JHWCR JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH 3007-0570

DOI: https://doi.org/10.61919/ecab7h38

Original Article

Prevalence of Surgical Site Infections Among Cesarean Section Patients at a Tertiary Care Hospital in Faisalabad: A Comparative Study of Care Bundle vs. Standard Care

Sehar Gul[1], Rana Dawood Naseer[2], Taimoor Farooq[3], Muhammad Husnain Ahmad[4], Rafia Imtiaz [5]

[1] Department of Epidemiology and Public Health, University of Agriculture, Faisalabad, Pakistan
[2] Department of Pharmacy, University of Agriculture, Faisalabad, Pakistan
[3] Department of Emergency, Mujahid Hospital, Faisalabad, Pakistan
[4] Department of Pediatrics, Mujahid Hospital, Faisalabad, Pakistan
[5] College of Physical Therapy, Government College University Faisalabad

***Corresponding author: Rana Dawood Naseer, drdawood.naseer@uaf.edu.pk, Rafia Imtiaz, rafiaimtiaz@gcuf.edu.pk**

"Cite this Article" **Received**: 12 March 2026; **Accepted**: 19 June 2026; **Published**: 10 July 2026

Author Contributions: SG contributed to concept, data collection, analysis, and drafting; RDN contributed to study design, supervision, methodology review, and critical revision; TF contributed to clinical coordination, data collection, and manuscript review; MHA contributed to clinical input, interpretation, and manuscript review. **Ethical Approval**: niversity of Agriculture, Faisalabad, Pakistan. **Informed Consent**: Written informed consent was obtained from all participants; **Conflict of Interest**: The authors declare no conflict of interest. **Funding**: No external funding; **Data Availability**: Available from the corresponding author on reasonable request; **Acknowledgments**: NA

ABSTRACT

Background: Surgical site infection after cesarean section is a major contributor to preventable maternal morbidity, particularly in resource-constrained obstetric settings where emergency surgery, variable infection-prevention practices, and affordability barriers may affect postoperative outcomes. Objective: To estimate the prevalence of surgical site infection among cesarean-section patients at a tertiary-care hospital in Faisalabad and compare observed infection rates between patients receiving a structured perioperative care bundle and those receiving standard care. Methods: This prospective non-randomized comparative study was conducted at Mujahid Hospital, Faisalabad, from October 2025 to February 2026. A total of 300 women undergoing cesarean section were included: 150 received a complete care bundle and 150 received standard care, comprising 100 emergency cesarean-section patients and 50 non-affording elective patients. The bundle included antiseptic skin preparation, pre-incision cefazolin prophylaxis, vaginal preparation, sterile draping and instrument handling, suture wound closure, and structured postoperative wound review. Surgical site infection was assessed within 30 days. Categorical data were analyzed using frequencies, percentages, and chi-square testing. Results: Overall surgical site infection prevalence was 12.33% (37/300). No infections occurred in the care bundle group, while 37 infections occurred in standard-care controls, giving a control-group infection rate of 24.67% ($p < 0.001$). Emergency controls accounted for 25 infections and non-affording elective controls for 12 infections. Month-wise SSI rates declined from 18.67% in October and 20.00% in November to 0.00% in February ($\chi^2 = 13.38$, df = 4, $p = 0.010$), although calendar time and exposure category may have been confounded. Conclusion: Complete care bundle receipt was associated with no observed surgical site infections, whereas standard-care patients had a substantial infection burden. Wider bundle coverage may improve post-cesarean infection prevention, but non-randomized allocation and lack of baseline risk adjustment require cautious interpretation. Keywords: surgical site infection; cesarean section; care bundle; infection control; tertiary care; Pakistan; maternal health.

INTRODUCTION

Cesarean section is one of the most frequently performed obstetric surgical procedures worldwide, and surgical site infection remains a major contributor to preventable maternal morbidity after delivery. Post-cesarean surgical site infections are clinically important because they increase postoperative pain, antibiotic use, wound care requirements, hospital stay, readmission risk, and healthcare costs, with a

particularly heavy burden in low- and middle-income settings where infection-prevention resources may be inconsistent or unaffordable for many patients (1). Global estimates show wide variation in post-cesarean surgical site infection rates across regions and healthcare systems, reflecting differences in patient risk profiles, emergency obstetric workload, perioperative antibiotic practices, skin and vaginal antisepsis, theatre sterility, postoperative wound surveillance, and access to timely follow-up (2). In resource-constrained maternity units, these infections are especially consequential because they affect both maternal recovery and household financial stability during the early postnatal period (3).

The risk of surgical site infection after cesarean delivery is influenced by both clinical and health-system factors. Emergency cesarean section is commonly associated with higher infection risk because of prolonged labour, repeated vaginal examinations, premature rupture of membranes, reduced preparation time, and a greater likelihood of contamination before incision (4). Patient-level factors such as diabetes, obesity, anemia, parity, immune status, and pre-existing infection may further increase susceptibility, while facility-level factors such as inconsistent antibiotic timing, variable antiseptic preparation, wound-closure technique, and irregular postoperative wound assessment can modify infection risk (5). In Pakistan and similar healthcare contexts, the burden may be amplified by delayed presentation, high emergency caseload, uneven compliance with infection-prevention protocols, and patients' limited ability to afford all perioperative preventive components.

Care bundles have been introduced as practical infection-prevention strategies because they combine several evidence-based interventions into a standardized perioperative protocol rather than relying on isolated measures. For cesarean delivery, such bundles commonly include appropriate pre-incision antibiotic prophylaxis, chlorhexidine-alcohol skin preparation, vaginal antiseptic preparation where indicated, sterile draping and instrument handling, appropriate wound closure, and structured postoperative wound monitoring (6). Evidence from implementation studies and systematic reviews suggests that standardized bundle-based approaches can reduce post-cesarean surgical site infection rates when applied consistently, particularly in settings where baseline infection-prevention practices are variable (7). However, bundle effectiveness in real-world settings depends not only on clinical efficacy but also on feasibility, affordability, emergency applicability, staff compliance, and equitable access for patients with limited financial resources.

Despite the recognized importance of surgical site infection prevention after cesarean delivery, locally generated comparative evidence from tertiary-care hospitals in Faisalabad remains limited. Existing data from Pakistan have reported substantial post-cesarean infection burdens, but many studies either describe infection frequency without evaluating bundle exposure or do not adequately address the implementation gap between elective and emergency obstetric care (8). In particular, the distinction between patients receiving a complete structured care bundle and those receiving standard care because of emergency presentation or inability to afford bundle components has important clinical and equity implications. This gap is relevant for tertiary-care obstetric units where emergency cesarean sections and financially constrained patients form a large proportion of the surgical workload.

Therefore, this prospective non-randomized comparative study was conducted at Mujahid Hospital, Faisalabad, to estimate the prevalence of surgical site infection among women undergoing cesarean section and to compare observed infection rates between patients receiving a structured perioperative care bundle and those receiving standard care. The study further examined infection distribution by month and cesarean-section category to identify clinically relevant patterns associated with emergency surgery, affordability-related non-receipt of bundle components, and implementation over the study period. The primary question was whether receipt of a structured perioperative care bundle was associated with a lower observed prevalence of surgical site infection within 30 days after cesarean section compared with standard care in this tertiary-care setting.

MATERIAL AND METHODS

This prospective non-randomized quasi-experimental comparative study was conducted at Mujahid Hospital, Faisalabad, Pakistan, from October 2025 to February 2026. The hospital is a tertiary-care obstetric centre serving a broad socioeconomic patient population and managing both elective and emergency cesarean deliveries. The study was designed to compare the observed 30-day prevalence of surgical site infection among women who received a structured perioperative care bundle with those who received standard facility care. Because group assignment was based on clinical pathway, emergency status, and ability to receive all bundle components rather than random allocation, the study was treated analytically as a non-randomized comparison, and interpretation was focused on association rather than definitive causal effect.

A total of 300 women undergoing cesarean section were enrolled. The care bundle group included 150 ward-admitted women scheduled for elective cesarean section who received all components of the structured perioperative bundle. The standard-care control group included 150 women who did not receive the complete bundle, comprising 100 emergency cesarean-section patients and 50 elective cesarean-section patients who were unable to obtain all bundle components because of financial constraints. Eligible participants were women undergoing elective or emergency cesarean section during the study period who provided informed consent and were available for postoperative follow-up. Women were excluded if they had evidence of wound infection or other active pelvic infection at admission, were immunocompromised, declined participation, or were unwilling to complete follow-up.

The intervention consisted of a six-component perioperative surgical site infection prevention bundle. The bundle included preoperative chlorhexidine-alcohol antiseptic skin preparation, intravenous cefazolin prophylaxis administered 30–60 minutes before skin incision, povidone-iodine vaginal preparation before incision, universal sterile draping and standardized instrument handling, wound closure using sutures rather than staples, and structured postoperative wound review using a standardized dressing protocol at 24–48 hours and on postoperative Day 7. Patients in the standard-care control group received routine facility care without documented completion of all six bundle components. The comparison therefore reflected real-world differences in complete bundle receipt versus standard practice among emergencies and financially constrained patients.

The primary outcome was surgical site infection within 30 days after cesarean section. Surgical site infection was defined according to standard surveillance principles as infection involving the incision site within 30 postoperative days and classified clinically as superficial incisional, deep incisional, or organ/space infection where applicable. Diagnosis was based on postoperative clinical findings, including erythema, wound discharge, wound dehiscence, fever, localized tenderness, or other signs suggestive of infection, and microbiological confirmation was used when wound samples were obtained as part of clinical care. All participants were monitored postoperatively for 30 days, with wound assessment during early postoperative dressing review and follow-up assessment by the treating team.

Data was collected using hospital records and postoperative follow-up documentation. The main exposure variable was receipt of the complete care bundle versus standard care. Additional grouping variables included cesarean-section category, defined as elective care-bundle cesarean section, emergency control cesarean section, and non-affording elective control cesarean section, and month of enrollment from October 2025 to February 2026. Monthly enrollment was recorded as 75 patients in October, 65 in November, 55 in December, 55 in January, and 50 in February. The main outcome variable was presence or absence of surgical site infection within 30 days, reported as frequency and percentage overall, by study group, by month, and by cesarean-section category.

Data were analyzed using SPSS version 26.0. Categorical variables were summarized as frequencies and percentages. Surgical site infection prevalence was calculated overall and separately for the care bundle and standard-care control groups using the relevant group denominators. Group-wise differences in

surgical site infection rates were assessed using chi-square testing, with statistical significance set at $p < 0.05$. Month-wise differences in infection rates were also examined using chi-square testing; however, because intervention exposure and calendar month may not have been fully independent, month-wise findings were interpreted descriptively and cautiously. Given the non-randomized design and the absence of complete individual-level baseline risk-factor data, adjusted regression analysis for potential confounders such as emergency status, affordability, diabetes, obesity, anemia, parity, duration of labour, rupture of membranes, operative duration, and antibiotic timing was not performed. Absolute differences in observed infection proportions were emphasized to support clinical interpretation while avoiding causal overstatement.

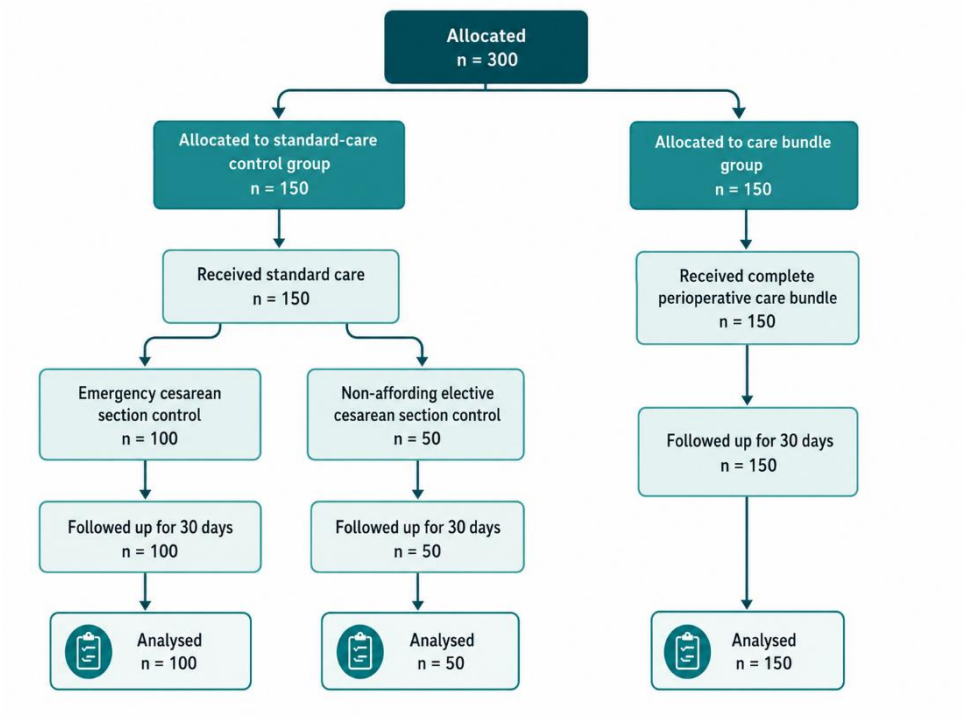

Figure 1 CONSORT Flowchart

The study was approved by the Institutional Review Board of the University of Agriculture, Faisalabad. Written informed consent was obtained from all participants before enrollment. Participant confidentiality was maintained by using de-identified study data for analysis and reporting. The study was conducted in accordance with ethical principles for human-subject research, and all postoperative infections identified during follow-up were managed according to routine clinical care.

RESULTS

A total of 300 women undergoing cesarean section were included in the analysis, with 150 patients in the care bundle group and 150 patients in the standard-care control group. The control group comprised 100 emergency cesarean-section patients and 50 elective cesarean-section patients who did not receive the complete bundle because of financial constraints. Surgical site infection was assessed within 30 days after surgery.

Table 1. Prevalence of Surgical Site Infection by Study Group

Study Group	Total Patients, n	SSI Cases, n	SSI Rate, %	Absolute Difference, Percentage Points	p-value
Care bundle	150	0	0.00	-24.67	<0.001
Standard-care control	150	37	24.67	Reference	<0.001
Total	300	37	12.33	—	—

SSI, surgical site infection. p-value based on chi-square comparison between the care bundle and standard-care control groups.

Overall, 37 of 300 patients developed surgical site infection within 30 days, giving an overall SSI prevalence of 12.33%. No SSI cases were observed among the 150 patients who received the complete care bundle, whereas all 37 SSI cases occurred in the standard-care control group, corresponding to an SSI rate of 24.67% in controls. The observed absolute difference in SSI rate between the care bundle and control groups was 24.67 percentage points, with a reported group-wise difference of $p < 0.001$. Because the study was non-randomized and the groups differed by clinical pathway and affordability, this finding should be interpreted as an observed association rather than definitive causal evidence.

Table 2. Month-Wise Distribution of Surgical Site Infection

Month	Total Patients, n	SSI Cases, n	SSI Rate, %	Study Exposure Category
October	75	14	18.67	Control
November	65	13	20.00	Control
December	55	7	12.73	Control
January	55	3	5.45	Control
February	50	0	0.00	Bundle
Total	300	37	12.33	—

SSI, surgical site infection. Month-wise comparison: $\chi^2 = 13.38$, df = 4, $p = 0.010$.

Month-wise SSI rates varied across the five-month study period. The highest monthly SSI rate was observed in November, with 13 infections among 65 patients, followed by October, with 14 infections among 75 patients. Rates declined to 12.73% in December and 5.45% in January, while no SSI cases were recorded in February. The reported month-wise chi-square analysis showed $\chi^2 = 13.38$ with 4 degrees of freedom and $p = 0.010$. However, because the study exposure category also changed across months, with February representing bundle exposure while earlier months were listed as control exposure, this trend should be interpreted cautiously because calendar time and intervention exposure may be confounded.

Table 3. Surgical Site Infection by Cesarean-Section Category

Cesarean-Section Category	Total Patients, n	SSI Cases, n	SSI Rate, %	Proportion of All SSI Cases, %
Elective care bundle	150	0	0.00	0.00
Emergency control	100	25	25.00	67.57
Non-affording elective control	50	12	24.00	32.43
Total	300	37	12.33	100.00

SSI, surgical site infection.

By cesarean-section category, 25 of the 37 SSI cases occurred among emergency control patients, representing 67.57% of all infections and an SSI rate of 25.00% within that subgroup. The remaining 12 SSI cases occurred among non-affording elective control patients, representing 32.43% of all infections and an SSI rate of 24.00% within that subgroup. No infections were observed among elective patients who received the complete care bundle. The similar SSI rates in emergency control patients and non-affording elective control patients suggest that both emergency clinical context and incomplete access to bundle components were important observed contexts for infection occurrence, although the available aggregated data do not permit adjustment for individual-level confounders.

Table 4. Distribution of Control-Group Surgical Site Infection by Control Subgroup

Control Subgroup	Total Patients, n	SSI Cases, n	Non-SSI Cases, n	SSI Rate, %
Emergency control	100	25	75	25.00
Non-affording elective control	50	12	38	24.00
Total control group	150	37	113	24.67

SSI, surgical site infection.

Within the standard-care control group, the SSI burden was distributed across both emergency and non-affording elective patients. Emergency control patients accounted for 25 of 37 infections, while non-affording elective control patients accounted for 12 of 37 infections. The subgroup-specific infection rates were numerically close, at 25.00% and 24.00%, respectively. This pattern indicates that infections

were not limited to emergency surgery alone; incomplete receipt of bundle components among elective patients was also associated with a comparable observed infection rate within the control group.

Taken together, the results show an overall post-cesarean SSI prevalence of 12.33% in the full sample, with all infections occurring among patients who did not receive the complete care bundle. The observed difference between care bundle and standard-care patients was large, but the non-randomized design, unequal clinical pathways, affordability-related group assignment, and absence of baseline risk-factor adjustment limit causal interpretation. The results therefore support the clinical relevance of complete bundle coverage while highlighting the need for adjusted or randomized evaluation in future studies.

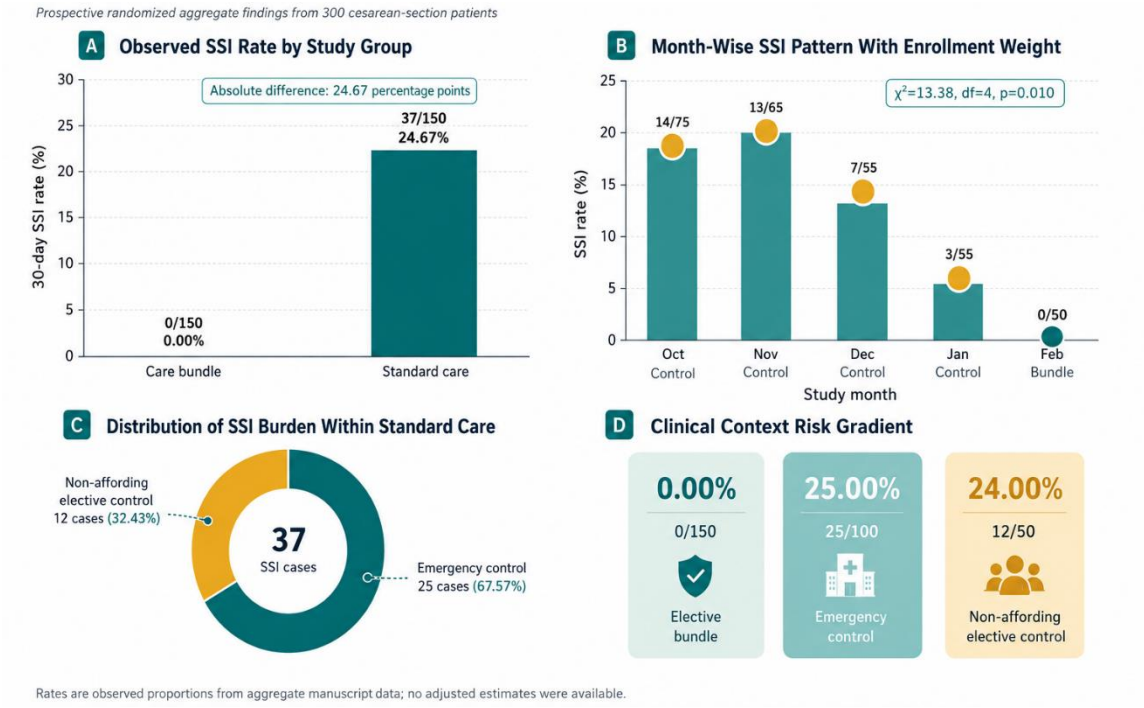

Figure 2 Post-cesarean surgical site infection patterns by care exposure, month, and clinical context. Among 300 cesarean-section patients, 37 surgical site infections were observed within 30 days, giving an overall prevalence of 12.33%. No infections occurred among 150 patients receiving the complete care bundle, whereas 37 infections occurred among 150 standard-care controls, corresponding to an observed SSI rate of 24.67% in the control group. Month-wise infection rates were highest in November (20.00%) and October (18.67%), followed by December (12.73%), January (5.45%), and February (0.00%). Within the standard-care group, emergency cesarean patients accounted for 25 of 37 infections, while non-affording elective control patients accounted for 12 of 37 infections. The figure is based on aggregate manuscript data only; causal interpretation is limited by non-randomized group allocation and absence of individual-level confounder adjustment.

DISCUSSION

This prospective non-randomized comparative study found an overall 30-day surgical site infection prevalence of 12.33% among women undergoing cesarean section at a tertiary-care hospital in Faisalabad. The observed distribution of infections was highly unequal between groups: no surgical site infections were recorded among 150 patients who received the complete perioperative care bundle, whereas 37 infections occurred among 150 patients managed with standard care. This produced an observed control-group infection rate of 24.67% and a large absolute difference between the study groups. Although this difference is clinically important, it should be interpreted as an association rather than definitive causal evidence because patients were not randomly assigned and group membership was influenced by elective status, emergency presentation, and affordability-related access to bundle components.

The overall SSI prevalence observed in this study is consistent with the recognized burden of post-cesarean infection in resource-constrained settings, where infection rates vary substantially according to patient risk profile, emergency obstetric workload, perioperative antibiotic timing, antiseptic

preparation, surgical technique, and postoperative wound surveillance. The 24.67% infection rate among standard-care controls is particularly important because it falls within the range reported from settings where standardized infection-prevention practices may be inconsistently implemented. In contrast, the absence of observed infections among bundle recipients suggests that standardized perioperative prevention may be associated with meaningful reduction in postoperative infection burden when all components are applied together. However, because the bundle group consisted of elective patients and the control group included emergency and financially constrained patients, the observed difference cannot be attributed to the bundle alone without adjustment for baseline clinical and socioeconomic differences.

The distribution of infections by cesarean-section category provides an important implementation insight. Emergency control patients accounted for 25 of 37 infections, representing 67.57% of the total SSI burden and an infection rate of 25.00% within that subgroup. This finding is clinically plausible because emergency cesarean sections are often performed under less controlled conditions, with limited time for preparation, greater likelihood of prolonged labour, repeated vaginal examinations, membrane rupture, and increased contamination risk. However, infections were not confined to emergency surgery. Non-affording elective control patients had 12 infections among 50 patients, corresponding to a similarly high infection rate of 24.00%. This pattern suggests that incomplete access to bundle components among elective patients may also be an important context for infection occurrence. The similar infection rates in emergency control and non-affording elective control groups indicate that both clinical urgency and affordability-related non-receipt of preventive care deserve attention in local infection-prevention planning.

The month-wise findings showed an apparent decline in SSI rates from October and November to January, followed by no infections in February. The reported month-wise difference was statistically significant, but interpretation of this trend requires caution. The exposure category was not evenly distributed across months, and February was recorded as the bundle period, whereas the preceding months were recorded as control exposure. Therefore, the apparent month-wise reduction may reflect the introduction or concentration of bundle exposure rather than a true independent time trend. It may also reflect increasing staff awareness, improved wound monitoring, or progressive standardization of practice during the study period, but these explanations remain speculative because process-compliance measures were not reported. Future implementation studies should prospectively monitor bundle fidelity, antibiotic timing, antiseptic compliance, wound-review completion, and staff adherence across time to distinguish temporal learning effects from intervention effects.

The findings support the clinical rationale for structured perioperative SSI-prevention bundles in cesarean delivery, particularly in hospitals managing high obstetric caseloads and socioeconomically diverse patients. A bundle approach is practical because it converts multiple evidence-based steps into a standardized workflow, reducing dependence on individual provider preference or inconsistent routine practice. In this study, the bundle included chlorhexidine-alcohol skin preparation, pre-incision cefazolin prophylaxis, vaginal povidone-iodine preparation, sterile draping and instrument handling, suture-based wound closure, and structured postoperative wound review. The absence of infections among patients receiving the complete bundle suggests that comprehensive and consistent implementation may be clinically valuable. Nevertheless, the study's design does not allow the individual contribution of each bundle component to be separated, and it remains unclear whether the observed pattern was driven mainly by antibiotic timing, antiseptic preparation, postoperative surveillance, patient selection, or combined bundle fidelity.

A key strength of this study is its prospective follow-up of 300 cesarean-section patients over 30 postoperative days, which aligns with standard SSI surveillance timing. The study also addresses a locally relevant gap by comparing patients who received a complete perioperative care bundle with those who did not receive the complete bundle because of emergency presentation or financial constraints. This

real-world comparison is useful because implementation barriers in low-resource settings are often related to access, urgency, and affordability rather than lack of knowledge alone. The subgroup distinction between emergency controls and non-affording elective controls adds practical value by showing that infection-prevention inequity may affect both clinically urgent and financially constrained patients.

The study also has important limitations. The most significant limitation is the non-randomized design, which resulted in unequal and non-equivalent groups. The care bundle group consisted of elective patients, whereas the control group included emergency patients and elective patients who could not afford the full bundle. This creates confounding by clinical urgency, socioeconomic status, and likely baseline health risk. Important individual-level risk factors such as age, body mass index, diabetes, anemia, parity, labour duration, membrane rupture, number of vaginal examinations, operative duration, surgeon experience, antibiotic timing, and wound class were not reported, preventing adjusted analysis. Because no multivariable regression, propensity adjustment, or stratified risk adjustment was performed, the magnitude of the bundle effect may be overestimated. The study was also conducted at a single centre, which limits generalizability. Finally, microbiological confirmation was used only when samples were taken as part of clinical care, so SSI classification may have relied primarily on clinical diagnosis in some cases.

Future research should use a stronger design to confirm these findings. A randomized controlled trial, stepped-wedge implementation design, or prospective cohort with baseline risk adjustment would provide more reliable evidence regarding bundle effectiveness. Future studies should also collect and report baseline patient characteristics, emergency indications, operative details, antibiotic timing, antiseptic compliance, wound-closure method, postoperative dressing adherence, and follow-up completeness. Reporting adjusted effect estimates with 95% confidence intervals would improve clinical interpretability. Cost-effectiveness analysis would also be valuable because the present study suggests that affordability-related lack of bundle access may be an important contributor to infection burden. In settings where patients cannot afford complete prevention protocols, institutional provision of core bundle components may be a practical and equitable strategy to reduce maternal morbidity.

CONCLUSION

In this prospective non-randomized study of 300 cesarean-section patients at a tertiary-care hospital in Faisalabad, the overall 30-day surgical site infection prevalence was 12.33%. No infections were observed among patients receiving the complete perioperative care bundle, whereas 24.67% of standard-care controls developed surgical site infection. Most infections occurred among emergency cesarean-section patients, but non-affording elective control patients had a similarly high infection rate, highlighting both emergency surgical context and incomplete access to preventive bundle components as important observed infection-related contexts. These findings support wider and more equitable implementation of standardized perioperative SSI-prevention bundles, especially for emergency and financially constrained patients. However, because group allocation was non-randomized and baseline risk factors were not adjusted, the findings should be interpreted cautiously as an observed association requiring confirmation through adjusted prospective studies or randomized implementation trials.

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