NHSN criteria. Data were analysed on SPSS version 26 using the Chi-square/Fisher's exact test and independent samples t-test; $p \leq 0.05$ was significant.
**Results:** The two groups were comparable at baseline for age, sex, BMI, comorbidities, ASA grade, indication, wound class and operative duration (all $p>0.05$). Overall 30-day SSI fell from 18.8% (15/80) in Group A to 2.5% (2/80) in Group B (relative risk 7.50, absolute risk reduction 16.2%, number needed to treat 6; $p=0.001$, Fisher's exact). Superficial SSI fell from 12.5% to 1.3% ($p=0.009$); deep and organ-space reductions were not independently significant given low event numbers. On logistic regression adjusting for age, BMI, diabetes and wound class, bundle implementation remained independently protective (adjusted odds ratio 0.09, 95% CI 0.02–0.42, $p=0.002$). Mean bundle compliance was 4.6/5 elements, with full compliance in 63.8% of Group B patients.
**Conclusion:** Implementation of a low-cost, structured perioperative SSI prevention bundle was associated with a significant reduction in 30-day SSI, particularly superficial incisional infection, after colorectal surgery in this resource-limited South Asian setting.

**KEYWORDS:** Care Bundle, Colorectal Surgery, Infection Control, Organ/Space Infection, Surgical Site Infection.

## INTRODUCTION
Surgical site infection (SSI) is one of the most frequent healthcare-associated infections and is disproportionately common after colorectal surgery because of the high bacterial load of the colon and the procedural complexity involved, with reported colorectal SSI rates worldwide ranging from 15% to over 30%[1]. The Centers for Disease Control and Prevention (CDC) classifies SSI occurring within 30 days of operation into superficial incisional, deep incisional and organ/space categories; SSI prolongs hospital stay, increases readmission, and adds substantially to healthcare costs[2]. Contemporary reviews continue to identify SSI as a largely preventable, evidence-addressable complication rather than an inevitable consequence of colorectal surgery[3]. Local data mirror this global burden: SSI rates of 7–13% have been reported from tertiary surgical units in Karachi, with gastrointestinal and colorectal surgery repeatedly identified as settings of disproportionate risk[4,5].
Multi-component 'prevention bundles' combining pre-, intra- and post-operative measures — mechanical bowel preparation with oral antibiotics, chlorhexidine skin and bathing preparation, intraoperative normothermia, and pre-closure glove change

— have consistently reduced colorectal SSI rates[6]. A widely cited meta-analysis of 35 studies (54,221 patients) reported overall SSI reductions of 44%, with superficial, deep and organ-space reductions of 44%, 33% and 37% respectively[6]. More recent before-after and multicentre cohort studies reproduce this benefit: Falconer et al. reduced colorectal SSI from 16.4% to 9.4% over a staged bundle rollout[7], Guerrero et al. reduced colon-surgery SSI from 8.7% to 1.2% after implementing a 2tandardized bundle[8], Nikolic et al. reduced overall SSI from 18.5% to 3.8% using a patient-engagement bundle 2tandardize education and chlorhexidine bathing[9], and a large Catalan network reported a 50% relative reduction in SSI (18.16% to 8.19%) after sequential rollout of a six- then ten-element bundle across 32,205 colorectal operations[11]. A recent scoping review of 48 studies confirms that grouping interventions by peri-operative phase, rather than adding isolated measures, is associated with the greatest gains in compliance and effect[1].

Despite this robust international evidence, SSI prevention bundles are not yet 2tandardized practice in the Department of Surgery at JPMC, Karachi, and locally reported SSI rates remain high[4,5]. Most bundle evidence originates from high- and upper-middle-income settings with different comorbidity profiles, theatre infrastructure and infection-control resources; a national Pakistani cohort of 1,711 patients recently confirmed an overall elective-surgery SSI incidence of 9.5% and identified contaminated wounds, prolonged hospital stay and inconsistent skin-preparation practice as modifiable, locally relevant risk factors[12,13], yet prospective evidence on bundle-based prevention specifically in colorectal surgery from South Asian, high-volume public-sector centres such as JPMC remains scarce. We therefore aimed to determine the effect of implementation of a structured, low-cost SSI prevention bundle on the frequency of 30-day superficial, deep and organ-space SSI in patients undergoing colorectal surgery at the Department of Surgery, JPMC, Karachi.

## MATERIAL AND METHODS

**Study Design:** Quasi-experimental study (pre- and post-intervention / before-after design).

**Settings:** Department of Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi.

**Duration:** Group A (pre-bundle) comprised the 80 most recent consecutive eligible patients operated between September and December 2025, reviewed retrospectively; Group B (post-bundle) comprised 80 patients enrolled prospectively over four months, April to July 2026, following approval of the study synopsis by the Research Evaluation Unit (REU), College of Physicians and Surgeons Pakistan (CPSP).

**Sample Size:** Calculated using the WHO formula for comparison of two proportions, based on the before-after cohort of Nikolic et al. which reported colorectal SSI of 18.5% before and 3.8% after bundle implementation[9]. With a 95% confidence level ($Z\alpha/2=1.96$), power of 80% ($Z\beta=0.84$), $p1=0.185$ and $p2=0.038$, the calculated sample size was 71 patients per group; after adjusting for an anticipated 10% incomplete follow-up, this was rounded up to 80 patients per group (total N=160): 80 patients undergoing colorectal surgery before bundle implementation (Group A) and 80 after implementation (Group B).

**Sampling Technique:** Non-probability, purposive sampling.

### Inclusion Criteria

Patients aged 18 years and above, of either gender, undergoing elective or emergency colorectal surgery (resection with or without anastomosis/stoma) at the Department of Surgery, JPMC. Group A required complete medical records with documented 30-day follow-up; Group B required written informed consent for prospective enrolment.

### Exclusion Criteria

Pre-existing wound infection or a contaminated/dirty wound class at presentation with established faecal peritonitis; immunocompromised patients (chemotherapy, long-term steroids, known HIV); palliative or non-resectional surgery; patients who died within 30 days from causes unrelated to SSI; and patients lost to follow-up before the 30-day assessment.

### SSI Prevention Bundle

Group B patients received a structured set of six evidence-based perioperative measures: (i) combined mechanical bowel preparation with oral antibiotics the day before surgery, (ii) pre-operative chlorhexidine bathing, (iii) intravenous antibiotic prophylaxis within 60 minutes of incision, with a repeat dose if surgery exceeded three hours, (iv) 2% chlorhexidine-alcohol skin preparation, (v) maintenance of intraoperative normothermia (core temperature ≥36°C), and (vi) change of gloves and instruments prior to fascial/skin closure. Compliance with each element was recorded by the operating team on a checklist for every Group B patient. Group A patients received standard perioperative care without a structured bundle protocol.

### Data Collection Procedure

After approval from the Institutional Review Board (IRB) of JPMC, Group A records were reviewed retrospectively for demographic, clinical and operative details, with 30-day SSI status ascertained from inpatient records, outpatient follow-up notes and readmission records. Group B patients were enrolled prospectively from the Surgical Emergency and Outpatient

Department after written informed consent; baseline data were recorded on a structured proforma and the bundle was applied and its compliance documented. All patients in both groups were assessed for superficial, deep and organ/space SSI using CDC/NHSN criteria during inpatient stay and at a scheduled 30-day outpatient visit, or by structured telephonic assessment where attendance was not possible. Each participant was assigned a unique study identification number; personal identifiers were not used in analysis or reporting.

**Data / Statistical Analysis**

Data were entered and analysed using the Statistical Package for Social Sciences (SPSS) version 26. Quantitative variables (age, BMI, duration of surgery) were expressed as mean ± standard deviation and compared between groups using the independent-samples t-test. Categorical variables (gender, comorbidities, wound class, SSI status by subtype) were expressed as frequencies and percentages and compared using the Chi-square test, with Fisher's exact test applied where expected cell frequency was <5; relative risk, absolute risk reduction and number needed to treat were calculated for the primary outcome. Effect modifiers — age, BMI, diabetes mellitus and wound class — were controlled by stratification with post-stratification Chi-square/Fisher's exact analysis, and an exploratory multivariable logistic regression (SSI30 as outcome; group, age, BMI, diabetes and wound class as covariates) was performed, interpreted cautiously given the limited number of SSI events. A p-value of ≤0.05 was considered statistically significant.

**Ethical Approval**

The study was approved by the Institutional Review Board of JPMC. Written informed consent was obtained from all prospectively enrolled (Group B) patients; confidentiality was maintained throughout data collection, entry and analysis.

**RESULTS**

A total of 160 patients were included, 80 in each group. The overall mean age was 51.0±13.5 years (range 18–85), and the overall mean BMI was 25.4±4.0 kg/m². The two groups were well matched at baseline for all measured demographic, clinical and operative variables (Table I). Mean age was 50.3±11.6 years in Group A versus 51.7±15.3 years in Group B (p=0.529); mean BMI was 25.9±3.9 versus 25.0±4.1 kg/m² (p=0.151); and mean operative duration was 149.4±38.2 versus 144.1±42.4 minutes (p=0.401). Gender distribution, diabetes, hypertension, anaemia, ASA grade, indication for surgery, elective/emergency status, procedure type, stoma formation and CDC wound class did not differ significantly between groups (all p>0.05); smoking was more frequent in Group A (22.5% vs 10.0%, p=0.054), a borderline difference. As expected given the bundle definition, combined mechanical bowel preparation with oral antibiotics was far more frequent in Group B (95.0% vs 38.8%, p<0.001), confirming that this core bundle element was consistently applied only after implementation.

**Table-I: Baseline demographic, clinical and operative characteristics (n=160)**

| Characteristic | Group A – Pre-bundle (n=80) | Group B – Post-bundle (n=80) | Test | p-value |
|---|---|---|---|---|
| Age, years (mean ± SD) | 50.3 ± 11.6 | 51.7 ± 15.3 | t | 0.529 |
| BMI, kg/m² (mean ± SD) | 25.9 ± 3.9 | 25.0 ± 4.1 | t | 0.151 |
| Duration of surgery, min (mean ± SD) | 149.4 ± 38.2 | 144.1 ± 42.4 | t | 0.401 |
| Male gender, n (%) | 46 (57.5%) | 46 (57.5%) | $\chi^2$ | 1.000 |
| Diabetes mellitus, n (%) | 19 (23.8%) | 13 (16.3%) | $\chi^2$ | 0.323 |
| Hypertension, n (%) | 16 (20.0%) | 19 (23.8%) | $\chi^2$ | 0.702 |
| Smoking, n (%) | 18 (22.5%) | 8 (10.0%) | $\chi^2$ | 0.054 |
| Anaemia (Hb<11 g/dL), n (%) | 16 (20.0%) | 15 (18.8%) | $\chi^2$ | 1.000 |
| ASA grade I/II/III, n (%) | 17/48/15 | 26/39/15 | $\chi^2$ | 0.245 |
| Malignant indication, n (%) | 43 (53.8%) | 54 (67.5%) | $\chi^2$ | 0.196 |
| Emergency surgery, n (%) | 18 (22.5%) | 25 (31.3%) | $\chi^2$ | 0.285 |
| Stoma formed, n (%) | 30 (37.5%) | 24 (30.0%) | $\chi^2$ | 0.403 |
| Wound class I/II/III, n (%) | 72.5/16.3/11.3 | 72.5/21.3/6.3 | $\chi^2$ | 0.433 |

| Characteristic | Group A – Pre-bundle (n=80) | Group B – Post-bundle (n=80) | Test | p-value |
|---|---|---|---|---|
| Mechanical bowel prep + oral antibiotics, n (%) | 31 (38.8%) | 76 (95.0%) | $\chi^2$ | <0.001* |

*Mechanical bowel preparation with oral antibiotics is itself a bundle element and was, by definition, applied more consistently after bundle implementation; it is presented for completeness rather than as a baseline confounder.

Overall 30-day SSI occurred in 15/80 patients (18.8%) in Group A compared with 2/80 patients (2.5%) in Group B, a statistically significant reduction ($\chi^2$=9.48, p=0.002; Fisher's exact p=0.001). This corresponds to a relative risk of 7.50 (i.e., patients in the pre-bundle group were 7.5 times as likely to develop SSI), an absolute risk reduction of 16.2%, and a number needed to treat of approximately 6 patients with the bundle to prevent one SSI (Table-II, Figure-1).

**Table-II: 30-day SSI outcomes by study group (n=160)**

| 30-day outcome | Group A (n=80) | Group B (n=80) | p-value* | RR (95% CI) / ARR |
|---|---|---|---|---|
| Overall SSI, n (%) | 15 (18.8%) | 2 (2.5%) | 0.001 | RR 7.50; ARR 16.2%; NNT ≈ 6 |
| Superficial incisional SSI, n (%) | 10 (12.5%) | 1 (1.3%) | 0.009 | — |
| Deep incisional SSI, n (%) | 2 (2.5%) | 1 (1.3%) | 1.000 | — |
| Organ/space SSI, n (%) | 3 (3.8%) | 0 (0.0%) | 0.245 | — |
| Readmission for SSI within 30 days, n (%)† | 5/15 (33.3%) | 0/2 (0.0%) | 1.000 | — |

*Fisher's exact test. †Denominator restricted to patients who developed SSI in each group; small numbers preclude a reliable group comparison. RR=relative risk; ARR=absolute risk reduction; NNT=number needed to treat.

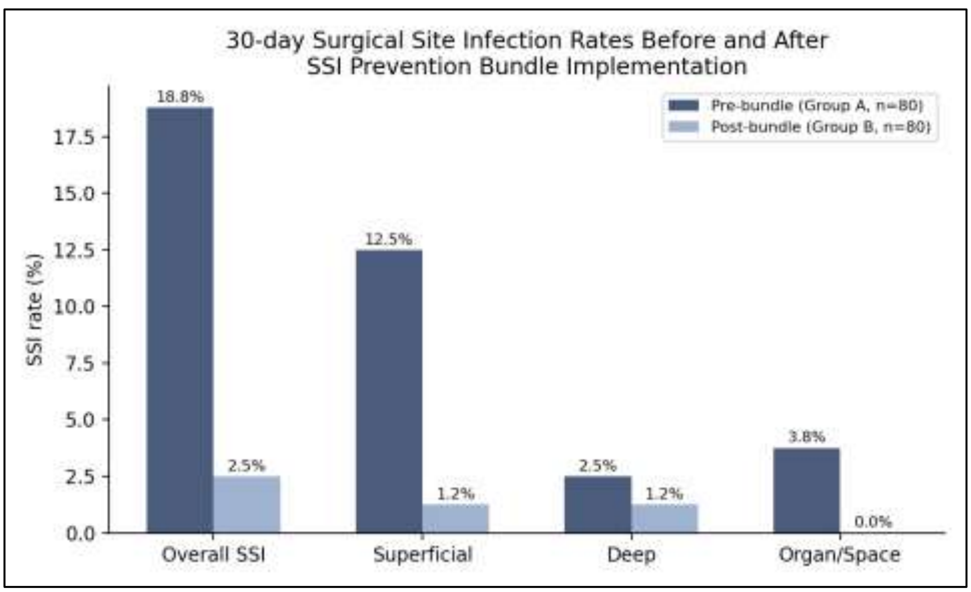


**Figure-1: 30-day SSI rates by subtype, pre- versus post-bundle**

By subtype, superficial incisional SSI fell from 12.5% (10/80) to 1.3% (1/80) (Fisher's exact p=0.009). Deep incisional SSI occurred in 2.5% (2/80) versus 1.3% (1/80) of patients (p=1.000), and organ/space SSI in 3.8% (3/80) versus 0% (0/80) (p=0.245); neither of these subtype comparisons reached statistical significance independently, reflecting the small absolute number of deep and organ-space events in a single-centre cohort of this size.

Among the 17 patients who developed SSI, 11 (64.7%) were superficial incisional, 3 (17.6%) deep incisional and 3 (17.6%) organ/space. Management was with antibiotics alone in 5 (29.4%), bedside drainage in 8 (47.1%) and return to theatre in 4 (23.5%). Overall, 5/17 (29.4%) SSI patients required readmission within 30 days. The mean postoperative day of SSI onset was 10.2±5.5 days in Group A (range 5–27) and 9.5±2.1 days in the two Group B cases (range 8–11); the very small number of post-bundle events precludes a meaningful statistical comparison of timing.

On stratified analysis, the protective effect of the bundle was most pronounced and statistically significant in patients aged ≤50 years (SSI 24.3% vs 0%, p=0.001), in patients with BMI ≥25 kg/m² (17.4% vs 0%, p=0.006), in non-diabetics (23.0% vs 3.0%, p<0.001), and in clean-contaminated wounds (17.2% vs 1.7%, p=0.008). The corresponding reductions among patients aged >50 years, BMI <25 kg/m², diabetics, and contaminated/dirty wounds were directionally consistent but did not reach statistical significance, largely reflecting smaller stratum sizes and, for diabetics, an already low baseline SSI rate. On multivariable logistic regression adjusting for age, BMI, diabetes and wound class, bundle implementation (Group B) remained an independent predictor of lower SSI risk, with an adjusted odds ratio of 0.09 (95% CI 0.02–0.42, p=0.002); age, BMI, diabetes and wound class did not reach independent significance in this model, which should be interpreted cautiously given the limited number of SSI events (n=17).

Compliance with individual bundle elements among Group B patients was: chlorhexidine bathing 93.8% (75/80), intravenous antibiotic prophylaxis within 60 minutes 96.3% (77/80), 2% chlorhexidine-alcohol skin preparation 92.5% (74/80), intraoperative normothermia 83.8% (67/80), and glove/instrument change before closure 91.3% (73/80), giving a mean of 4.6 of 5 elements applied per patient. Full compliance with all five elements was achieved in 63.8% (51/80) of Group B patients and at least four of five elements in 95.0% (76/80); the two post-bundle SSI cases occurred one each in the full- and partial-compliance subgroups (Fisher's exact p=1.000), a comparison limited by the very small number of post-bundle events.

## DISCUSSION

This before-after study demonstrates that implementation of a structured, low-cost, six-element SSI prevention bundle was associated with a significant reduction in 30-day SSI after colorectal surgery, from 18.8% to 2.5%, at a high-volume public-sector centre in Karachi. The magnitude of this reduction — a relative risk reduction of approximately 87% and a number needed to treat of around six — is at the upper end of, but broadly consistent with, the effect sizes reported internationally. The landmark meta-analysis by Pop-Vicas et al. of 35 studies (54,221 patients) reported an overall SSI risk reduction of 44% with colorectal bundles[6], while more recent single- and multi-centre before-after studies have reported reductions of comparable or greater magnitude: Guerrero et al. observed SSI falling from 8.7% to 1.2% after bundle implementation[8], Nikolic et al. reported a fall from 18.5% to 3.8% (a 79.5% relative reduction) with a patient-education-centred bundle[9], and the large Catalan VINCat network reported a cumulative 50% relative reduction (18.16% to 8.19%) after sequential bundle expansion across more than 32,000 colorectal operations[11]. Our baseline SSI rate of 18.8% sits within the range typically reported for colorectal surgery in resource-limited settings and is comparable to the pre-implementation rates in these index studies, supporting the internal validity of the observed effect.

The reduction in our cohort was driven predominantly by superficial incisional SSI, which fell from 12.5% to 1.3% (p=0.009), while deep incisional and organ/space reductions, though directionally favourable, did not reach independent statistical significance. This pattern mirrors the wider literature: superficial SSI is the subtype most consistently and substantially reduced by bundle interventions, whereas deep and organ/space infection — more closely linked to anastomotic integrity, intra-abdominal contamination and patient physiology than to skin-level asepsis — responds less predictably to bundles built around skin preparation, bathing and glove change[6,11]. The scoping review by Cunha et al. similarly concluded that bundles grouped by peri-operative phase improve compliance and superficial-SSI outcomes, but that organ/space infection remains comparatively bundle-resistant and may require targeted measures such as oral antibiotic prophylaxis and mechanical bowel preparation, or intra-abdominal irrigation[1]. Consistent with this, oral antibiotic prophylaxis combined with mechanical bowel preparation — a core element of our bundle — has itself been independently associated with reduced organ/space SSI in a large pragmatic Catalan cohort[16], and its near-universal application in our post-bundle group (95.0% vs 38.8% at baseline) is a plausible contributor to the observed effect, alongside high compliance with skin preparation, chlorhexidine bathing and timely antibiotic prophylaxis.

Stratified analysis suggested that the protective effect of the bundle was most evident in younger patients, in those with a raised BMI, in non-diabetics, and in clean-contaminated wounds, while smaller strata (older patients, diabetics, contaminated/dirty wounds) showed directionally consistent but non-significant reductions. This pattern most likely reflects reduced statistical power in smaller subgroups and a low baseline event rate among diabetics rather than a true absence of benefit, since diabetes and high BMI are independently associated with SSI risk in colorectal surgery[15]. On multivariable logistic regression, bundle implementation remained independently protective after adjustment for age, BMI, diabetes and wound class (adjusted OR 0.09, 95% CI 0.02–0.42), reinforcing that the observed reduction is unlikely to be explained by the (non-significant) baseline imbalances between groups; nonetheless, with only 17 total SSI events, this model should be interpreted as hypothesis-generating rather than definitive.

Bundle compliance in our cohort (mean 4.6 of 5 elements; full compliance in 63.8%) compares favourably with international benchmarks: a Thai series linked ≥70% compliance to significantly lower incisional SSI[17], while a 2024 survey of 49 SHEA Research Network hospitals found that fewer than half formally audited compliance with most individual bundle elements, and even fewer fed this back to surgeons[18]. The checklist-based, single-team implementation model used here — similar in principle to quality-improvement bundle rollouts described by White et al. and by Falconer et al.[7,19] — may partly explain the high compliance achieved even in an early implementation phase, though whether this is sustainable beyond the four-month prospective window of this study remains to be established. Intraoperative normothermia showed the lowest compliance of the five elements (83.8%), consistent with the practical difficulty of maintaining active warming in resource-limited theatre environments and suggesting a specific target for future quality-improvement effort locally.

These findings should be interpreted against the broader Pakistani context. A recent national multicentre cohort of 1,711 elective-surgery patients (PakSurg 1) reported an overall SSI incidence of 9.5%, and identified contaminated/dirty wounds and combined chlorhexidine–povidone-iodine skin preparation as significant modifiable factors[12,13], while earlier single-centre Karachi series reported SSI rates of 7.3–15% in general and gastrointestinal surgery[4,5]. Our pre-bundle SSI rate of 18.8%, specific to colorectal resections rather than general surgery, is consistent with the higher risk long 6andomized for colorectal procedures relative to other specialties, and underlines the case for 6andomized6il bundle-based prevention in colorectal units specifically, rather than relying on generic surgical-safety measures alone.

This study has several limitations. First, and most importantly, it is a single-centre, non-randomised, before-after design with sequential rather than concurrent control and intervention groups; secular trends in perioperative care, surgeon experience, or unmeasured confounders occurring between the two study periods cannot be fully excluded, although baseline demographic, clinical and operative characteristics were closely matched between groups. Second, Group A data were collected retrospectively from medical records, which may under-ascertain SSI relative to the structured prospective follow-up used for Group B, potentially inflating the observed treatment effect. Third, the total number of SSI events (n=17) is small, limiting the power of subtype-specific and stratified comparisons and requiring cautious interpretation of the multivariable model. Finally, this was a single high-volume public-sector centre, and compliance, resources and case-mix may differ at other institutions, limiting 6andomized6ility. Multicentre, ideally 6andomized or stepped-wedge, studies with longer follow-up are needed to confirm these findings and to determine their durability beyond initial implementation.

## CONCLUSION

Implementation of a structured, low-cost, six-element SSI prevention bundle was associated with a significant reduction in 30-day surgical site infection, from 18.8% to 2.5%, after colorectal surgery at a high-volume public-sector centre in Karachi, with the benefit driven mainly by superficial incisional infection. These findings support the routine adoption of colorectal-specific SSI prevention bundles in similar resource-limited settings, alongside larger, multicentre confirmatory studies.

## LIMITATIONS

As a single-centre, non-randomised before-after study with a retrospectively assessed comparison group and a relatively small number of SSI events, this study is best regarded as hypothesis-generating; multicentre studies with concurrent or randomised design and longer follow-up are recommended to confirm the magnitude and durability of the observed effect.

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