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Antimicrobial Prescription Patterns in Perioperative Orthopaedic Procedures at a Tertiary Care Teaching Hospital: A Cross-Sectional Study Using the WHO AWaRe Classification and Correlating Prescribing Practices with Antimicrobial Resistance Patterns

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Abstract

Background: Perioperative antimicrobial prescribing is essential in orthopaedic surgery, but excessive broad-spectrum use may contribute to antimicrobial resistance. WHO AWaRe classification supports stewardship assessment.

Objectives: To characterize prescribing patterns, AWaRe categories, bacterial isolates, susceptibility findings, and their descriptive relationship.

Methods: This prospective observational cross-sectional study enrolled adults receiving perioperative antimicrobials at a tertiary-care teaching hospital over two months through convenience sampling. Prescriptions, clinical characteristics, and available culture-susceptibility findings were analyzed descriptively using SPSS.

Results: Among 201 prescriptions, mean participant age was 47.94 ± 14.60 years. Open reduction and internal fixation was the commonest procedure; cefuroxime predominated perioperatively and at discharge. Watch antibiotics accounted for 70.39% perioperatively and 71.48% at discharge, Reserve for 22.02% and 25.85%, and Access for 7.58% and 2.66%, respectively. Of 20 isolates, Pseudomonas aeruginosa (30%) was most frequent, followed by Staphylococcus aureus (25%), Escherichia coli (20%), Acinetobacter baumannii (10%), Staphylococcus haemolyticus (10%), and Klebsiella species (5%). Recorded predominant susceptibility/resistance pairs were ciprofloxacin/imipenem for P. aeruginosa, linezolid/penicillin for S. aureus, amikacin/imipenem for E. coli, polymyxin B/amikacin for A. baumannii, linezolid/erythromycin for S. haemolyticus, and polymyxin B/gentamicin for Klebsiella. High Watch and Reserve use coexisted with resistance to several agents, including imipenem, but patient-level prescribing–resistance associations were not established. Mean antibiotics per encounter were 2.68; generic prescribing was 3.98%, injection use 71%, and Essential Medicines List use 58%.

Conclusion: Perioperative antimicrobial prescribing in orthopaedic procedures was characterized by a predominance of Watch and Reserve antibiotics, frequent injectable use, and limited generic prescribing. The observed bacterial resistance patterns highlight potential antimicrobial stewardship concerns. The findings underscore the need for rational antibiotic selection, adherence to surgical prophylaxis guidelines, and culture-guided antimicrobial therapy.

Recommendations: Strengthen indication-based prophylaxis, culture-guided de-escalation, Reserve restrictions, and AWaRe audits informed by local antibiograms.

Keywords: Antimicrobial resistance; antimicrobial stewardship; AWaRe; orthopaedic surgery; surgical prophylaxis; surgical site infection.

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1. Introduction

Antimicrobial resistance (AMR) threatens the effectiveness of routine infection management and increasingly complicates surgical care. Antibiotic exposure is a major modifiable selection pressure, making prescribing quality central to both patient safety and resistance containment [1,2]. The World Health Organization (WHO) Access, Watch, and Reserve (AWaRe) framework was developed to translate stewardship principles into an actionable classification: Access agents are preferred for many common infections, Watch antibiotics carry greater resistance potential and require closer stewardship, and Reserve agents are intended for selected multidrug-resistant infections [1,2]. This framework is now widely used to benchmark hospital antibiotic consumption and to identify prescribing patterns that warrant intervention.

Orthopaedic practice is a particularly relevant setting for antimicrobial stewardship. Trauma operations, fracture fixation, arthroplasty, spinal instrumentation, and other implant-associated procedures create a genuine need for effective perioperative prophylaxis, while postoperative surgical-site infection (SSI) can lead to prolonged hospitalization, repeat debridement, implant failure, revision surgery, and substantial cost[3,4]. Evidence-based

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surgical prophylaxis therefore requires the right agent, dose, timing, and duration; extending prophylaxis or broadening coverage without a defined indication increases exposure without necessarily improving protection . Indian surveillance studies also show that antimicrobial use is common in surgical populations and that Watch antibiotics frequently dominate hospital prescribing [3,4].

Orthopaedic data from India have demonstrated high antimicrobial exposure, substantial use of cephalosporins, limited culture-directed treatment, and institutional variation in prescribing practice [5,6]. These concerns are clinically important because orthopaedic SSIs can involve both Gram-positive organisms, including Staphylococcus aureus, and resistant Gram-negative bacilli. Surveillance from Indian trauma settings has documented meaningful SSI burden and high antimicrobial resistance among recovered isolates [7-11]. International trauma data likewise indicate that the bacterial spectrum and susceptibility of orthopaedic infections can diverge from the activity expected from routine prophylactic regimens [12]. Consequently, local prescribing information should be interpreted alongside local microbiology rather than relying only on customary empirical practice.

Despite the availability of stewardship frameworks, department-specific evidence linking perioperative prescribing with AWaRe categories and resistance patterns remains limited. A focused assessment can identify over-reliance on Watch or Reserve agents, low generic prescribing, excessive injection use, and discordance between empirical antibiotic selection and microbiological susceptibility. Accordingly, the objectives of this study were to analyze antimicrobial prescriptions in perioperative orthopaedic procedures; classify prescribed agents according to WHO AWaRe; identify microorganisms isolated from SSIs; describe their antimicrobial sensitivity and resistance patterns; and examine the descriptive relationship between AWaRe-based prescribing patterns and resistance findings.

2. Methodology

2.1 Study design and setting

This observational, prospective, cross-sectional study was conducted from August 2024 to September 2024 in the Department of Orthopaedics of Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Gannavaram, Andhra Pradesh, India. The setting provided perioperative orthopaedic care and access to microbiology services for culture, organism identification, and antimicrobial susceptibility testing. The planned sample size in the study protocol was 202. The study contained 201 analyzable perioperative prescriptions, and these records formed the analysis set.

2.2 Study population and sampling

Adult patients aged 18 years or older who underwent a perioperative orthopaedic procedure and received antimicrobial prophylaxis or antimicrobial treatment were considered eligible. Convenience sampling was used. Participants were required to have at least 10 days of postoperative follow-up and complete medical records, including medication administration information. Patients with a known antimicrobial allergy or sensitivity, antimicrobial therapy for a condition unrelated to the orthopaedic episode, clinically significant immunocompromise such as HIV/AIDS, cancer, or immunosuppressive treatment, incomplete records, or unwillingness to participate were excluded.

2.3 Data collection

Data were recorded prospectively in a predesigned case report form without altering clinical management. Variables included age, sex, clinical diagnosis, orthopaedic procedure, comorbidities, antimicrobial class, Anatomical Therapeutic Chemical (ATC) code, fixed-dose combinations, generic or brand-name prescribing, and the number and route of antimicrobials. Perioperative and discharge prescriptions were recorded separately. Antimicrobials were categorized as Access, Watch, or Reserve according to the WHO AWaRe approach [1,2]. ATC names and codes were standardized during manuscript preparation where clear transcription inconsistencies were present in the source record.

2.4 Microbiology and prescribing indicators

For patients with available culture and susceptibility reports, the isolated organism, commonly sensitive antimicrobial, and commonly resistant antimicrobial were abstracted. The resistance findings were summarized by organism and compared descriptively with the antimicrobial categories used in the department. Patient-level linkage required for a formal correlation coefficient or regression analysis was not available in the supplied dataset; therefore, no inferential association estimate was generated. Prescribing indicators included the average number of antibiotics per encounter, percentage prescribed by generic name, percentage of encounters with an antibiotic, percentage prescribed as injections, and percentage from the Essential Medicines List. Surgical prophylaxis and SSI prevention principles were interpreted in the context of established evidence-based guidance [13,14].

2.5 Bias

Potential sources of bias included selection bias, information bias, observer bias, and confounding. Selection bias was a concern because participants were enrolled through convenience sampling at a single tertiary care teaching hospital over a two-month period. To minimize

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information bias, antimicrobial prescribing details, patient characteristics, surgical procedures, and microbiological findings were extracted using a structured data collection format and documented hospital records. Antimicrobial agents were categorized according to the standardized World Health Organization Access, Watch, and Reserve (AWaRe) classification to ensure consistency in prescribing assessments. Culture and antimicrobial susceptibility findings were obtained from available microbiology laboratory reports rather than subjective clinical assessments. Potential confounding related to differences in surgical procedures, comorbidities, infection severity, and indications for antimicrobial therapy was considered during descriptive interpretation. Because microbiological testing was not available for every patient, the possibility of detection bias and incomplete representation of resistance patterns was acknowledged. The analysis was restricted to 201 analyzable prescriptions, and findings were interpreted descriptively without assuming a causal relationship between antimicrobial utilization and resistance. The short study duration, convenience sampling, and single-centre setting were recognized as limitations affecting the generalizability of the findings.

2.6 Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS). The final analysis included 201 eligible perioperative antimicrobial prescription records. Descriptive statistics were used to summarize demographic characteristics, orthopaedic procedures, comorbidity profiles, antimicrobial utilization, and microbiological findings. Continuous variables, including age, were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Antimicrobial prescribing patterns were assessed separately for the perioperative and discharge periods, with frequencies and percentages calculated for individual antimicrobial agents and surgical procedures. Prescribed antimicrobials were categorized according to the World Health Organization Access, Watch, and Reserve (AWaRe) classification, and their proportional distribution was calculated using the total number of antimicrobial prescriptions at each stage as the denominator. WHO prescribing indicators, including the average number of antibiotics per encounter, generic prescribing, injectable antibiotic use, and adherence to the Essential Medicines List, were evaluated descriptively. Bacterial isolates were summarized according to organism frequency, Gram-staining characteristics, and recorded antimicrobial susceptibility and resistance patterns. The relationship between antimicrobial prescribing practices and resistance findings was examined through descriptive comparisons of antimicrobial utilization and observed microbiological resistance profiles.

2.7 Ethical considerations

The study was approved by Institutional Ethics Committee Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Gannavaram, Andhra Pradesh, India. (UG/1419/25). Written informed consent was obtained before participation, and patient and prescriber confidentiality were maintained through de-identified data handling. Standard operating procedures were followed for data collection and entry, with periodic quality checks.

3. Results

The study sample size was 202; however, final study dataset contained 201 analyzable prescriptions with complete antimicrobial dosage information. All analyzed encounters included antimicrobial use either during the perioperative period, at discharge, or both. The mean age was 47.94 ± 14.60 years. Participants aged 46-60 years formed the largest age stratum, followed by those older than 60 years (Table 1).

Table 1

Age distribution of study participants (N = 201)

Age group (years)	n	%
18-30	36	17.91
31-45	43	21.39
46-60	66	32.83
>60	56	27.86

Note. Percentages are based on 201 analyzed participants.

Open reduction and internal fixation (ORIF) was the most frequent procedure, accounting for 42 of 201 cases (20.89%). Closed reduction and internal fixation, implant removal, and posterior spinal decompression with internal fixation each accounted for 25 procedures (12.44%); wound debridement was least frequent (Table 2).

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Table 2

Distribution of orthopaedic procedures (N = 201)

Orthopaedic procedure	n	%
Open reduction and internal fixation	42	20.89
Closed reduction and internal fixation	25	12.44
Implant removal	25	12.44
Arthroscopic reconstruction of ACL	17	8.46
Posterior spinal decompression with internal fixation	25	12.44
Total knee replacement	14	6.97
Total hip replacement	5	2.49
K-wire fixation	14	6.97
Bipolar hemiarthroplasty	8	3.98
Wound debridement	3	1.49

Note. ACL = anterior cruciate ligament.

Most participants had no recorded comorbidity (118, 58.70%). Diabetes mellitus with hypertension was the commonest recorded profile (26, 12.93%), followed by hypertension alone (24, 11.94%) and diabetes mellitus alone (16, 7.96%) (Table 3).

Table 3

Comorbidity profile of study participants (N = 201)

Comorbidity profile	n	%
Hypertension + diabetes mellitus + chronic renal failure	2	0.99
Diabetes mellitus + hypertension + ischaemic heart disease	1	0.49
Diabetes mellitus + hypertension + asthma	1	0.49
Hypertension + asthma	1	0.49
Diabetes mellitus + asthma	1	0.49
Hypertension + ischaemic heart disease	2	0.99
Diabetes mellitus + hypertension	26	12.93
Chronic renal failure	2	0.99
Hypertension	24	11.94
Diabetes mellitus	16	7.96
Epilepsy	1	0.49
Asthma	5	2.48
Ischaemic heart disease	1	0.49
No recorded comorbidity	118	58.70

Note. Percentages are based on 201 participants. Categories are mutually exclusive as recorded in the source dataset.

Fourteen antimicrobial agents were recorded. Cefuroxime was the dominant agent, prescribed in 174 encounters (86.56%) perioperatively and 177 (88.06%) at discharge. Linezolid was the next most frequent agent, with 59 perioperative and 68 discharge prescriptions. Piperacillin-tazobactam and amikacin were used more often perioperatively than at discharge, whereas ofloxacin and ciprofloxacin were more frequently recorded at discharge. Antimicrobial classes, ATC codes, and AWaRe categories are shown in Table 4, and stage-specific utilization is summarized in Table 5.

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Table 4

Antimicrobial agents, ATC codes, and AWaRe categories

Antimicrobial	Class	ATC code	AWaRe
Cefuroxime	Cephalosporin	J01DC02	Watch
Ceftriaxone	Cephalosporin	J01DD04	Watch
Metronidazole	Nitroimidazole	J01XD01	Access
Amikacin	Aminoglycoside	J01GB06	Access
Piperacillin-tazobactam	Penicillin + beta-lactamase inhibitor	J01CR05	Watch
Linezolid	Oxazolidinone	J01XX08	Reserve
Meropenem	Carbapenem	J01DH02	Watch
Ofloxacin	Fluoroquinolone	J01MA01	Watch
Vancomycin	Glycopeptide	J01XA01	Watch
Gentamicin	Aminoglycoside	J01GB03	Access
Ciprofloxacin	Fluoroquinolone	J01MA02	Watch
Clindamycin	Lincosamide	J01FF01	Access
Doxycycline	Tetracycline	J01AA02	Access
Polymyxin B	Polymyxin	J01XB02	Reserve

Note. AWaRe groups reproduce the study coding; ATC codes were standardized where a clear transcription error was evident. ATC = Anatomical Therapeutic Chemical; AWaRe = Access, Watch, Reserve.

Table 5

Antimicrobial utilization during the perioperative period and at discharge

Antimicrobial	Perioperative n	Perioperative %	Discharge n	Discharge %
Cefuroxime	174	86.57	177	88.06
Piperacillin-tazobactam	14	6.97	5	2.49
Amikacin	17	8.46	1	0.50
Linezolid	59	29.35	68	33.83
Metronidazole	4	1.99	1	0.50
Ceftriaxone	1	0.50	0	0.00
Meropenem	2	1.00	2	1.00
Ofloxacin	3	1.49	7	3.48
Vancomycin	4	1.99	1	0.50
Gentamicin	1	0.50	2	1.00
Ciprofloxacin	2	1.00	4	1.99
Clindamycin	1	0.50	1	0.50
Doxycycline	1	0.50	2	1.00
Polymyxin B	3	1.49	0	0.00

Note. Percentages use 201 encounters as the denominator. Because more than one antimicrobial could be prescribed per encounter, totals exceed 201 and percentages do not sum to 100%.

Cefuroxime was the leading perioperative antimicrobial across most orthopaedic procedures and remained the most frequent discharge agent for nearly all procedure groups. It was used perioperatively in all 17 arthroscopic anterior cruciate ligament reconstructions and in 24 of 25 closed reduction/internal fixation procedures. Exceptions were observed in bipolar hemiarthroplasty, where linezolid was the leading discharge drug, and wound debridement, where vancomycin predominated perioperatively (Table 6).

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Table 6

Most frequently prescribed antimicrobial by orthopaedic procedure

Procedure	Leading perioperative agent	n (%)	Leading discharge agent	n (%)
Open reduction and internal fixation	Cefuroxime	36 (85.71)	Cefuroxime	35 (83.33)
Closed reduction and internal fixation	Cefuroxime	24 (96.00)	Cefuroxime	21 (84.00)
Implant removal	Cefuroxime	19 (76.00)	Cefuroxime	18 (72.00)
Arthroscopic ACL reconstruction	Cefuroxime	17 (100.00)	Cefuroxime	15 (88.23)
Posterior spinal decompression + internal fixation	Cefuroxime	21 (84.00)	Cefuroxime	20 (80.00)
Total knee replacement	Cefuroxime	11 (78.57)	Cefuroxime	13 (92.85)
Total hip replacement	Cefuroxime	4 (80.00)	Cefuroxime	4 (80.00)
K-wire fixation	Cefuroxime	13 (92.85)	Cefuroxime	13 (92.85)
Bipolar hemiarthroplasty	Cefuroxime	5 (62.50)	Linezolid	6 (75.00)
Wound debridement	Vancomycin	2 (66.66)	Cefuroxime	2 (66.66)

Note. ACL = anterior cruciate ligament.

AWaRe analysis demonstrated a prescribing pattern dominated by Watch antimicrobials. Of 277 perioperative antimicrobial prescriptions, 195 (70.39%) were Watch, 61 (22.02%) Reserve, and 21 (7.58%) Access. At discharge, 188 of 263 prescriptions (71.48%) were Watch, 68 (25.85%) Reserve, and 7 (2.66%) Access. Thus, the Access share decreased at discharge while the Reserve share increased (Table 7).

Table 7

Distribution of antimicrobial prescriptions by WHO AWaRe category

AWaRe category	Perioperative n	Perioperative %	Discharge n	Discharge %
Access	21	7.58	7	2.66
Watch	195	70.39	188	71.48
Reserve	61	22.02	68	25.85

Note. Denominators are 277 perioperative antimicrobial prescriptions and 263 discharge antimicrobial prescriptions.

Generic prescribing was uncommon. Only 8 of 201 prescriptions (3.98%) were written exclusively by generic name, 121 (60.19%) used brand names, and 72 (35.82%) contained both generic and brand names. This pattern was concordant with the low generic prescribing proportion captured by the WHO prescribing indicators.

Twenty culture isolates were reported. Gram-negative organisms accounted for 13 isolates (65%), and Gram-positive organisms for 7 (35%). Pseudomonas aeruginosa was the most common organism (6, 30%), followed by Staphylococcus aureus (5, 25%) and Escherichia coli (4, 20%). The leading sensitive and resistant antimicrobials varied by species: P. aeruginosa was most commonly sensitive to ciprofloxacin and resistant to imipenem, while S. aureus was most commonly sensitive to linezolid and resistant to penicillin (Table 8).

Table 8

Culture isolates and recorded antimicrobial susceptibility pattern (n = 20 isolates)

Organism	n	%	Most common sensitive antimicrobial	Most common resistant antimicrobial
Acinetobacter baumannii	2	10	Polymyxin B	Amikacin
Escherichia coli	4	20	Amikacin	Imipenem
Staphylococcus aureus	5	25	Linezolid	Penicillin
Pseudomonas aeruginosa	6	30	Ciprofloxacin	Imipenem
Staphylococcus haemolyticus	2	10	Linezolid	Erythromycin
Klebsiella species	1	5	Polymyxin B	Gentamicin

Note. The table reports the most common sensitive and resistant antimicrobial recorded for each organism in the supplied study data.

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The average number of antibiotics prescribed per encounter was 2.68, confirming frequent multidrug exposure. Antibiotics were present in 100% of encounters, 71% were prescribed as injections, only 3.98% were prescribed by generic name, and 58% were from the Essential Medicines List (Table 9). Taken together, the descriptive prescribing and culture data showed high exposure to Watch and Reserve agents alongside resistant Gram-negative and Gram-positive isolates. A formal patient-level statistical correlation could not be calculated from the supplied aggregate dataset.

Table 9

WHO prescribing indicators

WHO prescribing indicator	Value
Average number of antibiotics prescribed per encounter	2.68
Antibiotics prescribed by generic name	3.98%
Encounters with antibiotics prescribed	100%
Antibiotics prescribed as injections	71%
Antibiotics prescribed from Essential Medicines List	58%

Note. Values reproduce the study's prescribing-indicator summary.

4. Discussion

This study demonstrates a perioperative orthopaedic prescribing pattern characterized by universal antimicrobial exposure, an average of 2.68 antibiotics per encounter, and marked dominance of Watch and Reserve agents. Cefuroxime was prescribed in 86.56% of encounters perioperatively and 88.06% at discharge, while Access agents represented only 7.58% of perioperative antimicrobial prescriptions and 2.66% at discharge. These findings indicate substantial broad-spectrum antimicrobial pressure. Indian multicentre surveys similarly report frequent antimicrobial use and predominance of Watch drugs; however, the 57.03% Watch share reported by Bhattacharjee et al. was lower than that observed here [4]. Earlier Indian point-prevalence data also identified cephalosporins and Watch agents as major components of inpatient prescribing [3].

The orthopaedic-specific pattern is consistent with evidence that cephalosporins are heavily used around fracture and implant procedures. In two Central Indian orthopaedic departments, Skender et al. found third-generation cephalosporins to be the most frequently prescribed class and documented prophylactic antibiotic exposure in almost all operated patients [5]. Their SSI study also emphasized resistant pathogens in this setting [6]. In the present study, Reserve use reached 22.02% perioperatively and 25.85% at discharge, driven largely by linezolid. By contrast, a Tanzanian tertiary hospital reported 62.41% Access and only 0.17% Reserve use [8]. An Indian AWaRe audit likewise showed that rising Watch and Reserve consumption can function as a stewardship warning signal [9].

Microbiological findings reinforce the need for local surveillance. Pseudomonas aeruginosa accounted for 30% of isolates, followed by Staphylococcus aureus (25%) and Escherichia coli (20%); Gram-negative organisms collectively represented 65%. Orthopaedic trauma surveillance in India has reported high resistance among SSI isolates [10], while a recent decade-long analysis from an apex trauma facility describes a changing bacterial landscape in orthopaedic infections [11]. The species-specific findings here - including imipenem resistance among P. aeruginosa and E. coli, amikacin resistance in Acinetobacter baumannii, and preserved linezolid sensitivity in staphylococci - favor culture-guided selection rather than routine escalation. Comparable discordance between standard cefuroxime prophylaxis and contemporary susceptibility patterns has been reported in trauma surgery [12].

The low rate of generic prescribing (3.98%), high injection use (71%), and 58% Essential Medicines List use identify additional stewardship targets. Rational perioperative prophylaxis should be indication-specific, correctly timed, and not prolonged beyond evidence-based recommendations [13,14]. The aggregate dataset did not permit a patient-level correlation coefficient between AWaRe exposure and resistance; the observed relationship is therefore descriptive rather than causal. Routine AWaRe audits linked to culture results, de-escalation, and procedure-specific prophylaxis protocols offer a practical route to reduce avoidable broad-spectrum exposure.

4.1 Generalizability

The findings are most directly applicable to tertiary-care orthopaedic services with comparable surgical case-mix, prescribing culture, antimicrobial availability, and microbiology support. The prominence of fixation procedures and the local distribution of resistant organisms should be considered when extrapolating results. Nevertheless, the study's use of standardized AWaRe categories and WHO prescribing indicators provides a transferable audit framework that other hospitals can reproduce, benchmark against their own antibiograms, and use to identify locally relevant stewardship priorities.

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5. Conclusion

Perioperative antimicrobial prescribing in this orthopaedic cohort was dominated by cefuroxime and by WHO Watch-category agents, while Access use was low and Reserve exposure was substantial. Generic prescribing was uncommon, injection use was frequent, and only 58% of antibiotics were drawn from the Essential Medicines List. Culture findings were led by Pseudomonas aeruginosa, Staphylococcus aureus, and Escherichia coli, with clinically relevant resistance to several commonly used agents. These observations support closer alignment of prophylaxis and treatment with procedure-specific indications, local susceptibility data, and AWaRe stewardship principles. Regular audit, culture-guided de-escalation, stronger microbiological surveillance, and restriction of Reserve antibiotics are central to improving antimicrobial quality in orthopaedic surgical care and outcomes.

6. Limitations

This single-centre, two-month study used convenience sampling and therefore reflects local prescribing behavior and resistance ecology. The final analyzed dataset contained 201 prescriptions against a planned sample of 202, without a documented reason for the difference. Culture testing was available only for a limited set of isolates, and aggregate data did not permit patient-level statistical correlation between AWaRe exposure and antimicrobial resistance.

7. Recommendations

The orthopaedic department should implement an antimicrobial stewardship bundle that links perioperative prescriptions with procedure-specific prophylaxis guidance, indication documentation, and stop or review dates. Access antibiotics should be selected whenever clinically appropriate, while Watch agents require explicit justification and Reserve drugs should be restricted to defined resistant infections or specialist approval. Culture specimens should be obtained before escalation whenever feasible, followed by prompt de-escalation according to susceptibility results. Quarterly AWaRe audits should be paired with the local antibiogram and feedback to prescribers. Generic prescribing, Essential Medicines List adherence, and early conversion from injectable to suitable oral therapy should be strengthened.

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List of abbreviations

ACL – anterior cruciate ligament
AMA – antimicrobial agent
AMR – antimicrobial resistance
AST – antimicrobial susceptibility testing
ATC – Anatomical Therapeutic Chemical
AWaRe – Access, Watch, Reserve
CRIF – closed reduction and internal fixation
IEC – Institutional Ethics Committee
MDR – multidrug resistant
ORIF – open reduction and internal fixation
SSI – surgical site infection
THR – total hip replacement
TKR – total knee replacement
WHO – World Health Organization

Conflict of interest

Conflict-of-interest declaration to be completed and confirmed by all authors at the time of journal submission.

Data availability

The de-identified study data are retained by the investigators and institution. Requests for access can be directed to the corresponding author after author details are finalized, subject to institutional, ethical, and confidentiality requirements.

Author contributions

Dr. Sirisha Annavarapu: Conceptualization, study design, methodology, literature review, data interpretation, manuscript drafting, critical revision, and final approval of the manuscript.

Dr. Merugu Padma Latha: Data collection, data curation, literature review, statistical interpretation, preparation of the results, manuscript review, and critical revision for important intellectual content.

Dr. Marupaka Janardhan: Methodological support, analysis and interpretation of antimicrobial prescription patterns and WHO AWaRe classification, review of resistance-pattern data, manuscript editing, and final approval of the manuscript.

Dr. I. Sridhar: Supervision, methodological guidance, interpretation of study findings, critical review of antimicrobial prescribing and resistance-pattern analyses, manuscript revision for important intellectual content, and final approval of the manuscript. He also provided senior academic oversight throughout the study and contributed to ensuring the scientific and clinical relevance of the work.

All authors contributed substantially to the work, reviewed and approved the final version of the manuscript, and agree to be accountable for all aspects of the work

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