

## Original Research Article

# Surgical site infection prevention bundle: changes in staff nurses' practices and SSI outcomes

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## ABSTRACT

**Background:** Surgical site infection (SSI) remains an important postoperative problem, and prevention depends on consistent care. This study examined changes in nurses' observed SSI-prevention practice and in-hospital SSI occurrence after a structured bundle intervention.

**Methods:** A pre-post interventional study was conducted from November 2025 to April 2026 in General Surgery and Orthopaedic Surgery wards of a tertiary hospital in Kolkata. Seventy-six nurses were observed before and after intervention using a 10-item checklist. Patient surveillance included 386 patients before and 470 after intervention. The bundle combined teaching, demonstration, bedside reinforcement, observation and feedback. Practice scores were compared using the Wilcoxon signed-rank test and SSI proportions using Pearson's chi-square test. Risk estimates and multivariable logistic regression were calculated.

**Results:** Mean practice score increased from  $5.21 \pm 1.36$  to  $6.78 \pm 2.96$ ; median score increased from 5 to 8, and good practice from 2.6% to 53.9% ( $Z = -4.01$ ,  $p < 0.001$ ;  $r = 0.46$ ). SSI decreased from 20.21% (78/386) to 14.89% (70/470) ( $\chi^2 = 4.185$ ,  $p = 0.041$ ). RR was 0.74 (95% CI 0.55-0.99) and ARR 5.32 percentage points (95% CI 0.17-10.45). Adjusted odds were lower after intervention (AOR=0.70, 95% CI 0.489-0.999;  $p = 0.0495$ ).

**Conclusions:** The bundle was followed by better observed nursing practice and lower in-hospital SSI occurrence. The adjusted result was close to the 0.05 threshold; the absence of a concurrent control group and post-discharge surveillance limits causal interpretation.

**Keywords:** Surgical site infection, Bundle care, Nursing practice, Infection prevention, Postoperative patients, Quality improvement

## INTRODUCTION

Surgical site infection (SSI) remains a preventable complication of surgery, but prevention depends on several steps being carried out correctly before, during and after an operation. Skin preparation, timely antimicrobial prophylaxis when indicated, aseptic practice, protection of the wound and surveillance all form part of this work.<sup>1-3</sup> Failure at any one point may add to risk, which is why SSI prevention is usually approached as a coordinated perioperative process rather than as a single procedure.

Reported SSI rates differ considerably between countries, hospitals and types of surgery. A systematic review of general surgical patients found wide variation in incidence, and the GlobalSurg cohort showed a substantial burden after gastrointestinal surgery in low- and middle-income countries.<sup>4,5</sup> These findings are relevant to Indian hospitals, where case mix, workload, staffing, infection-control resources and follow-up practices may differ from those in settings where many guidelines were developed.

Nursing care is part of this prevention pathway throughout the patient's stay. In surgical wards, nurses perform or support hand hygiene, preparation of clean and sterile materials, wound observation and dressing, patient education, documentation and reporting of abnormal findings. The value of these measures depends less on knowing that they are recommended than on carrying them out consistently during routine care.<sup>2,3,6</sup>

For that reason, a teaching session by itself may have limited effect. The WHO implementation manual recommends combining education with monitoring, feedback, reminders and changes that help staff apply the required practices in their own work setting.<sup>7</sup> An updated systematic review prepared for the WHO infection-prevention framework also supports multimodal implementation for complex infection-control interventions.<sup>8</sup>

Studies among perioperative nurses show why reinforcement may be needed. Aktaş and Damar found that the use of evidence-based SSI-prevention recommendations varied across individual practices among operating-room nurses.<sup>9</sup> Feng et al also reported differences in prevention practice in relation to training and professional characteristics.<sup>10</sup> These studies do not directly measure the same ward activities as the current work, but they indicate that guideline awareness does not automatically result in uniform practice.

Bundle care brings selected preventive actions together so that they are taught, observed and reinforced as a group. Reviews of SSI bundles, particularly in colorectal surgery, have generally reported lower infection rates after multicomponent programmes, although the exact bundle and surveillance method differ between studies.<sup>11-13</sup> Much of this literature concentrates on surgical outcomes. There is less information from routine ward settings in which nurses' observed practice and patient SSI occurrence are examined within the same implementation programme.

This study was undertaken in a tertiary care hospital in Kolkata to examine those two outcomes together. The first objective was to compare staff nurses observed pre- and postoperative SSI-prevention practice before and after a structured bundle intervention. The second was to compare in-hospital SSI occurrence in the pre-intervention and post-intervention patient groups and to examine the phase difference after adjustment for measured patient and procedural characteristics.

## METHODS

### *Study design and setting*

A quantitative pre-experimental pre-post interventional design was used. The nursing and patient components were related but were analysed differently. The same nurses were observed before and after the intervention,

whereas the patient analysis compared two separate groups of postoperative patients from the pre-intervention and post-intervention periods. The work was carried out in the male and female General Surgery and Orthopaedic Surgery wards of a tertiary care hospital in Kolkata, West Bengal, India.

### *Study period and phases*

The study ran for six months, from November 2025 to April 2026. Baseline nursing practice and inpatient SSI occurrence were recorded during November and December 2025. January and February 2026 were used for implementation of the bundle and for reinforcement of the practices included in it. The post-intervention assessment was carried out during March and April 2026. The patient groups in the two surveillance periods were independent; the design did not follow one patient cohort throughout the six months.

### *Participants and sampling*

The staff sample consisted of 76 registered nurses from the selected wards, and total enumeration was used. Eligibility required more than six months of professional experience, direct involvement in patient care in the selected units, availability during the study period and consent to participate. Floating and temporarily posted nurses were excluded. All 76 nurses were available for both the pre-intervention and post-intervention practice assessment.

For patient surveillance, adult patients aged  $\geq 18$  years who underwent surgery in the selected surgical units of the study hospital during either the pre-intervention or post-intervention surveillance period and were subsequently admitted to the selected General Surgery or Orthopaedic Surgery wards were eligible. The surgical wound had to be available for postoperative assessment, and sufficient perioperative and postoperative clinical information had to be available at clinical assessment and/or hospital records. Patients were followed for SSI during their inpatient postoperative stay until discharge.

Patients were excluded if the index surgical procedure had been performed at another healthcare facility or before admission to the study setting, or if they had an established surgical site/wound infection or another pre-existing infection involving the operative site at the time of admission.

### *Study instruments and outcome measures*

A structured proforma was used to record the nurses' demographic and professional characteristics. Pre- and postoperative SSI-prevention practice was assessed by direct observation with the same 10-item checklist at both assessments. A correctly performed item received 1 point and an incorrect or omitted item received 0, so the total possible score was 10. For descriptive reporting, scores of

0-4 were classified as poor (<50%), 5-7 as average (50-75%) and 8-10 as good ( $\geq 75\%$ ). The score reflected observed practice and was not based on self-report.

Patient information was recorded on a structured surveillance proforma and included age, sex, ward or surgical specialty, duration of surgery, duration of hospital stays and SSI status. WHO, CDC and NHSN guidance informed the surveillance approach. SSI was identified using a modified NHSN-based surveillance checklist covering superficial incisional, deep incisional and organ/space SSI. A patient was recorded as having SSI when the relevant checklist criteria for any one of these categories were met during the postoperative inpatient surveillance period. Patients were assessed during the postoperative inpatient period using clinical assessment and available hospital records until discharge. Systematic post-discharge follow-up was not part of this study; consequently, the outcome reported here is in-hospital SSI occurrence. The same method was used in both patient groups. The content of both instruments was reviewed by four subject experts, including two Professors of Community Medicine and two experts in Medical-Surgical Nursing. Inter-rater reliability was assessed using Cohen's kappa. The coefficient was 0.92 for the nursing practice checklist and 0.88 for the SSI surveillance checklist.

### ***SSI-prevention bundle intervention***

The bundle was based on established SSI-prevention recommendations and on the multimodal implementation approach described by WHO.<sup>1-3,7,8</sup> Small-group teaching sessions of about 30-45 minutes were used at the start. Demonstration was included rather than relying only on verbal instruction. The content covered hand hygiene, aseptic technique, preparation and protection of the surgical site, postoperative wound assessment and dressing, prevention of contamination, handling of clean or sterile and contaminated materials, recognition and reporting of abnormal wound findings, patient and caregiver education and documentation.

Follow-up occurred during routine ward work. The investigator observed relevant practices at the bedside, reinforced important steps and gave immediate feedback when an omission or incorrect technique was seen. Return demonstration or re-demonstration was used when needed. Thus, the intervention involved repeated clinical contact over the two-month implementation period rather than a single teaching session.

### ***Data collection procedure***

A unique code was assigned to each nurse so that pre- and post-intervention observations could be matched without using personal identifiers. Pre-intervention observations of nursing practice were completed under routine ward conditions with the 10-item checklist. After the two-month intervention period, the same nurses were

observed again with the same checklist and scoring method. Patient surveillance was conducted separately in the two defined periods. For each eligible postoperative patient, demographic and clinical information and SSI status were obtained from direct assessment and available hospital records until discharge.

### ***Statistical analysis***

Categorical variables were summarised as frequency and percentage. Practice scores were described using mean, standard deviation and median. The paired pre-post practice scores were compared with the Wilcoxon signed-rank test because the difference scores were not treated as normally distributed. Effect size  $r$  was calculated from the Wilcoxon  $Z$  value and the number of paired observations.

Pearson's chi-square test was used to compare the distributions of age group, sex, ward, duration-of-surgery category and hospital-stay category between the two patient groups. The overall comparison of SSI proportions also used Pearson's chi-square test without continuity correction. Relative risk (RR), absolute risk reduction (ARR) and 95% confidence intervals (CI) were calculated from the observed SSI proportions.

For the regression analysis, SSI status was entered as the dependent variable and intervention phase was the principal exposure. The adjusted binary logistic model included age, sex, surgical specialty (Orthopaedic versus General Surgery), duration of surgery and hospital stay. Crude and adjusted odds ratios (OR and AOR) with 95% CI were reported. Model contribution was assessed with the likelihood-ratio test and calibration with the Hosmer-Lemeshow test. The exact  $p$  value for the adjusted phase estimate was retained to four decimal places because it was very close to 0.05. Tests were two-sided, with  $p < 0.05$  considered statistically significant. Analyses were performed using Python 3.13.5.

### ***Ethical considerations***

The Institutional Ethics Committee of R. G. Kar Medical College, Kolkata approved the study (Memo No. RKC/1384; IEC Registration No. EC/NEW/INST/2023/3404; 29 April 2025). Administrative permission was obtained from the hospital authority. Participating nurses and postoperative patients gave individual informed consent. Participation was voluntary, and confidentiality and anonymity were maintained during data collection and analysis.

## **RESULTS**

All 76 nurses completed both practice assessments. The patient analysis included 856 postoperative patients: 386 in the pre-intervention period and 470 in the post-intervention period. The two patient groups were independent.

### Characteristics of staff nurses

Most nurses were 22-30 years old (68.4%). Basic B.Sc. Nursing was the largest single qualification group (31.6%), followed by GNM (28.9%) and Post Basic B.Sc. Nursing (27.6%). More than five years of professional experience was reported by 47.4%. General Surgery wards accounted for 63.2% of the nurses, and 53.9% had received previous training related to SSI prevention (Table 1).

### Change in observed SSI-prevention practice

The practice scores were higher after the intervention. Mean score increased from  $5.21 \pm 1.36$  to  $6.78 \pm 2.96$  and the median from 5 to 8. Only 2.6% of nurses were in the good-practice category before the intervention; after the intervention, 53.9% were in this category. Average practice decreased from 65.8% to 19.7%, while poor practice changed from 31.6% to 26.3%. The paired difference was statistically significant ( $Z = -4.01$ ,  $p < 0.001$ ), with  $r = 0.46$  (Table 2).

### Patient characteristics and SSI occurrence

Age, sex, ward, duration of surgery and duration of hospital stay showed no statistically significant distributional difference between the pre-intervention and

post-intervention groups (all  $p > 0.05$ ). SSI was recorded in 78 of 386 patients before the intervention (20.21%) and in 70 of 470 after the intervention (14.89%). Pearson's chi-square test gave  $\chi^2 = 4.185$ ,  $df = 1$  and  $p = 0.041$  (Table 3).

### Magnitude of the change in SSI

The risk ratio for the post-intervention period compared with the pre-intervention period was 0.74 (95% CI 0.55-0.99). This corresponds to a relative reduction of approximately 26.3%. The absolute difference between the two observed SSI proportions was 5.32 percentage points (95% CI 0.17-10.45) (Table 4).

### Multivariable analysis

In the crude logistic model, the post-intervention phase was associated with lower odds of SSI (OR=0.69, 95% CI 0.484-0.986;  $p = 0.041$ ). Surgery duration also had a significant crude association (OR per hour=1.13, 95% CI 1.006-1.262;  $p = 0.039$ ). After age, sex, surgical specialty, surgery duration and hospital stay were included in the same model, the post-intervention estimate remained below 1 (AOR=0.70, 95% CI 0.489-0.999;  $p = 0.0495$ ). None of the other covariates was statistically significant after adjustment. The likelihood-ratio test for the model was  $\chi^2 = 13.596$ ,  $df = 6$ ,  $p = 0.034$ . The Hosmer-Lemeshow result was  $\chi^2 = 7.233$ ,  $df = 8$ ,  $p = 0.512$  (Table 5).

**Table 1: Demographic and professional characteristics of staff nurses (n=76).**

| Variables                                          | Frequency (%) |
|----------------------------------------------------|---------------|
| <b>Age (years)</b>                                 |               |
| 22–30                                              | 52 (68.4)     |
| 31–39                                              | 16 (21.1)     |
| 40–49                                              | 8 (10.5)      |
| <b>Professional qualification</b>                  |               |
| GNM                                                | 22 (28.9)     |
| Basic B.Sc. Nursing                                | 24 (31.6)     |
| Post Basic B.Sc. Nursing                           | 21 (27.6)     |
| M.Sc. Nursing                                      | 9 (11.8)      |
| <b>Professional experience (years)</b>             |               |
| <1                                                 | 11 (14.5)     |
| 1–5                                                | 29 (38.2)     |
| >5                                                 | 36 (47.4)     |
| <b>Area of work</b>                                |               |
| General Surgery – Male                             | 23 (30.3)     |
| General Surgery – Female                           | 25 (32.9)     |
| Orthopaedic Surgery – Male                         | 14 (18.4)     |
| Orthopaedic Surgery – Female                       | 14 (18.4)     |
| <b>Previous training related to SSI prevention</b> |               |
| Yes                                                | 41 (53.9)     |
| No                                                 | 35 (46.1)     |

\*GNM = General Nursing and Midwifery; B.Sc. = Bachelor of Science. All nurses had more than six months of professional experience; therefore, the <1 year category denotes >6 months to <1 year.

**Table 2: Comparison of pre- and postoperative SSI-prevention practice before and after the intervention (n=76).**

| Measure                 | Pre-intervention | Post-intervention |
|-------------------------|------------------|-------------------|
| Mean±SD                 | 5.21±1.36        | 6.78±2.96         |
| Median                  | 5                | 8                 |
| Mean percentage         | 52.1%            | 67.8%             |
| Poor practice, f (%)    | 24 (31.6)        | 20 (26.3)         |
| Average practice, f (%) | 50 (65.8)        | 15 (19.7)         |
| Good practice, f (%)    | 2 (2.6)          | 41 (53.9)         |
| Wilcoxon Z              | -4.01            |                   |
| p-value                 | <0.001*          |                   |
| Effect size (r)         | 0.46             |                   |

Practice level was classified from the total possible score of 10: Poor = <50% (0–4), Average = 50–<75% (5–7), Good = ≥75% (8–10). SD = standard deviation. \*Statistically significant at p<0.05.

**Table 3: Comparison of demographic and clinical characteristics and SSI occurrence among postoperative patients between pre-intervention and post-intervention phases.**

| Variables                               | Pre-intervention<br>(n=386), f (%) | Post-intervention<br>(n=470), f (%) | χ <sup>2</sup> (df) | p value |
|-----------------------------------------|------------------------------------|-------------------------------------|---------------------|---------|
| <b>Age (years)</b>                      |                                    |                                     | 2.393 (4)           | 0.664   |
| 18–30                                   | 138 (35.75)                        | 160 (34.04)                         |                     |         |
| 31–45                                   | 141 (36.53)                        | 182 (38.72)                         |                     |         |
| 46–60                                   | 70 (18.13)                         | 86 (18.30)                          |                     |         |
| 61–75                                   | 22 (5.70)                          | 31 (6.60)                           |                     |         |
| ≥76                                     | 15 (3.89)                          | 11 (2.34)                           |                     |         |
| <b>Sex</b>                              |                                    |                                     | 1.025 (1)           | 0.311   |
| Male                                    | 239 (61.92)                        | 275 (58.51)                         |                     |         |
| Female                                  | 147 (38.08)                        | 195 (41.49)                         |                     |         |
| <b>Ward</b>                             |                                    |                                     | 3.261 (3)           | 0.353   |
| Male Surgery                            | 140 (36.27)                        | 160 (34.04)                         |                     |         |
| Female Surgery                          | 94 (24.35)                         | 109 (23.19)                         |                     |         |
| Orthopaedic Male Surgery                | 99 (25.65)                         | 115 (24.47)                         |                     |         |
| Orthopaedic Female Surgery              | 53 (13.73)                         | 86 (18.30)                          |                     |         |
| <b>Duration of surgery (Hours)</b>      |                                    |                                     | 1.743 (3)           | 0.627   |
| <1                                      | 51 (13.21)                         | 76 (16.17)                          |                     |         |
| 1–2                                     | 147 (38.08)                        | 168 (35.74)                         |                     |         |
| >2–4                                    | 125 (32.38)                        | 146 (31.06)                         |                     |         |
| >4                                      | 63 (16.32)                         | 80 (17.02)                          |                     |         |
| <b>Duration of hospital stay (days)</b> |                                    |                                     | 0.221 (2)           | 0.895   |
| <3                                      | 128 (33.16)                        | 156 (33.19)                         |                     |         |
| 4–7                                     | 101 (26.17)                        | 129 (27.45)                         |                     |         |
| >7                                      | 157 (40.67)                        | 185 (39.36)                         |                     |         |
| <b>SSI occurrence</b>                   |                                    |                                     | 4.185 (1)           | 0.041*  |
| Yes                                     | 78 (20.21)                         | 70 (14.89)                          |                     |         |
| No                                      | 308 (79.79)                        | 400 (85.11)                         |                     |         |

\*Statistically significant at p<0.05.

**Table 4: Measures of effect for postoperative surgical site infection.**

| Measure                       | Estimate        | 95% CI      | P value |
|-------------------------------|-----------------|-------------|---------|
| SSI occurrence                | 20.21% → 14.89% | —           | 0.041*  |
| Relative risk (RR)            | 0.74            | 0.55–0.99   | —       |
| Absolute risk reduction (ARR) | 5.32%           | 0.17–10.45% | —       |

Effect estimates compare the post-intervention period with the pre-intervention period. The p-value for SSI occurrence is from Pearson's chi-square test. Separate p-values are not shown for RR and ARR. CI = confidence interval. \*Statistically significant at p<0.05.

**Table 5: Logistic regression analysis of factors associated with surgical site infection among postoperative patients (n=856).**

| Variables                                    | Crude OR (95% CI)  | P value | Adjusted OR (95% CI) | P value |
|----------------------------------------------|--------------------|---------|----------------------|---------|
| <b>Post-intervention vs pre-intervention</b> | 0.69 (0.484–0.986) | 0.041*  | 0.70 (0.489–0.999)   | 0.0495* |
| <b>Age, per 1-year increase</b>              | 1.01 (0.997–1.018) | 0.184   | 1.01 (0.997–1.020)   | 0.160   |
| <b>Female vs male</b>                        | 0.70 (0.482–1.019) | 0.062   | 0.69 (0.475–1.012)   | 0.058   |
| <b>Orthopaedic vs General Surgery</b>        | 1.10 (0.772–1.580) | 0.586   | 0.98 (0.668–1.436)   | 0.917   |
| <b>Surgery duration, per 1-hour increase</b> | 1.13 (1.006–1.262) | 0.039*  | 1.22 (0.886–1.668)   | 0.225   |
| <b>Hospital stay, per 1-day increase</b>     | 1.03 (0.997–1.069) | 0.072   | 0.97 (0.883–1.074)   | 0.590   |

OR = odds ratio; CI = confidence interval. The adjusted model included intervention phase, age, sex, surgical specialty, duration of surgery and hospital stay. \* $p < 0.05$ . Model fit: likelihood-ratio  $\chi^2 = 13.596$ ,  $df = 6$ ,  $p = 0.034$ ; Hosmer–Lemeshow  $\chi^2 = 7.233$ ,  $df = 8$ ,  $p = 0.512$ . The adjusted phase p-value is shown to four decimal places because the exact value lies close to 0.05.

## DISCUSSION

Both study outcomes changed after the bundle, although the two components need to be read differently. The nursing comparison involved the same 76 nurses at two time points. Their median practice score moved from 5 to 8, and the proportion classified as good practice increased from 2.6% to 53.9%. The patient comparison, in contrast, involved separate groups. In-hospital SSI was 20.21% before the intervention and 14.89% afterwards. This was a statistically significant crude difference, and the adjusted phase estimate remained just below the 0.05 cut-off.

The change in nurses' practice is understandable in relation to how the intervention was carried out. The nurses were not only given information; key procedures were demonstrated, their practice was observed during routine work and feedback was given when a step was missed or performed incorrectly. WHO implementation guidance uses the same general principle of combining education with monitoring, feedback and reminders rather than expecting a single educational session to change practice.<sup>7,8</sup>

Previous nursing studies have also reported uneven use of SSI-prevention recommendations. Aktaş et al found variation across evidence-based practices among operating-room nurses, and Feng et al reported differences associated with training and professional characteristics.<sup>9,10</sup> In this study, the movement into the good-practice category was marked, but it was not uniform. One quarter of the nurses (26.3%) were still in the poor-practice category after the intervention. This is worth noting because the mean and median improvement could otherwise give the impression that practice became consistent across the whole group. Continued observation and feedback would still be needed for the nurses who did not reach the expected level. The intervention used a selected set of nursing actions that could be applied and checked in the study wards. This is consistent with the broader idea behind an SSI bundle: standardising a manageable group of evidence-based measures while adapting the way they are implemented to the local service. A recent scoping review of clinical practice

guidelines by Radman et al brought together perioperative recommendations that can be organised in this way.<sup>11</sup>

The patient result is also comparable in direction with earlier bundle studies, although the size of the effect should not be directly compared because the procedures and bundle contents were different. Meta-analyses by Pop-Vicas et al and Zywtot et al reported lower SSI rates after multicomponent colorectal programmes.<sup>12,13</sup> Weiser et al reported a sustained reduction after a multidisciplinary colorectal bundle.<sup>14</sup> Bagga et al working in India, found a lower SSI rate after introducing a simple infection-prevention bundle for elective caesarean and gynaecological surgery, while Albert et al reported improvement after combining an infection-prevention bundle with an enhanced-recovery programme.<sup>15,16</sup>

Other implementation reports have reached similar conclusions in different surgical populations. White et al. used a colorectal bundle and checklist with staff education as part of the programme.<sup>17</sup> Dhandapani et al reported a fall in SSI after a care bundle for elective gastrointestinal surgery in India and found higher risk where compliance with the bundle was poor.<sup>18</sup> These studies support the practical value of bundle implementation, but they do not establish that the same numerical reduction should be expected in another hospital.

In the current data, the absolute difference in SSI was 5.32 percentage points and the RR was 0.74. These measures help show the size of the observed change without relying only on the p value. At the same time, the two patient groups were assembled in different time periods. Changes in case mix, staffing, operative activity, antimicrobial use or other aspects of care could have occurred between the periods even though the measured distributions of age, sex, ward, surgery duration and hospital stay were not significantly different. The available comparisons reduce some concern about major baseline imbalance, but they cannot exclude unmeasured confounding.

The regression analysis gives a similar but more cautious picture. After adjustment for age, sex, surgical specialty,

duration of surgery and hospital stay, the odds of SSI in the post-intervention period were about 30% lower (AOR=0.70). The confidence interval ended at 0.999 and the exact p value was 0.0495. Because the estimate lies so close to the conventional 0.05 threshold, it should not be presented as strong proof of an intervention effect. It does show that the direction of the phase difference persisted after adjustment for the variables available in the master data. A concurrent control group would have provided a firmer basis for separating an intervention effect from changes occurring over time.

Duration of surgery was significant in the crude analysis but not in the adjusted model. Longer operations are recognised in the literature as a risk factor for SSI.<sup>19</sup> The adjusted result here does not overturn that evidence. It only means that, after the variables in this model were considered together, surgery duration was not independently associated with SSI at the 0.05 level in this dataset.

Maintaining the improvement in nursing practice may be as important as achieving the initial change. Studies of SSI bundle implementation describe practical barriers related to workflow, professional roles and the local clinical environment.<sup>20</sup> In these circumstances, periodic observation, feedback on low-compliance items and reinforcement during routine supervision are more realistic than assuming that one intervention period will produce a permanent change.

The surveillance period is another limitation when interpreting the patient outcome. SSI surveillance commonly continues beyond hospital discharge, depending on the procedure and the surveillance definition.<sup>4,6</sup> This study ended systematic assessment at discharge. An infection that became evident only after a patient went home would therefore not have been counted. For this reason, the percentages reported in the study represent in-hospital SSI occurrence during the two defined surveillance periods.

### **Strengths and limitations**

A major strength of this study was the assessment of both nursing practice and patient outcome within the same SSI-prevention programme. Nursing practice was measured by direct observation rather than self-report, and the same 76 nurses were assessed before and after the intervention, allowing a true paired comparison. All eligible postoperative patients during the defined pre- and post-intervention surveillance periods were included, reducing selection within each phase. The patient analysis also went beyond a simple comparison of SSI proportions by reporting RR, ARR and multivariable logistic regression, which allowed the phase difference to be examined after adjustment for measured patient and procedural characteristics.

This study was limited by its single-centre pre-post design without a concurrent control group. Residual confounding cannot be excluded, and SSI surveillance was restricted to the inpatient period. Long-term sustainability of the improvement in nursing practice was not assessed.

### **CONCLUSION**

In this study, implementation of the SSI-prevention bundle was associated with a marked improvement in nurses' observed practice and a reduction in in-hospital SSI among postoperative patients. The decrease in SSI occurrence was statistically significant, and the adjusted phase estimate remained narrowly significant (p=0.0495). The findings indicate that a structured bundle approach, supported by direct observation, reinforcement and feedback, may strengthen SSI-prevention practice and contribute to improved postoperative infection outcomes in surgical wards.

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### **REFERENCES**

1. World Health Organization. Global guidelines for the prevention of surgical site infection. 2nd ed. Geneva: World Health Organization; 2018. Available at: <https://www.who.int/publications/i/item/9789241550475>. Accessed on 10 September 2026.
2. Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. *JAMA Surg*. 2017;152(8):784-91.
3. Calderwood MS, Anderson DJ, Bratzler DW, Dellinger EP, Garcia-Houchins S, Maragakis LL, et al. Strategies to prevent surgical site infections in acute-care hospitals: 2022 update. *Infect Control Hosp Epidemiol*. 2023;44(5):695-720.
4. Gillespie BM, Harbeck E, Rattray M, Liang R, Walker R, Latimer S, et al. Worldwide incidence of surgical site infections in general surgical patients: a systematic review and meta-analysis of 488,594 patients. *Int J Surg*. 2021;95:106136.
5. GlobalSurg Collaborative. Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a

- prospective, international, multicentre cohort study. *Lancet Infect Dis*. 2018;18(5):516-25.
6. Centers for Disease Control and Prevention. 2025 NHSN Surgical Site Infection (SSI) Checklist. Atlanta (GA): Centers for Disease Control and Prevention; 2025. Available at: <https://www.cdc.gov/nhsn/pdfs/checklists/2025-NHSN-Surgical-Site-Infection-SSI-Checklist-FINAL.pdf>. Accessed on 10 Sep 2026.
7. World Health Organization. Implementation manual to support the prevention of surgical site infections at the facility level: turning recommendations into practice. Geneva: World Health Organization; 2018. Available at: <https://www.who.int/publications/i/item/WHO-HIS-SDS-2018-18>. Accessed on 10 Sep 2026.
8. Sonpar A, Hundal CO, Totté JEE, Wang J, Klein SD, Twyman A, et al. Multimodal strategies for the implementation of infection prevention and control interventions-update of a systematic review for the WHO guidelines on core components of infection prevention and control programmes at the facility level. *Clin Microbiol Infect*. 2025;31(6):948-57.
9. Aktaş FO, Damar HT. Determining operating room nurses' knowledge and use of evidence-based recommendations on preventing surgical site infections. *J Perianesth Nurs*. 2022;37(3):404-10.
10. Feng W, Sae-Sia W, Kitrungrate L. Knowledge, attitude, and practice of surgical site infection prevention among operating room nurses in southwest China. *Belitung Nurs J*. 2022;8(2):124-31.
11. Radman I, Poklepovic Pericic T, Krizanac Z, Babic A, Bodys-Cupak I, Bala MM, et al. Developing a standardised surgical site infection prevention bundle: a scoping review of clinical practice guidelines. *J Hosp Infect*. 2026;174:170-84.
12. Pop-Vicas AE, Abad C, Baubie K, Osman F, Heise C, Safdar N. Colorectal bundles for surgical site infection prevention: a systematic review and meta-analysis. *Infect Control Hosp Epidemiol*. 2020;41(7):805-12.
13. Zywtot A, Lau CSM, Fletcher HS, Paul S. Bundles prevent surgical site infections after colorectal surgery: meta-analysis and systematic review. *J Gastrointest Surg*. 2017;21(11):1915-30.
14. Weiser MR, Gonen M, Usiak S, Pottinger T, Samedy P, Patel D, et al. Effectiveness of a multidisciplinary patient care bundle for reducing surgical-site infections. *Br J Surg*. 2018;105(12):1680-7.
15. Bagga R, Suri V, Thami M, Nehra R, Dhaliwal N, Biswal M, et al. A simple infection prevention 'bundle' including preoperative bath with hair-wash to reduce surgical site infection (SSI) following elective caesarean and gynaecological surgery in India. *J Family Med Prim Care*. 2022;11(5):1970-9.
16. Albert H, Bataller W, Masroor N, Doll M, Cooper K, Spencer P, et al. Infection prevention and enhanced recovery after surgery: a partnership for implementation of an evidence-based bundle to reduce colorectal surgical site infections. *Am J Infect Control*. 2019;47(6):718-9.
17. White C, Kurtz S, Lusk L, Wilson B, Britton V, Hayden K, et al. Implementation of a colorectal surgical site infection prevention bundle and checklist: a quality improvement project. *AORN J*. 2023;118(5):297-305.
18. Dhandapani S, Raja K, Priyadarshi K, Sastry AS. Implementation of surgical site infection care bundle in patients undergoing gastrointestinal surgeries. *Indian J Med Microbiol*. 2024;51:100670.
19. Cheng H, Chen BPH, Soleas IM, Ferko NC, Cameron CG, Hinoul P. Prolonged operative duration increases risk of surgical site infections: a systematic review. *Surg Infect (Larchmt)*. 2017;18(6):722-35.
20. Dukes KC, Schacht Reisinger H, Schweizer M, Ward MA, Chapin L, Ryken TC, et al. Examining barriers to implementing a surgical-site infection bundle. *Infect Control Hosp Epidemiol*. 2024;45(1):13-20.

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