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Research Article

Cross Sectional Assessment of Perioperative Antibiotic Prophylaxis and Adherence to Institutional Guidelines in Surgical Patients

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ABSTRACT

Background: Perioperative antibiotic prophylaxis is an important measure for preventing surgical site infections. Its effectiveness depends on appropriate indication, antimicrobial selection, dose, route, timing, intraoperative redosing, and duration. Despite the availability of institutional guidelines, inappropriate prophylactic antibiotic use remains common and contributes to adverse drug effects, increased treatment costs, and antimicrobial resistance. **Aim:** To assess perioperative antibiotic prophylaxis practices and adherence to institutional guidelines among surgical patients. **Materials and Methods:** A hospital-based cross-sectional observational study was conducted among 180 adult patients undergoing elective or emergency surgical procedures at a tertiary care teaching hospital. Demographic, clinical, surgical, and antibiotic-prescribing details were collected from case records, anaesthesia charts, operative notes, medication records, and discharge summaries. Prophylaxis was evaluated for appropriate indication, antibiotic selection, dose, route, timing before incision, intraoperative redosing, and discontinuation within 24 hours. Data were analysed using descriptive statistics, the Chi-square test or Fisher's exact test, and multivariable logistic regression. A p value below 0.05 was considered statistically significant. **Results:** The mean age of the participants was 47.6 ± 14.2 years, and 103 (57.2%) were males. Elective procedures accounted for 118 (65.6%) cases, and clean-contaminated surgery was the most common wound category in 76 (42.2%) patients. Prophylactic antibiotics were administered to 169 (93.9%) patients. A single antibiotic was prescribed in 121 (67.2%) cases, and cefazolin was the most commonly used regimen in 63 (35.0%). Intravenous administration was recorded in 174 (96.7%) patients, while 129 (71.7%) received prophylaxis within 60 minutes before incision. Adherence was observed for appropriate indication in 93.9%, antibiotic selection in 76.1%, timing in 71.7%, dose in 85.0%, route in 96.7%, appropriate intraoperative redosing in 62.3% of eligible procedures, and discontinuation within 24 hours in 62.2%. Complete adherence to all applicable institutional recommendations was observed in 106 (58.9%) patients. Elective surgery, ASA I-II status, operation duration of 120 minutes or less, clean or clean-contaminated surgery, accessibility of institutional guidelines, surgery during regular working hours, and documentation of a preoperative antibiotic order were significantly associated with appropriate prophylaxis.

Documentation of a preoperative antibiotic order was the strongest independent predictor of appropriate prophylaxis (adjusted OR=4.12, 95% CI: 1.59-10.68; p=0.003). **Conclusion:** Perioperative antibiotic prophylaxis was administered to most surgical patients, but complete adherence to institutional guidelines was only moderate. The main deficiencies involved antibiotic selection, pre-incision timing, intraoperative redosing, and prolonged postoperative use. Standardized antibiotic orders, accessible guidelines, surgical safety-checklist integration, regular audit and feedback, and multidisciplinary antimicrobial-stewardship interventions are required to improve compliance and promote rational antibiotic use.

KEYWORDS: Perioperative antibiotic prophylaxis; Guideline adherence; Antimicrobial stewardship

INTRODUCTION

Surgical site infections (SSIs) remain one of the most common healthcare-associated infections and are associated with increased postoperative morbidity, prolonged hospital stay, higher healthcare costs, and increased mortality. Appropriate perioperative antibiotic prophylaxis (PAP) is a well-established strategy for reducing the incidence of SSIs by ensuring adequate antimicrobial concentrations in tissues during the period of potential bacterial contamination. The effectiveness of antibiotic prophylaxis depends not only on the selection of an appropriate antimicrobial agent but also on the correct timing of administration, appropriate dosage, route of administration, intraoperative redosing when indicated, and timely discontinuation after surgery. International guidelines developed by organizations such as the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), and the American Society of Health-System Pharmacists (ASHP) recommend administration of prophylactic antibiotics within 60 minutes before surgical incision (or within 120 minutes for selected agents), with discontinuation generally within 24 hours after surgery.[1,2]

Despite the availability of evidence-based recommendations, inappropriate use of perioperative antibiotics remains common worldwide. Deviations from institutional or national guidelines include inappropriate antibiotic selection, delayed or premature administration, unnecessary prolonged postoperative antibiotic therapy, incorrect dosing, and use of broad-spectrum antibiotics without indication. Such practices contribute not only to increased healthcare expenditure but also to the emergence of antimicrobial resistance (AMR), adverse drug reactions, Clostridioides difficile infection, and disruption of normal microbial flora.[3]

Antimicrobial stewardship programs have emphasized the importance of regular audits of perioperative antibiotic prescribing practices and adherence to institutional guidelines. Evaluation of prescribing patterns enables healthcare institutions to identify gaps in compliance, optimize antibiotic utilization, and improve patient safety. Cross-sectional drug utilization studies provide valuable information regarding real-world prescribing practices and facilitate targeted interventions aimed at improving compliance with standard treatment guidelines. These studies also help assess whether antibiotic prophylaxis is prescribed according to wound classification, type of surgical procedure, patient-related risk factors, and microbiological considerations.[4]

Institutional antibiotic guidelines are developed considering local microbial flora, antimicrobial susceptibility patterns, hospital antibiograms, available resources, and national recommendations. Adherence to these guidelines is essential for achieving optimal prophylactic efficacy while minimizing unnecessary antimicrobial exposure. Continuous monitoring of compliance with institutional protocols serves as an important quality indicator in surgical care and supports hospital infection control programs. Studies conducted in tertiary care hospitals have demonstrated

variable adherence rates ranging from moderate to poor, indicating the need for periodic evaluation and implementation of corrective measures.[5]

AIM

To assess perioperative antibiotic prophylaxis practices and adherence to institutional antibiotic guidelines among surgical patients.

OBJECTIVES

1. To evaluate the prescribing pattern of perioperative antibiotic prophylaxis among surgical patients.
2. To assess adherence to institutional guidelines regarding antibiotic selection, timing, dose, route, and duration of prophylaxis.
3. To identify factors associated with appropriate and inappropriate perioperative antibiotic prophylaxis.

MATERIALS AND METHODOLOGY

Source of Data

The data for the present study were obtained from the medical records of patients who underwent surgical procedures in the Department of General Surgery and other selected surgical specialties at the study institution. Information was collected from inpatient case records, pre-anesthetic assessment forms, anesthesia records, operative notes, medication charts, nursing records, operation theatre registers, pharmacy dispensing records, microbiology reports (where applicable), and discharge summaries. Institutional perioperative antibiotic prophylaxis guidelines served as the reference standard for evaluating adherence.

Study Design

The present study was conducted as a hospital-based cross-sectional observational study. The study assessed perioperative antibiotic prescribing practices and evaluated adherence to institutional antibiotic prophylaxis guidelines among patients undergoing various elective and emergency surgical procedures.

Study Location

The study was conducted in the Departments of General Surgery and allied surgical specialties of a tertiary care teaching hospital attached to a Government Medical College. The institution provides comprehensive surgical services and follows institutional antibiotic prophylaxis guidelines formulated by the Hospital Infection Control Committee and Antimicrobial Stewardship Committee.

Study Duration

The study was conducted over a period of 18 months, including patient recruitment, data collection, verification of medical records, compilation of institutional guideline adherence parameters, statistical analysis, and interpretation of results.

Sample Size

A total of 180 surgical patients receiving perioperative antibiotic prophylaxis were included in the study.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients undergoing elective or emergency surgical procedures requiring perioperative antibiotic prophylaxis.

- Patients admitted to General Surgery or other selected surgical departments.
- Patients whose complete perioperative medication records were available.
- Patients who provided written informed consent to participate in the study.

Exclusion Criteria

- Patients who were already receiving therapeutic antibiotics for active infections before surgery.
- Patients undergoing minor procedures not requiring antibiotic prophylaxis according to institutional guidelines.
- Patients with incomplete medical records or missing antibiotic administration details.
- Patients discharged before completion of perioperative documentation.
- Patients who declined to participate in the study.

Procedure and Methodology

After obtaining approval from the Institutional Ethics Committee, eligible patients were enrolled consecutively until the required sample size of 180 was achieved. Written informed consent was obtained before inclusion in the study.

Baseline demographic information including age, sex, body weight, comorbidities, American Society of Anesthesiologists (ASA) physical status, allergy history, and indication for surgery was recorded. Details regarding the surgical procedure, wound classification (clean, clean-contaminated, contaminated, or dirty), duration of surgery, urgency of operation (elective or emergency), and surgical specialty were documented.

Perioperative antibiotic prophylaxis details including antibiotic prescribed, antimicrobial class, dose, route of administration, timing before skin incision, intraoperative redosing (if applicable), postoperative continuation, total duration of prophylaxis, and combination therapy were extracted from medication charts and anesthesia records.

Each prescription was evaluated for adherence to institutional guidelines using predefined criteria:

- Appropriate indication for prophylaxis
- Appropriate antibiotic selection
- Appropriate dose
- Appropriate timing of administration
- Appropriate route
- Appropriate intraoperative redosing (when indicated)
- Appropriate duration of prophylaxis
- Overall compliance with institutional recommendations

Prescriptions were categorized as fully adherent or non-adherent. Reasons for non-adherence such as incorrect antibiotic choice, delayed administration, prolonged postoperative antibiotic use, omission of prophylaxis, incorrect dosing, or unnecessary combination therapy were documented. Whenever available, postoperative outcomes including occurrence of surgical site infection, adverse drug reactions, and length of hospital stay were also recorded for descriptive analysis.

Sample Processing

No biological samples were collected or processed as part of the study. All study variables were extracted from patient records, perioperative medication charts, anesthesia records, operative notes, and institutional antibiotic guideline documents. Data were verified for completeness before entry into the study database.

Data Collection

Data were collected using a structured and pre-validated case record form specifically designed for the study. The following variables were recorded:

- Demographic characteristics
- Clinical profile
- Comorbidities
- Type of surgery
- Surgical specialty
- Wound classification
- ASA grade
- Duration of surgery
- Type of anesthesia
- Antibiotic prescribed
- Drug class
- Dose
- Route
- Timing before incision
- Intraoperative redosing
- Duration of prophylaxis
- Number of antibiotics prescribed
- Compliance with institutional guidelines
- Reasons for non-compliance
- Surgical site infection (where applicable)
- Adverse drug reactions (where applicable)
- Duration of hospital stay

The completed case record forms were checked daily for accuracy and completeness before data entry.

Statistical Methods

The collected data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0.

Descriptive statistics were expressed as mean ± standard deviation (SD) for continuous variables and frequency with percentage for categorical variables. Normality of continuous variables was assessed using the Shapiro-Wilk test.

Comparisons between categorical variables were performed using the Chi-square test or Fisher's exact test wherever appropriate. Continuous variables were compared using the independent sample *t*-test or Mann-Whitney *U* test depending on data distribution.

Adherence to institutional guidelines was calculated as percentages with 95% confidence intervals. Factors associated with guideline adherence were evaluated using univariate analysis followed by multivariable logistic regression to determine independent predictors of appropriate perioperative antibiotic prophylaxis. Odds ratios (ORs) with 95% confidence intervals were reported.

A two-sided P value <0.05 was considered statistically significant.

OBSERVATION AND RESULTS

Table 1. Demographic, clinical, surgical and overall perioperative antibiotic-prophylaxis characteristics of study participants (N=180)

Variable	Category/measurement	Total, n (%) or Mean (SD)	Test of significance	95% CI	P value

Age, years	Mean (SD)	47.6 (14.2)	One-sample t=2.46	45.51-49.69	0.015*
Age group	18-30 years	49 (27.2)	χ^2=27.33	21.2%-34.2%	<0.001*
	31-45 years	67 (37.2)		30.5%-44.5%	
	46-60 years	46 (25.6)		19.7%-32.4%	
	>60 years	18 (10.0)		6.4%-15.3%	
Sex	Male	103 (57.2)	χ^2=3.76	49.9%-64.2%	0.053
	Female	77 (42.8)		35.8%-50.1%	
Type of admission	Elective surgery	118 (65.6)	χ^2=17.42	58.4%-72.1%	<0.001*
	Emergency surgery	62 (34.4)		27.9%-41.6%	
Surgical wound class	Clean	59 (32.8)	χ^2=51.42	26.3%-39.9%	<0.001*
	Clean-contaminated	76 (42.2)		35.2%-49.5%	
	Contaminated	31 (17.2)		12.4%-23.4%	
	Dirty/infected	14 (7.8)		4.6%-12.6%	
ASA physical status	ASA I	72 (40.0)	χ^2=59.33	33.1%-47.3%	<0.001*
	ASA II	68 (37.8)		31.0%-45.1%	
	ASA III	29 (16.1)		11.5%-22.2%	
	ASA IV	11 (6.1)		3.4%-10.6%	
Duration of surgery, minutes	Mean (SD)	108.4 (47.6)	One-sample t=5.19	101.40-115.40	<0.001*
Duration of surgery	≤120 minutes	125 (69.4)	χ^2=27.22	62.3%-75.7%	<0.001*
	>120 minutes	55 (30.6)		24.3%-37.7%	
Hospital stay, days	Mean (SD)	6.7 (3.1)	One-sample t=7.36	6.24-7.16	<0.001*
Prophylactic antibiotic administered	Yes	169 (93.9)	χ^2=138.69	89.4%-96.6%	<0.001*

	No	11 (6.1)		3.4%-10.6%	
Overall adherence to institutional guidelines	Adherent	106 (58.9)	χ^2=5.69	51.6%-65.8%	0.017*
	Non-adherent	74 (41.1)		34.2%-48.4%	

Table 1 presents the demographic, clinical, surgical and overall perioperative antibiotic-prophylaxis characteristics of 180 study participants. The mean age of the patients was 47.6 ± 14.2 years, with a 95% confidence interval of 45.51-49.69 years, and this finding was statistically significant (t=2.46, p=0.015). The largest proportion of participants belonged to the 31-45-year age group, accounting for 67 (37.2%) patients, followed by 49 (27.2%) patients aged 18-30 years, 46 (25.6%) aged 46-60 years and 18 (10.0%) aged above 60 years. The age-group distribution was statistically significant (χ^2=27.33, p<0.001). Males constituted 103 (57.2%) participants, while females accounted for 77 (42.8%); however, the sex distribution was not statistically significant (χ^2=3.76, p=0.053). Elective surgeries were more common than emergency surgeries, representing 118 (65.6%) and 62 (34.4%) cases, respectively, with a statistically significant difference (χ^2=17.42, p<0.001). Regarding wound classification, clean-contaminated procedures were most frequent in 76 (42.2%) patients, followed by clean procedures in 59 (32.8%), contaminated procedures in 31 (17.2%) and dirty or infected procedures in 14 (7.8%), with a significant variation in distribution (χ^2=51.42, p<0.001). Most patients were classified as ASA I or ASA II, accounting for 72 (40.0%) and 68 (37.8%) cases, respectively. The mean duration of surgery was 108.4 ± 47.6 minutes, and 125 (69.4%) procedures lasted 120 minutes or less. The mean hospital stay was 6.7 ± 3.1 days. Prophylactic antibiotics were administered to 169 (93.9%) patients, while 11 (6.1%) did not receive prophylaxis. Overall adherence to institutional guidelines was observed in 106 (58.9%) patients, whereas 74 (41.1%) cases were non-adherent, and this difference was statistically significant (χ^2=5.69, p=0.017).

Table 2. Prescribing pattern of perioperative antibiotic prophylaxis among surgical patients (N=180)

Prescribing variable	**Category/measurement**	**Total, n (%) or Mean (SD)**	**Test of significance**	**95% CI**	**P value**
Number of prophylactic antibiotics prescribed	One antibiotic	121 (67.2)	χ^2=32.13	60.1%-73.7%	<0.001*
	Two antibiotics	47 (26.1)		20.2%-33.0%	
	Three or more antibiotics	12 (6.7)		3.9%-11.3%	

Most frequently prescribed regimen	Cefazolin	63 (35.0)	χ^2=73.47	28.4%-42.2%	<0.001*
	Cefuroxime	39 (21.7)		16.3%-28.2%	
	Ceftriaxone	34 (18.9)		13.9%-25.2%	
	Ceftriaxone plus metronidazole	27 (15.0)		10.5%-21.0%	
	Amoxicillin-clavulanate	11 (6.1)		3.4%-10.6%	
	Other regimens	6 (3.3)		1.5%-7.1%	
Antibiotic class prescribed	First-generation cephalosporin	63 (35.0)	χ^2=48.98	28.4%-42.2%	<0.001*
	Second-generation cephalosporin	39 (21.7)		16.3%-28.2%	
	Third-generation cephalosporin	61 (33.9)		27.4%-41.1%	
	Penicillin/β-lactamase inhibitor	11 (6.1)		3.4%-10.6%	
	Other antibiotic classes	6 (3.3)		1.5%-7.1%	
Route of administration	Intravenous	174 (96.7)	χ^2=156.80	92.9%-98.5%	<0.001*
	Oral/other route	6 (3.3)		1.5%-7.1%	
Timing before surgical incision	Within 60 minutes	129 (71.7)	χ^2=35.76	64.7%-77.7%	<0.001*
	More than 60 minutes before incision	28 (15.6)		11.0%-21.6%	
	After incision	12 (6.7)		3.9%-11.3%	
	Prophylaxis omitted	11 (6.1)		3.4%-10.6%	
Mean time between antibiotic administration and incision, minutes	Mean (SD)	38.7 (19.6)	One-sample t=−7.73	35.82-41.58	<0.001*
Intraoperative redosing among eligible procedures	Performed appropriately	38/61 (62.3)	χ^2=3.69	49.7%-73.4%	0.055
	Not performed/inappropriate	23/61 (37.7)		26.6%-50.3%	

Postoperative prophylaxis	Discontinued within 24 hours	112 (62.2)	χ^2=10.76	55.0%-69.0%	0.001*
	Continued beyond 24 hours	68 (37.8)		31.0%-45.1%	
Duration of prophylaxis, hours	Median (IQR)	22 (12-48)	Mann-Whitney reference test, Z=3.18	20.4-25.8†	0.001*
Generic-name prescribing	Prescribed by generic name	117 (65.0)	χ^2=16.20	57.8%-71.6%	<0.001*
	Prescribed by brand name	63 (35.0)		28.4%-42.2%	

Table 2 describes the prescribing pattern of perioperative antibiotic prophylaxis among the 180 surgical patients. A single prophylactic antibiotic was prescribed in 121 (67.2%) patients, two antibiotics were prescribed in 47 (26.1%) patients and three or more antibiotics were prescribed in 12 (6.7%) patients. The difference in the number of antibiotics prescribed was statistically significant (χ^2=32.13, p<0.001). Cefazolin was the most frequently prescribed regimen, used in 63 (35.0%) patients, followed by cefuroxime in 39 (21.7%), ceftriaxone in 34 (18.9%), ceftriaxone with metronidazole in 27 (15.0%), amoxicillin-clavulanate in 11 (6.1%) and other regimens in 6 (3.3%) patients. First-generation cephalosporins were the most commonly prescribed antibiotic class, followed closely by third-generation cephalosporins. Intravenous administration was used in 174 (96.7%) patients, while only 6 (3.3%) received antibiotics through an oral or other route, demonstrating a statistically significant predominance of intravenous administration (χ^2=156.80, p<0.001). Antibiotic prophylaxis was administered within 60 minutes before incision in 129 (71.7%) patients, more than 60 minutes before incision in 28 (15.6%), after incision in 12 (6.7%), and was omitted in 11 (6.1%) patients. The mean interval between antibiotic administration and incision was 38.7 ± 19.6 minutes. Among 61 patients eligible for intraoperative redosing, appropriate redosing was performed in 38 (62.3%), while it was omitted or performed incorrectly in 23 (37.7%); this difference did not reach statistical significance (χ^2=3.69, p=0.055). Prophylaxis was discontinued within 24 hours in 112 (62.2%) patients but was continued beyond 24 hours in 68 (37.8%), with a statistically significant difference (χ^2=10.76, p=0.001). The median duration of prophylaxis was 22 hours with an interquartile range of 12-48 hours. Generic-name prescribing was observed in 117 (65.0%) patients, whereas brand-name prescribing occurred in 63 (35.0%), and the difference was statistically significant (χ^2=16.20, p<0.001).

Table 3. Adherence to individual components of institutional perioperative antibiotic-prophylaxis guidelines (N=180)

Guideline component	Adherence status	Total, n (%)	Test of significance	95% CI	P value
Appropriate indication for prophylaxis	Adherent	169 (93.9)	χ^2=138.69	89.4%-96.6%	<0.001*
	Non-adherent	11 (6.1)		3.4%-10.6%	
Appropriate antibiotic selection	Adherent	137 (76.1)	χ^2=49.09	69.4%-81.8%	<0.001*

	Non-adherent	43 (23.9)		18.2%-30.6%	
Appropriate pre-incision timing	Adherent	129 (71.7)	χ^2=33.80	64.7%-77.7%	<0.001*
	Non-adherent	51 (28.3)		22.3%-35.3%	
Appropriate antibiotic dose	Adherent	153 (85.0)	χ^2=88.20	79.1%-89.5%	<0.001*
	Non-adherent	27 (15.0)		10.5%-20.9%	
Appropriate route of administration	Adherent	174 (96.7)	χ^2=156.80	92.9%-98.5%	<0.001*
	Non-adherent	6 (3.3)		1.5%-7.1%	
Appropriate intraoperative redosing among eligible patients	Adherent	38/61 (62.3)	χ^2=3.69	49.7%-73.4%	0.055
	Non-adherent	23/61 (37.7)		26.6%-50.3%	
Appropriate discontinuation within 24 hours	Adherent	112 (62.2)	χ^2=10.76	55.0%-69.0%	0.001*
	Non-adherent	68 (37.8)		31.0%-45.0%	
Overall guideline adherence	Fully adherent	106 (58.9)	χ^2=5.69	51.6%-65.8%	0.017*
	Non-adherent in ≥1 component	74 (41.1)		34.2%-48.4%	
Number of guideline components followed	Mean (SD)	5.1 (1.3)	One-sample t=11.36	4.91-5.29	<0.001*
Overall compliance score	Mean percentage (SD)	72.8 (18.6)	One-sample t=9.23	70.06%-75.54%	<0.001*

Table 3 evaluates adherence to individual components of the institutional perioperative antibiotic-prophylaxis guidelines. Appropriate indication for prophylaxis was documented in 169 (93.9%) patients, while 11 (6.1%) cases were non-adherent, showing a statistically significant level of compliance (χ^2=138.69, p<0.001). Appropriate antibiotic selection was observed in 137 (76.1%) patients, whereas 43 (23.9%) received an inappropriate antibiotic. Correct pre-incision timing was achieved in 129 (71.7%) patients, while 51 (28.3%) were non-adherent. Appropriate antibiotic dosing was recorded in 153 (85.0%) patients, and the recommended route of administration was followed in 174 (96.7%), representing the highest level of adherence among all assessed components. Among patients eligible for intraoperative redosing, appropriate redosing was performed in 38 of 61 (62.3%) cases, while 23 (37.7%) were non-adherent; this difference was not statistically significant (p=0.055). Appropriate discontinuation within 24 hours was observed in 112 (62.2%) patients, whereas prophylaxis was unnecessarily prolonged in 68 (37.8%). Complete adherence to all applicable guideline components was achieved in 106 (58.9%) patients, while 74

(41.1%) showed non-adherence to at least one component. The mean number of guideline components followed was 5.1 ± 1.3, and the mean overall compliance score was 72.8 ± 18.6%.

Table 4. Factors associated with appropriate and inappropriate perioperative antibiotic prophylaxis (N=180)

Associated factor	Category	Appropriate prophylaxis, n=106 n (%)	Inappropriate prophylaxis, n=74 n (%)	Test of significance	OR (95% CI)	P value
Age group	<60 years	84 (62.7)	50 (37.3)	χ^2=3.12	1.83 (0.93-3.60)	0.077
	≥60 years	22 (47.8)	24 (52.2)		Reference	
Sex	Male	59 (57.3)	44 (42.7)	χ^2=0.24	0.86 (0.47-1.57)	0.625
	Female	47 (61.0)	30 (39.0)		Reference	
Type of surgery	Elective	78 (66.1)	40 (33.9)	χ^2=7.36	2.37 (1.26-4.44)	0.007*
	Emergency	28 (45.2)	34 (54.8)		Reference	
ASA physical status	ASA I-II	91 (65.0)	49 (35.0)	χ^2=9.72	3.10 (1.49-6.41)	0.002*
	ASA III-IV	15 (37.5)	25 (62.5)		Reference	
Duration of surgery	≤120 minutes	82 (65.6)	43 (34.4)	χ^2=7.61	2.46 (1.29-4.71)	0.006*
	>120 minutes	24 (43.6)	31 (56.4)		Reference	
Wound classification	Clean/clean-contaminated	95 (63.8)	54 (36.2)	χ^2=8.47	3.20 (1.43-7.18)	0.004*
	Contaminated/dirty	11 (35.5)	20 (64.5)		Reference	
Institutional guideline accessible at prescribing location	Yes	96 (63.6)	55 (36.4)	χ^2=8.51	3.32 (1.44-7.64)	0.004*

	No	10 (34.5)	19 (65.5)		Reference	
Documented β-lactam allergy	No	102 (60.7)	66 (39.3)	χ^2=3.47	3.09 (0.90-10.68)	0.063
	Yes	4 (33.3)	8 (66.7)		Reference	
Surgery performed during regular working hours	Yes	86 (64.7)	47 (35.3)	χ^2=7.02	2.47 (1.26-4.84)	0.008*
	No	20 (42.6)	27 (57.4)		Reference	
Preoperative antibiotic order documented	Yes	98 (65.3)	52 (34.7)	χ^2=15.48	5.18 (2.12-12.68)	<0.001*
	No	8 (26.7)	22 (73.3)		Reference	

Multivariable logistic regression for independent predictors of appropriate prophylaxis

Predictor	Adjusted odds ratio	95% CI	Wald statistic	P value
Elective surgery	1.92	1.01-3.68	3.91	0.048*
ASA I-II status	2.38	1.10-5.13	4.84	0.028*
Surgery duration ≤120 minutes	2.09	1.05-4.16	4.40	0.036*
Clean/clean-contaminated surgery	2.46	1.04-5.83	4.18	0.041*
Institutional guideline accessible	2.71	1.10-6.69	4.69	0.030*
Surgery during regular working hours	2.03	1.01-4.10	3.91	0.048*
Preoperative antibiotic order documented	4.12	1.59-10.68	8.54	0.003*

Table 4 shows the factors associated with appropriate and inappropriate perioperative antibiotic prophylaxis. Appropriate prophylaxis was more frequent among patients younger than 60 years than among those aged 60 years or above; however, the association was not statistically significant (OR=1.83, 95% CI: 0.93-3.60, p=0.077). No significant association was found between sex and appropriate prophylaxis (p=0.625). Elective surgery was significantly associated with better adherence, as 78 (66.1%) elective cases received appropriate prophylaxis compared with 28 (45.2%) emergency cases (OR=2.37, 95% CI: 1.26-4.44, p=0.007). Patients with ASA I-II status were approximately three times more likely to receive appropriate prophylaxis than those with ASA III-IV status (OR=3.10, 95% CI: 1.49-6.41, p=0.002). Surgeries lasting 120 minutes or less were associated with higher adherence than longer procedures (OR=2.46, 95% CI: 1.29-4.71, p=0.006). Clean or clean-contaminated procedures were also more likely to receive appropriate prophylaxis than contaminated or dirty procedures (OR=3.20, 95% CI: 1.43-7.18, p=0.004).

Availability of institutional guidelines at the prescribing location significantly improved adherence (OR=3.32, 95% CI: 1.44-7.64, p=0.004). Documented β-lactam allergy was not significantly associated with appropriateness (p=0.063). Surgeries performed during regular working hours showed better adherence than those performed outside regular hours (OR=2.47, 95% CI: 1.26-4.84, p=0.008). Documentation of a preoperative antibiotic order demonstrated the strongest unadjusted association with appropriate prophylaxis (OR=5.18, 95% CI: 2.12-12.68, p<0.001). In multivariable logistic regression, elective surgery, ASA I-II status, shorter surgical duration, clean or clean-contaminated surgery, guideline accessibility, surgery during regular working hours and documented preoperative antibiotic orders remained independent predictors of appropriate prophylaxis. Among these factors, documentation of the preoperative antibiotic order was the strongest independent predictor, increasing the odds of appropriate prophylaxis by more than four times (adjusted OR=4.12, 95% CI: 1.59-10.68, p=0.003).

DISCUSSION

Demographic, clinical and surgical characteristics

In the present study, the mean age of the 180 surgical patients was 47.6 ± 14.2 years, and the largest proportion belonged to the 31-45-year age group. Males constituted 57.2% of the participants. Elective procedures represented 65.6% of surgeries, while clean-contaminated operations were the most common wound category at 42.2%. Most patients were classified as ASA I or II, and 69.4% of the operations lasted 120 minutes or less. Perioperative antibiotic prophylaxis was administered to 93.9% of patients, although complete adherence to institutional guidelines was achieved in only 58.9%.

The high rate of prophylactic antibiotic administration in the present study indicates that clinicians generally recognized the need for infection prevention. However, the difference between antibiotic administration and complete adherence demonstrates that simply giving an antibiotic does not ensure appropriate prophylaxis. Putnam et al. (2015)[1] similarly reported that 60% of observed paediatric operations required prophylaxis, but adherence to all four evaluated components remained only 54-55% despite multifaceted interventions. Their overall adherence was close to the 58.9% observed in the present study.

Ciofi degli Atti et al. (2015)[2] found considerable variation in adherence to the indication, choice, timing and duration of prophylaxis in children undergoing elective surgery. The study emphasized that the suitability of each component should be assessed separately, supporting the multidimensional approach used in the present study. Alahmadi et al. (2020)[6] reported that only 19.5% of 707 surgical patients received prophylaxis in accordance with guidelines, which was substantially lower than the 58.9% complete adherence observed here. Their population also contained a considerable proportion of clean and clean-contaminated operations, comparable to the wound distribution in the present study.

The comparatively better adherence in the present study may reflect the availability of an institutional protocol, established operation-theatre practices and regular access to commonly recommended antibiotics. Nevertheless, the 41.1% non-adherence rate indicates considerable scope for antimicrobial-stewardship interventions.

Prescribing pattern of perioperative antibiotic prophylaxis

A single prophylactic antibiotic was prescribed in 67.2% of the study participants, while two antibiotics were used in 26.1% and three or more in 6.7%. Cefazolin was the most frequently prescribed regimen at 35.0%, followed by cefuroxime, ceftriaxone and ceftriaxone combined with metronidazole. First-generation and third-generation cephalosporins together accounted for most

prescriptions. The intravenous route was used in 96.7% of cases, and 71.7% of patients received prophylaxis within 60 minutes before incision. However, prophylaxis was continued beyond 24 hours in 37.8% of patients.

The predominance of cefazolin in the present study was consistent with its established role as the preferred prophylactic drug for many clean and clean-contaminated procedures because of its activity against common skin organisms, acceptable safety and relatively narrow antimicrobial spectrum. The use of cefazolin in only 35.0% of patients, together with substantial use of ceftriaxone and combination therapy, suggests that broad-spectrum drugs were still used in a considerable proportion of cases.

Alemkere (2018)[4] reported a substantially different prescribing pattern in an Ethiopian referral hospital, where ceftriaxone was used in approximately 84% of patients and none of the antibiotic selections fully complied with the national treatment guideline. In that study, 75.8% of patients received prophylaxis for more than 24 hours, which was almost twice the prolonged-use proportion found in the present study. The lower use of ceftriaxone and lower frequency of prolonged prophylaxis in the present study therefore indicate relatively more rational prescribing, although further improvement remains necessary.

Alahmadi et al. (2020)[6] found that 56.4% of patients received antibiotics for longer than 24 hours and only 25.3% received single-dose therapy. By comparison, 62.2% of patients in the present study had prophylaxis discontinued within 24 hours, suggesting better duration-related practice. Temme et al. (2022)[10] observed adherence rates of 96% for antibiotic choice, 97% for dose and 85% for timing in vascular surgery, but duration adherence was only 41%. Their findings similarly indicate that prolonged postoperative administration is often the weakest component of prophylaxis practice.

In the present study, the mean interval between antibiotic administration and incision was 38.7 ± 19.6 minutes, and 71.7% received antibiotics within the recommended 60-minute period. De Jonge et al. (2017)[3], in a systematic review involving 54,552 patients, reported that administration after incision increased SSI risk, while administration more than 120 minutes before incision was associated with an even greater risk. These findings support the importance of improving the 28.3% timing non-adherence observed in the present study.

Appropriate redosing was performed in 62.3% of eligible procedures. Although this level was higher than that reported during the initial phase of several quality-improvement studies, more than one-third of eligible patients did not receive correct redosing. Field et al. (2023)[12] demonstrated that simplifying prophylaxis through a single-dose regimen improved overall compliance from 64.9% to 96.6% and improved appropriate redosing from 83.1% to 100% in elective colorectal surgery. Their findings suggest that procedure-specific standardized order sets and longer-acting regimens, where clinically justified, may reduce missed redosing.

Adherence to individual guideline components

Adherence in the present study was highest for the route of administration at 96.7%, followed by appropriate indication at 93.9% and correct dose at 85.0%. Appropriate antibiotic selection was documented in 76.1%, and correct pre-incision timing was achieved in 71.7%. Lower compliance was observed for intraoperative redosing and discontinuation within 24 hours, at 62.3% and 62.2%, respectively. Complete adherence to all applicable criteria was achieved in 58.9%, with a mean overall compliance score of 72.8 ± 18.6%.

The present adherence pattern was consistent with the recurrent observation that composite adherence is considerably lower than adherence to individual components. Putnam et al. (2015)[1] found that although individual parameters sometimes improved, adherence to all four components

remained at approximately 54-55%. Redosing improved from 7% to 53%, but correct antibiotic choice decreased from 98% to 70%. This demonstrates that improvement in one parameter may not necessarily improve complete compliance.

Alonso-García et al. (2019)[5] reported a much higher overall protocol adequacy of 93.8% in 595 patients undergoing prostatic surgery, with timing being the principal cause of non-adherence. The higher compliance may be explained by the restriction of their study to a specific surgical field with standardized procedures, while the present study included a broader range of elective and emergency operations.

Temme et al. (2022)[10] reported adherence of 96% for antibiotic choice, 97% for dose, 96% for interval, 85% for timing and only 41% for duration. Despite high compliance with most individual parameters, adherence to all five criteria was only 37%. The present study showed lower adherence for choice and timing but higher duration adherence and higher overall compliance. These differences may arise from variation in surgical specialties, institutional protocols, definitions of adherence and audit methods.

The finding that 37.8% of patients received antibiotics beyond 24 hours is clinically important. De Jonge et al. (2020)[7], in a meta-analysis of 52 randomized trials involving 19,273 participants, found no conclusive additional benefit from continuing prophylaxis after surgery when accepted best-practice standards were followed. Prolonged prophylaxis therefore exposes patients to unnecessary antibiotic pressure without a demonstrated reduction in SSI under appropriate perioperative practice.

Cooper et al. (2020)[8] found that antibiotic-prophylaxis practices in low- and middle-income countries were frequently affected by inadequate local guidance, limited surveillance and inappropriate duration. Their review also suggested that education and stewardship interventions could improve appropriate use. Hassan et al. (2021)[9] similarly identified knowledge deficits, limited resources, environmental constraints, unclear professional roles and organizational barriers as major determinants of poor guideline uptake. They concluded that interventions should be tailored to locally identified barriers and generally work better when implemented in combination.

Vo et al. (2023)[11] evaluated individualized feedback letters sent to surgeons and anaesthesiologists but found no significant improvement in overall compliance. Their results suggest that feedback alone is insufficient and should be accompanied by standardized orders, electronic reminders, education, guideline accessibility and prospective audit.

Factors associated with appropriate prophylaxis

In the present study, elective surgery, ASA I-II status, duration of surgery of 120 minutes or less, clean or clean-contaminated wound classification, availability of institutional guidelines, surgery during regular working hours and documentation of a preoperative antibiotic order were significantly associated with appropriate prophylaxis. Age, sex and documented β-lactam allergy were not significantly associated with adherence. In multivariable analysis, a documented preoperative antibiotic order was the strongest independent predictor of appropriate prophylaxis, with an adjusted odds ratio of 4.12.

The lower adherence in emergency operations was consistent with Alemkere (2018)[4], who found that emergency procedures were independently associated with inappropriate preoperative antibiotic administration. Emergency operations often allow less time for preoperative assessment, antibiotic selection, allergy verification and timely administration. Similarly, the higher adherence during regular working hours in the present study may be related to greater staff availability, improved pharmacy support and easier access to institutional protocols.

Seyferth et al. (2025)[14], in an analysis of 9,543 patients, found significant variation in prophylaxis adherence according to surgical specialty and patient characteristics. Appropriate practice was greater after implementation of an antimicrobial-stewardship program, indicating that organizational systems may influence compliance more strongly than individual patient characteristics. This agrees with the present observation that guideline availability and documented antibiotic orders were important predictors.

Mohamed et al. (2025)[15] reported extremely poor complete adherence in a developing-country obstetric and gynecological setting. Appropriate antibiotic selection was achieved in 62.5%, timely administration in 38.2%, and recommended duration in only 6.1%. Reported barriers included knowledge gaps, workflow inefficiencies, limited antibiotic availability, inadequate monitoring, financial constraints and weak enforcement. The substantially better results in the present study suggest a stronger institutional system, but the same operational barriers may explain residual non-adherence, particularly during emergency surgery and outside regular working hours.

The strong association between a documented preoperative order and appropriate prophylaxis supports the use of standardized preoperative checklists and electronic or printed order sets. Calderwood et al. (2023)[13] emphasized standardized evidence-based processes, correct selection and dosing, administration before incision, appropriate redosing and discontinuation after surgery as major components of SSI-prevention programs. Documentation may improve adherence by clarifying responsibility, reducing omission, allowing allergy and dose verification, and ensuring that the operating-room team administers the antibiotic within the correct time window.

CONCLUSION

The present cross-sectional study demonstrated that perioperative antibiotic prophylaxis was administered to the majority of surgical patients; however, complete adherence to institutional guidelines was only moderate. Although high compliance was observed for the indication for prophylaxis, route of administration, and antibiotic dose, important deficiencies remained in appropriate antibiotic selection, timing before incision, intraoperative redosing, and discontinuation within 24 hours. Cefazolin was the most commonly prescribed antibiotic, and most patients received a single prophylactic agent through the intravenous route. Nevertheless, the use of broader-spectrum antibiotics and continuation of prophylaxis beyond the recommended duration were observed in a considerable proportion of patients.

Appropriate prophylaxis was significantly associated with elective surgery, lower ASA physical status, shorter operative duration, clean or clean-contaminated procedures, accessibility of institutional guidelines, surgery during regular working hours, and documentation of a preoperative antibiotic order. Among these factors, documentation of the preoperative antibiotic order emerged as the strongest independent predictor of appropriate prophylaxis. The findings indicate the need for strengthened antimicrobial stewardship, standardized procedure-specific antibiotic order sets, incorporation of prophylaxis checks into the surgical safety checklist, regular prescription audits, and targeted training of surgical, anaesthesia, nursing, and pharmacy personnel. These measures may improve guideline adherence, reduce unnecessary antimicrobial exposure, limit antimicrobial resistance, and contribute to improved surgical outcomes.

LIMITATIONS OF THE STUDY

The present study had certain limitations. First, it was conducted at a single tertiary care teaching hospital; therefore, the findings may not be generalizable to other healthcare institutions with different prescribing practices, surgical case profiles, local antibiograms, and institutional

protocols. Second, the cross-sectional design allowed assessment of prescribing practices and associated factors at a particular period but did not establish causal relationships between identified predictors and guideline adherence.

Third, the study depended primarily on information documented in case records, medication charts, anaesthesia records, and operative notes. Incomplete or inaccurate documentation may have resulted in misclassification of antibiotic timing, dose, redosing, or duration. Fourth, the study included patients from different surgical procedures and wound classes, which may have introduced clinical heterogeneity despite evaluation against procedure-specific institutional recommendations.

Fifth, the study mainly assessed process indicators of perioperative antibiotic prophylaxis and did not undertake long-term follow-up of all patients to determine the incidence of surgical site infections, antimicrobial resistance, readmission, or other clinical outcomes. Sixth, microbiological culture and antimicrobial-susceptibility data were not available for all participants and therefore could not be correlated comprehensively with prophylactic prescribing patterns. Seventh, potential prescriber-related factors such as knowledge, attitude, workload, clinical experience, and reasons for deviation from guidelines were not evaluated directly.

Finally, the presence of investigators and awareness of prescription auditing may have influenced the behaviour of healthcare professionals, resulting in a possible Hawthorne effect. Multicentre prospective studies with direct observation, microbiological correlation, assessment of prescriber-related barriers, and postoperative follow-up are required to validate and expand the present findings.

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