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Assessment of surgical prophylactic antibiotic use in a Tertiary Care Hospital Serving a Coal-Mining Community

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Abstract

Surgical site infections (SSIs) are a major postoperative complication, and appropriate surgical antibiotic prophylaxis (SAP) is critical to reduce infection risk. This six-month prospective observational study evaluated the rational use of prophylactic antibiotics among 163 patients undergoing surgery in a tertiary care hospital serving a coal-mining workforce. Data on patient demographics, type and duration of surgery, wound classification, and details of antibiotic prophylaxis—including drug, dose, timing, and duration were collected using a structured proforma and analyzed with descriptive statistics in Microsoft Excel and GraphPad Prism 5.0. Results showed a mean patient age of 38.48 ± 15.9 years with a female predominance (54%), and the majority of surgeries were in Gynaecology (36.8%). Clean wounds constituted 69.3% of cases, and the average surgical duration was 70.93 ± 41.94 minutes. Patients received an average of 2.41 ± 1.14 antibiotics, with ceftriaxone used in 73% of cases; single-drug prophylaxis was administered in 30% of patients, while the remainder received combinations of up to five antibiotics. No significant association was observed between wound type, gender, or surgery duration. The findings highlight frequent use of broad-spectrum and multi-drug prophylactic regimens, emphasizing the need for improved adherence to evidence-based SAP guidelines and enhanced antimicrobial stewardship to optimize antibiotic use and reduce unnecessary exposure in surgical patients.

Keywords: Surgical Antibiotic Prophylaxis; Antimicrobial Stewardship; Ceftriaxone; Wound Classification; Surgical Site Infections

1. Introduction

Surgical site infections (SSIs) remain among the most common and serious postoperative complications worldwide, contributing substantially to increased morbidity, prolonged hospital stays, and elevated healthcare costs.[1] The burden is particularly high in low- and middle-income countries (LMICs), where limited resources, higher patient loads, and infrastructural challenges exacerbate infection risk.[2] In such settings, effective surgical antibiotic prophylaxis (SAP) is a critical component of infection prevention. SAP must be administered with careful consideration of antimicrobial spectrum, pharmacokinetic/pharmacodynamic properties of drugs, timing of administration, and local microbial resistance patterns to ensure effectiveness while limiting unnecessary antibiotic exposure and resistance emergence.[3] Global evidence-based guidelines released by WHO provide comprehensive recommendations for SSI prevention, including optimal SAP timing and duration, skin preparation, and perioperative care practices.[4] However, despite these guidelines, inappropriate SAP practices such as prolonged postoperative prophylaxis or antibiotic overuse remain common in resource-limited settings, undermining efforts to reduce SSIs and fuelling antimicrobial resistance (AMR).[5] Moreover, certain hospital populations, such as those serving coal-mining communities, may have unique occupational or environmental risk factors (e.g., comorbidities, poor baseline health, exposure to mining-related respiratory or skin

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hazards) that could influence wound healing, infection risk, and antibiotic effectiveness. Yet, to date, there is limited published data assessing SAP use and SSI outcomes specifically in such workforce-dependent hospital settings.

Against this background, the present study was designed to assess patterns of SAP use in relation to surgical wound classification and duration of surgery among patients in a tertiary care hospital serving a coal-mining community. The primary objective was to evaluate the rationality of antibiotic prophylaxis and identify areas for improvement to strengthen antimicrobial stewardship and optimize surgical outcomes in this understudied population.

2. Materials and Methodology

Study Design: This study was a prospective observational study aimed at evaluating the utilization of antibiotics for surgical prophylaxis. The primary objective was to analyze patterns of surgical antibiotic prophylaxis (SAP) in relation to surgical wound classification, duration of surgery, and rationality of antibiotic use. A prospective design was employed to allow real-time collection of accurate and complete data while minimizing recall bias. This approach facilitated detailed analysis of prescribing practices, antibiotic combinations, and adherence to hospital guidelines.

2.1. Study Setting and Duration

The study was conducted in the surgical wards of Singareni Collieries Company Limited (SCCL) Main Hospital, Kothagudem, a tertiary care hospital catering to coal-mining employees, their families, and residents. The hospital comprises:

- General Surgical Ward: 64 beds, including orthopaedic and ENT surgeries.
- Gynaecology and Obstetrics Ward: 32 beds.

During the study period, all patient records were maintained manually. The total duration of the study was six months, which allowed comprehensive monitoring of surgical procedures and antibiotic prescribing patterns across multiple departments.

2.2. Ethical Considerations

Ethical approval for the study was obtained from the Ethical Committee of the Department of Surgery, SCCL Main Hospital, and formal permission was secured from hospital administration. Oral informed consent was obtained from all patients before data collection. Confidentiality and anonymity of patient information were strictly maintained throughout the study, and all data were handled in accordance with ethical guidelines for clinical research.

2.3. Study Population

2.3.1. Inclusion Criteria

- Patients of all ages and genders admitted to the surgical, orthopaedic, ENT, or gynaecology wards and undergoing surgical procedures.
- Patients who received prophylactic antibiotics as part of surgical care.

2.3.2. Exclusion Criteria

- Patients from other hospital departments not under the study.
- Patients receiving only topical antibiotics, such as drops or ointments.
- Patients who did not provide consent for data collection.

A total of 163 patients meeting these criteria were enrolled in the study.

2.4. Data Collection

Data were collected prospectively using a structured patient data collection form designed specifically for this study. The following information was recorded from the patient's medical case sheets:

1. **Demographic and Clinical Data:**
    - Age, gender, and comorbidities.
    - Admission and discharge dates to monitor hospital stay duration.
2. **Surgical Data:**

    - Type of surgery (e.g., LSCS, appendectomy, tonsillectomy, septoplasty).
    - Duration of surgery (in minutes).
    - Surgical site and wound classification (clean, clean-contaminated, contaminated, dirty).
3. **Antibiotic Prophylaxis Data:**
    - Name and class of antibiotics administered.
    - Dose, route, and timing of administration (preoperative and postoperative).
    - Duration of prophylaxis (total number of doses and days).
    - Number of antibiotics administered per patient (single vs. combination therapy).
4. **Additional Variables:**
    - Adherence to hospital and international prophylactic guidelines.
    - Type of surgical wound in relation to antibiotic choice and duration.

Data collection was supervised by the principal investigator to ensure accuracy, completeness, and adherence to the study protocol.

2.5. Materials

The following materials were utilized during the study:

- Structured patient data collection forms for standardized data recording.
- Authorization and ethical approval documentation from SCCL Main Hospital.
- Microsoft Excel 2021 for data entry, cleaning, and initial organization.
- GraphPad Prism 5.0 for statistical analysis and graphical presentation of results.

2.6. Study Procedure

The study was conducted systematically as follows:

1. Verification of patient eligibility according to inclusion and exclusion criteria.
2. Explanation of the study and obtaining oral consent from patients.
3. Collection of patient demographic, surgical, and antibiotic data using the structured form.
4. Entry of all collected data into Microsoft Excel, ensuring standardization and accuracy.
5. Data cleaning to remove inconsistencies or missing information.
6. Preparation of graphical representations, including bar charts, pie charts, and tables, to summarize patterns of surgical procedures, wound types, and antibiotic usage.
7. Analysis of preoperative and postoperative antibiotic prophylaxis patterns for each surgical procedure.

2.7. Plan of Work

The study followed a structured six-month plan:

- **Month 1:** Comprehensive literature review and protocol development, including design of data collection forms.
- **Months 2–5:** Prospective collection of patient data, verification of eligibility, and recording of demographic, surgical, and antibiotic data.
- **Month 6:** Data entry, statistical analysis, interpretation of results, and preparation of tables, charts, and the final report.

2.8. Statistical Analysis

Collected data were analyzed using GraphPad Prism 5.0.

- Quantitative variables (e.g., age, surgery duration) were expressed as mean ± standard deviation (SD).
- Categorical variables (e.g., type of surgery, wound classification, antibiotics used) were expressed as percentages.
- Descriptive statistics were used to summarize patient characteristics, surgical data, and antibiotic utilization patterns.
- Graphical representations were generated to visualize trends in SAP, including the number of antibiotics per patient, commonly used drugs, and adherence to guidelines.

- Associations between surgical wound type, duration, and antibiotic usage were analyzed. A p-value < 0.05 was considered statistically significant.

2.9. Quality Assurance

- Data were cross-verified for accuracy and completeness.
- Standardization and cleaning of data ensured reliability.
- Confidentiality and ethical standards were strictly maintained throughout the study.
- Regular supervision by the principal investigator ensured adherence to hospital guidelines and proper execution of study protocols.

3. Results and Discussion

Surgical antibiotic prophylaxis (SAP) plays a critical role in reducing the risk of surgical site infections (SSIs), particularly in settings with limited resources and high patient load. The effectiveness of SAP depends on multiple key factors, including appropriate antibiotic selection, correct timing of administration, optimal duration, and alignment with surgical wound classification and operative complexity. Variations or deviations in these parameters can lead to suboptimal outcomes, unnecessary antimicrobial exposure, increased postoperative complications, and rising antimicrobial resistance.

The present study was conducted in a tertiary care hospital serving a coal-mining community, a population known for higher susceptibility to infections due to occupational and environmental exposures. Despite the importance of SAP in such settings, inappropriate antibiotic use, over-reliance on broad-spectrum agents, and prolongation of prophylaxis beyond recommended durations remain common challenges in clinical practice across low- and middle-income countries.

Against this background, the purpose of this section is to present detailed findings related to patient demographics, surgical wound classifications, operative durations, and patterns of SAP utilization. The analysis emphasizes the relationship between SAP practices and evidence-based guidelines, with a particular focus on identifying deviations that could compromise antimicrobial stewardship. The combined Results and Discussion further contextualize these findings within global literature and guideline recommendations to highlight areas requiring improvement for optimizing surgical outcomes and minimizing antimicrobial resistance.

3.1. Demographic Characteristics

A total of 163 surgical inpatients were included in the analysis. The mean age of the patients was 38.48 ± 15.9 years. The majority belonged to the 21–30-year age group (39.8%), followed by those aged 31–40 years (15.3%). Females accounted for 54.0% of the population, and males constituted 45.8%. The highest proportion of patients was admitted under Gynaecology and Obstetrics (36.8%), followed by General Surgery (26.9%), ENT (25.8%), and Orthopaedics (10.4%).

Table 1 Baseline Characteristics of Surgical Patients

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	Mean ± SD	38.48 ± 15.9	—
Age Group	10–20	10	6.1
	21–30	65	39.8
	31–40	25	15.3
	41–50	22	13.5
	51–60	18	11.0
	>60	23	14.1
Gender	Male	75	45.8
	Female	88	54.0

Department	Gynaecology & Obstetrics	60	36.8
	General Surgery	44	26.9
	ENT	42	25.8
	Orthopaedics	17	10.4

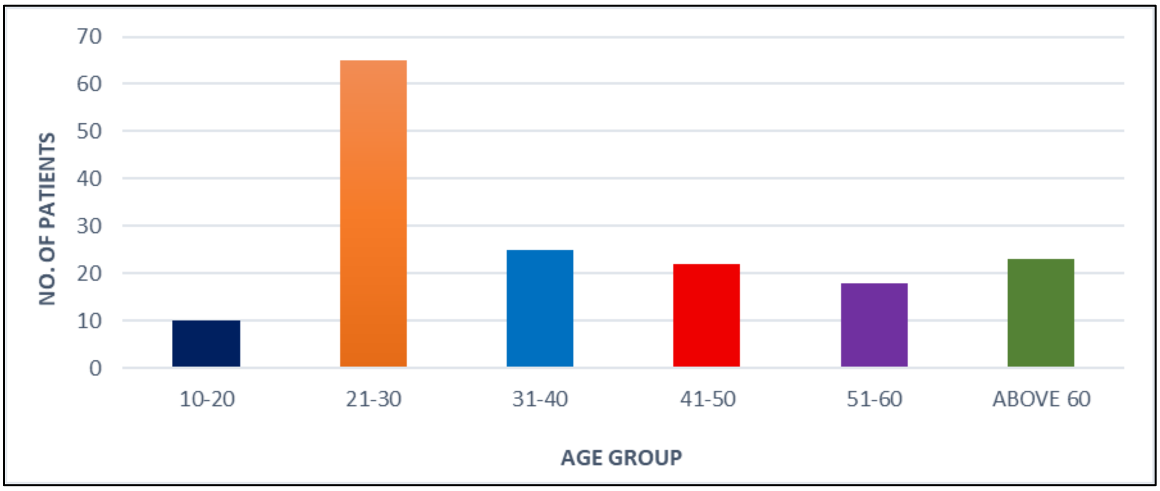

Figure 1 Age-wise Distribution of Study Participants

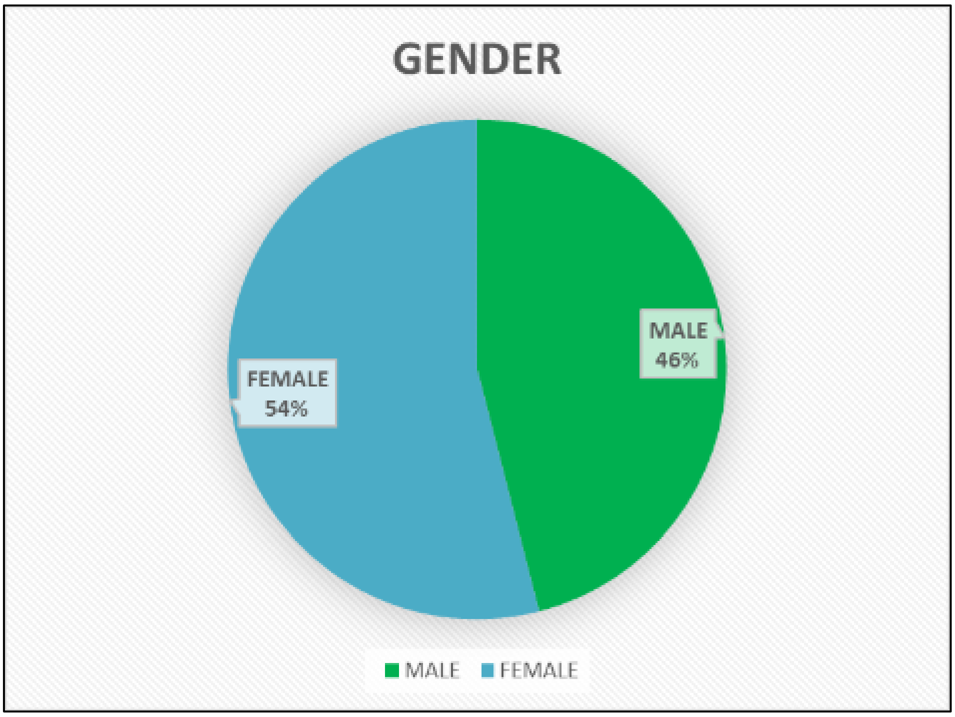

Figure 2 Gender-wise Distribution of Study Participants

The demographic trends reflect typical tertiary care patterns, particularly the higher proportion of women, driven by obstetric and gynaecological workload. This distribution aligns with findings from similar hospital-based SAP studies, where reproductive-age women constitute a major proportion of surgical admissions.[6] The predominance of younger adults also reflects surgical indications such as obstetric procedures, ENT surgeries, and trauma-related orthopaedic cases.[7]

3.2. Surgical Wound Classification

Clean surgeries were the most common (69.3%), followed by contaminated (19.0%), dirty (6.1%), and clean-contaminated procedures (5.5%).

No significant association was observed between wound classification and gender ($p > 0.05$).

Table 2 Distribution of Surgical Wound Categories

Wound Category	Frequency (n)	Percentage (%)
Clean	113	69.3
Clean-contaminated	9	5.5
Contaminated	31	19.0
Dirty	10	6.1
Total	163	100

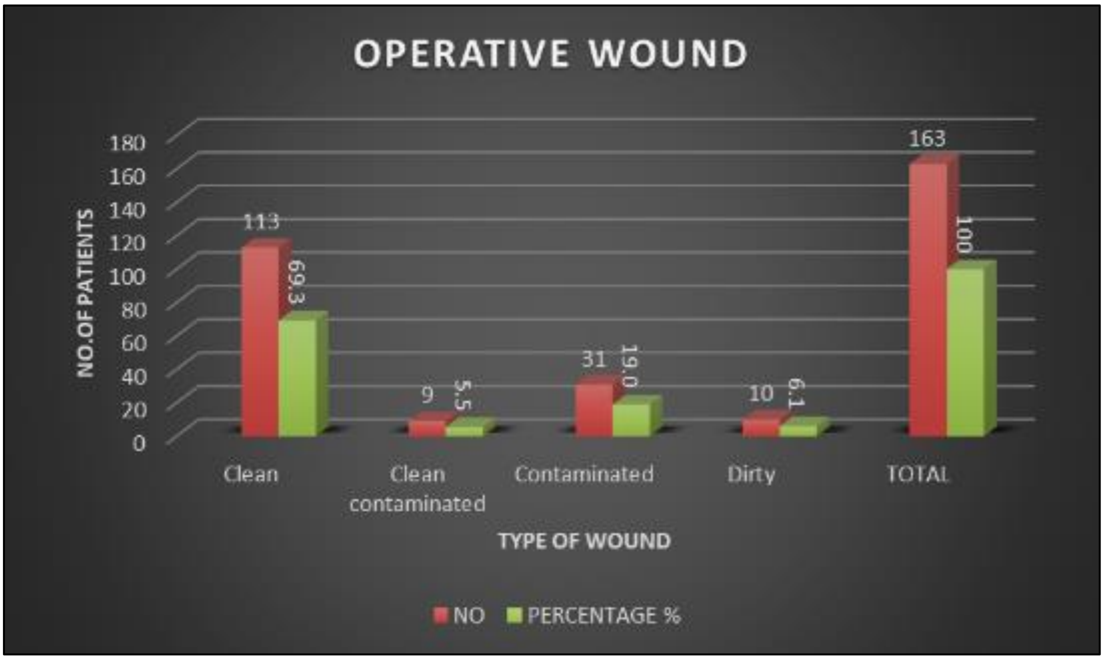

Figure 3 Operative-based Surgical Wound Classification

The predominance of clean surgeries suggests a high proportion of elective and controlled operative procedures where infection risk is inherently low. For such surgeries, international guidelines endorse single-dose, narrow-spectrum SAP, usually cefazolin. [6,7] However, as demonstrated in subsequent sections, broad-spectrum agents were commonly used even for clean cases, indicating significant deviation from stewardship standards.

Comparable studies from India and Ethiopia have similarly highlighted excessive ceftriaxone use for clean surgeries, which can contribute to resistance among *Enterobacteriaceae.* [8,9]

3.3. Duration of Surgery

The mean duration of surgery was 70.93 ± 41.94 minutes. Half (*50.3%*) of procedures lasted less than 1 hour, 38% lasted 1–2 hours, and 11.6% exceeded 2 hours.

Table 3 Duration of Surgery in Relation to Wound Category

Wound Type	Mean Duration (min)	SD
Clean	65.88	43.5
Clean-contaminated	91.5	41.1
Contaminated	80.9	32.0
Dirty	76.0	45.39

(ANOVA: $p > 0.05$)

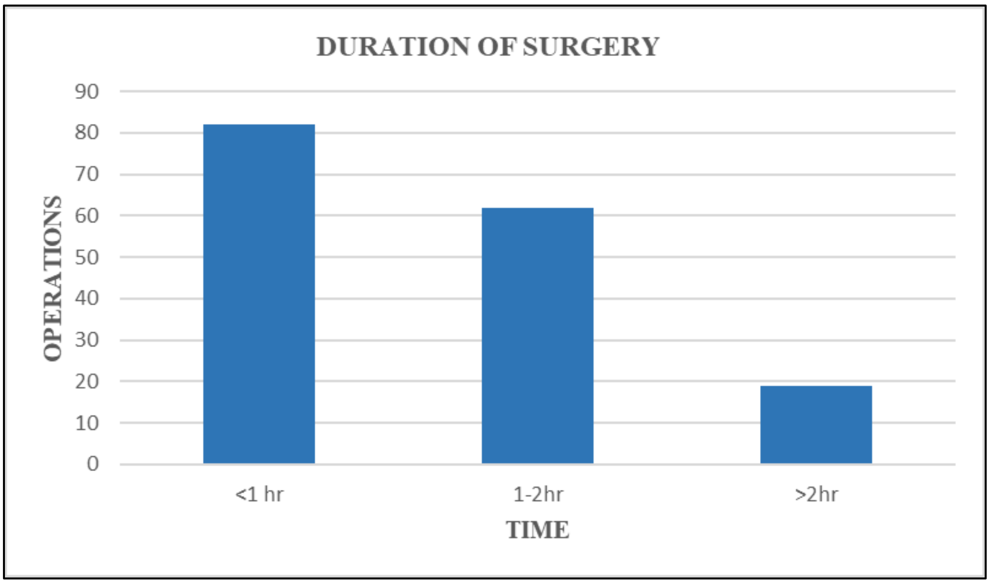

Figure 4 Distribution of Surgery Duration

Most surgeries were short-duration procedures, consistent with elective obstetric, ENT, and general surgical operations. Guidelines recommend intraoperative redosing for surgeries extending beyond two half-lives of the drug or exceeding two hours.[10] However, redosing was not documented in any of the long-duration surgeries, indicating a gap in compliance. Studies in similar settings report that postoperative prolongation is frequently (and incorrectly) used instead of proper intraoperative timing. [11,12]

3.4. SAP Utilization Patterns

Patients received an average of 2.41 ± 1.14 antibiotics. Only 30% received a single prophylactic dose, whereas 70% received multi-drug regimens.

Ceftriaxone was the predominant choice (86 uses preoperatively), followed by cefotaxime and metronidazole. Postoperative therapy commonly included ceftriaxone, ceftriaxone–sulbactam, metronidazole, and cefotaxime.

Table 4 Number of Antibiotics Used Per Patient

No. of Drugs	Frequency	%
1	49	30.0
2	34	20.8
3	46	27.6
4	33	20.8
5	1	0.6

Table 5 Pre- and Post-operative Antibiotic Usage

Antibiotic	Pre-op Use (n)	Post-op Use (n)
Ceftriaxone	86	58
Ceftriaxone–Sulbactam	12	42
Metronidazole	14	49
Cefotaxime	28	36
Amoxicillin–Clavulanate	9	17
Piperacillin–Tazobactam	4	11
Amikacin	1	10

The predominance of broad-spectrum, multi-drug prophylaxis illustrates a major departure from guideline recommendations. ASHP and WHO emphasize narrow-spectrum, single-dose SAP for clean surgeries. [6,7] However, our findings show excessive reliance on ceftriaxone, inconsistent with best practices. Multi-drug prophylaxis offers no additional benefit but increases risks of resistance, adverse reactions, and cost.[13]

Similar inappropriate SAP patterns have been reported in Ethiopia, Kenya, and South Asia, where the lack of standardized institutional protocols contributes to habitual over-prescription. [14,15]

3.5. SAP Appropriateness Relative to Wound Class & Duration

Table 6 Appropriateness of SAP Against Guidelines

Parameter	Guideline Standard	Study Observation	Interpretation
Clean Surgery	Single narrow-spectrum dose	Broad-spectrum + combinations	Irrational SAP
Contaminated/Dirty	Broad-spectrum + anaerobic cover	Ceftriaxone + Metronidazole	Appropriate
Duration of SAP	<24 hours	Often exceeded 24 hours	Non-compliant
Redosing (>2 hr surgeries)	Required	Not documented	Protocol gap

4. Conclusion

This study provides an in-depth evaluation of surgical antibiotic prophylaxis (SAP) practices in a tertiary care hospital serving a coal-mining community, highlighting both strengths and substantial gaps in current antimicrobial stewardship efforts. Although most surgeries performed were clean and of short duration, SAP utilization frequently deviated from established evidence-based guidelines. The extensive use of broad-spectrum antibiotics, particularly ceftriaxone, along with multi-drug prophylaxis and postoperative continuation beyond 24 hours, demonstrates a pattern of overprescription despite low predicted infection risk. Furthermore, the absence of documented intraoperative redosing for prolonged procedures underscores inconsistencies in adherence to optimal timing protocols.

While antibiotic selection for contaminated and dirty surgeries was generally appropriate, the overall SAP approach revealed significant areas needing improvement, especially in aligning prophylactic choice with wound classification and operative duration. These findings emphasize the necessity for implementing standardized institutional SAP protocols, enhancing surgical team awareness, and strengthening antimicrobial stewardship programs.

Improving guideline adherence can significantly reduce unnecessary antibiotic exposure, mitigate the risk of antimicrobial resistance, and enhance patient safety critical priorities for healthcare institutions serving high-risk populations such as coal-mine workers. Establishing regular audits, educational interventions, and multidisciplinary stewardship oversight will be essential to ensuring rational SAP practices and optimal surgical outcomes.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors declare no conflict of interest related to this study or the publication of this manuscript.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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