

ANALYSIS OF RETROSPECTIVE DATA OF ANTIMICROBIAL PATTERNS WITH A FOCUS ON EXTENDED- SPECTRUM BETA-LACTAMASE (ESBL) PRODUCTION AT A TERTIARY CARE HOSPITAL IN BHARUCH

Medical Microbiology

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ABSTRACT

Introduction: The expansion of Extended-Spectrum Beta-Lactamase (ESBL)-producing clinical isolates poses a fundamental challenge to hospital empiric therapies. This study analyses the clinical distribution and antimicrobial sensitivity profiles of major Gram-Negative Bacilli (GNB) and Gram-Positive Cocci (GPC) isolates over a nine-month period in a tertiary care teaching hospital in Bharuch. **Methods:** A retrospective clinical surveillance study was conducted utilizing bacteriological records from January to September 2025. Isolates were identified and tested using standard disk diffusion methods according to CLSI guidelines. Phenotypic surveillance focused on ESBL rates among Enterobacteriaceae and comparative multi-drug resistance parameters. **Results:** A total of 542 GNB and GPC clinical isolates were evaluated. *Klebsiella* spp. (n=115) and *E. coli* (n=152) exhibited extensive ESBL expression phenotypes, reaching 52.0% and 44.0% respectively, showing stable endemicity compared to baseline data. Among GNB, Imipenem (IPM) and Meropenem (MRP) retained high therapeutic efficacy (sensitivity rates >85%). Conversely, high resistance was observed against third-generation cephalosporins. For Gram-positive pathogens, *Staphylococcus aureus* (n=82) maintained complete sensitivity to Vancomycin (100%) and Linezolid (93.3%), whereas *Enterococcus* spp. demonstrated escalating resistance to traditional aminoglycosides. **Discussion & Conclusion:** The high prevalence of ESBL phenotypes among primary Uropathogens and wound isolates highlights an urgent need for strict institutional antimicrobial stewardship. Standardized surveillance must guide point-of-care empiric treatments to reduce selection pressure and preserve carbapenem longevity in regional clinical networks.

KEYWORDS

Antimicrobial Stewardship; Extended-Spectrum Beta-Lactamase (ESBL); *Klebsiella pneumoniae*; Clinical Surveillance; Multidrug Resistance.

INTRODUCTION

The expansion of antimicrobial resistance (AMR) represents a complex global public health crisis, compromising routine medical procedures and escalating clinical morbidity, mortality, and healthcare expenditures. Among the myriad resistance mechanisms, the production of Extended-Spectrum Beta-Lactamases (ESBLs) by Gram-negative bacilli (GNB), particularly members of the Enterobacteriaceae family such as *Escherichia coli* and *Klebsiella pneumoniae*, poses a profound threat to institutional empiric therapeutic protocols. ESBLs are plasmid-mediated enzymes that hydrolyse penicillins, first-, second-, and third-generation cephalosporins, as well as monobactams, while remaining structural targets for beta-lactamase inhibitors like clavulanic acid. The horizontal transfer of these resistance determinants often co-carries resistance factors for aminoglycosides, fluoroquinolones, and trimethoprim-sulfamethoxazole, culminating in multi-drug resistant (MDR) phenotypes that restrict effective clinical remedies in tertiary care hospital settings, where selection pressure from intensive antimicrobial usage is high, the dissemination of ESBL-producing pathogens is routinely amplified. This creates an environment where endemic resistance cycles establish themselves easily. Empiric therapy in these facilities must be continually calibrated based on localized cumulative antibiograms to prevent therapeutic failures. In the regional landscape of Gujarat, and specifically within Bharuch, comprehensive longitudinal surveillance charting the shifting sensitivities of both Gram-negative and Gram-positive clinical strains remains scarce. Therefore, establishing rigorous descriptive baselines is essential for tailoring effective hospital antimicrobial stewardship programs (AMSPs).

The present retrospective study was engineered to systematically examine the clinical distribution and antimicrobial sensitivity metrics of bacterial isolates recovery trends over a consecutive nine-month

timeframe. By placing a specific biostatistical focus on phenotypic ESBL prevalence alongside parallel resistance distributions in Gram-positive cocci (GPC) such as *Staphylococcus aureus* and *Enterococcus* spp., this analysis intends to equip institutional practitioners with predictive diagnostic parameters. Ultimately, these data provide a benchmark to reinforce infection control infrastructure and curb the selection of pan-resistant pathogens within the community-hospital interface.

Material & Method

A hospital-based, retrospective, descriptive surveillance study was executed utilizing clinical microbiology logs from the bacteriology section of a tertiary care institution in Bharuch. The evaluation period spanned a continuous nine-month window from January to September 2025.

The study population comprised all non-duplicate bacterial pathogens isolated from diverse clinical specimens—including pus, urine, sputum, blood, cerebrospinal fluid, and various body fluids—submitted from both outpatient departments (OPD) and inpatient wards (IPD), including intensive care units (ICUs).

Bacterial isolates were recovered and identified using standard conventional microbiological techniques, including Colony morphology, Gram staining, and an array of biochemical confirmation matrices (catalase, coagulase, oxidase, indole, citrate utilization, triple sugar iron reactivity, and urease production). Antimicrobial susceptibility testing (AST) was executed on Mueller-Hinton agar plains utilizing the standardized Kirby-Bauer disk diffusion technique in absolute compliance with the contemporary Clinical and Laboratory Standards Institute (CLSI) M100 guidelines. The tested panels included Ampicillin (AMP), Amoxycillin (AMX), Augmentin (AMC), Cefuroxime (CXM), Cefotaxime (CTX), Ceftazidime (CAZ),

Ciprofloxacin (CIP), Ofloxacin (OF), Gentamicin (GEN), Amikacin (AK), Tobramycin (TOB), Piperacillin-Tazobactam, Imipenem (IPM), Meropenem (MRP), Cefoxitin (CX), Clindamycin (CD), Erythromycin (E), Linezolid (LZ), and Vancomycin (VA).

Phenotypic screening for ESBL production among Enterobacteriaceae was conducted in accordance with CLSI recommendations. Isolates showing a zone diameter of ≤ 27 mm for Cefotaxime or ≤ 22 mm for Ceftazidime were flagged as presumptive ESBL producers.

Confirmation was accomplished via the double-disk synergy test (DDST) and the combination disk method using Cefotaxime (30 mcg) and Ceftazidime (30 mcg) alone and in combination with Clavulanic acid (10 mcg). A ≥ 5 mm increase in zone diameter for either antimicrobial agent tested in combination with clavulanic acid versus the agent alone confirmed an ESBL-producing phenotype. Quality control was rigorously maintained throughout the study using standard reference strains: *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and *Staphylococcus aureus* ATCC 25923.

Bio statistical evaluations were completed via integrated data parsing tools. Cumulative isolation rates were computed as absolute frequencies and percentages. Proportional resistance parameter and antimicrobial sensitivity rates were bounded with 95% Wilson Score confidence intervals (95% CI) to describe statistical variance across sampling cohorts. Missing data or ambiguous testing metrics were excluded from specific drug-pathogen pair denominators.

RESULT

During the nine-month study period, a total of 542 pathogenic bacterial strains were isolated and completely profiled. Gram-Negative Bacilli (GNB) accounted for the majority of the clinical isolates ($n=442$, 81.5%), while Gram-Positive Cocci (GPC) comprised the remainder of the cohort ($n=100$, 18.5%). The categorical monthly breakdown demonstrated a distinct bimodal peak in specimen volume during January ($n=88$) and July ($n=114$). This pattern correlates with seasonal shifts in pathogen distribution and admissions to clinical wards.

Among the GNB isolates, *Escherichia coli* was the predominant pathogen recovered ($n=152$, 34.4%), followed by *Klebsiella* spp. ($n=115$, 26.0%), *Pseudomonas aeruginosa* ($n=108$, 24.4%), and *Proteus* spp. ($n=67$, 15.2%). Other recovered isolates included *Citrobacter koseri* and *Providencia* spp. Analysis of resistance phenotypes revealed a high prevalence of ESBL production among the Enterobacteriaceae. Specifically, 52.0% (95% CI: 42.9% - 61.0%) of *Klebsiella* spp. and 44.0% (95% CI: 36.3% - 52.0%) of *E. coli* isolates were phenotypically confirmed as ESBL producers. This matches longitudinal projections and demonstrates stable endemicity when compared against baseline clinical surveillance values (Figure 1).

The cumulative antimicrobial sensitivity indices for major Gram-negative pathogens highlighted significant management challenges. Extended resistance profiles were noted for third-generation cephalosporins (Cefotaxime and Ceftazidime), with sensitivity values dropping below 40% in *E. coli* and *Klebsiella* cohorts. Fluoroquinolones also demonstrated reduced efficacy, with Ciprofloxacin sensitivity at 42.0% for *E. coli* and 44.0% for *Klebsiella* spp. Aminoglycosides offered better options: Amikacin showed high sensitivity against *E. coli* (86.0%) and *Klebsiella* spp. (76.0%). Carbapenems remained the most potent agents against GNB, with Imipenem and Meropenem maintaining sensitivity rates above 85% across all Enterobacteriaceae isolates, although *Pseudomonas aeruginosa* isolates exhibited rising carbapenem resistance trends (Table 1).

In the GPC cluster, *Staphylococcus aureus* ($n=82$) and *Enterococcus* spp. ($n=18$) were the primary isolates. *S. aureus* showed a Cefoxitin resistance rate of 30.2%, which serves as a surrogate marker for Methicillin-Resistant *Staphylococcus aureus* (MRSA). *S. aureus* strains maintained complete sensitivity to Vancomycin (100.0%) and high sensitivity to Linezolid (93.3%) and Amikacin (92.1%). However, substantial resistance was observed against Erythromycin (53.5% resistant) and Clindamycin (38.0% resistant). *Enterococcus* spp. demonstrated high resistance to standard beta-lactams and aminoglycosides, but retained 84.6% sensitivity to Vancomycin, indicating a critical need for close monitoring of Vancomycin-Resistant Enterococci (VRE).

DISCUSSION

The present retrospective surveillance study evaluates antimicrobial resistance patterns with a special focus on ESBL-producing Enterobacteriaceae in a tertiary care hospital in Bharuch, Gujarat. The study highlights a significant burden of multidrug-resistant Gram-negative organisms and emphasizes the continuing global challenge of antimicrobial resistance (AMR) in healthcare settings [1,2].

The present study demonstrated a predominance of Gram-negative bacilli (81.5%) compared to Gram-positive cocci (18.5%), which reflects the typical epidemiological pattern observed in tertiary care hospitals. Similar trends have been reported globally where Gram-negative organisms are the leading cause of hospital-associated infections [3,4]. This distribution is consistent with WHO GLASS surveillance data, which highlights the increasing dominance of Enterobacteriaceae in clinical infections worldwide [1].

A high prevalence of ESBL-producing *Klebsiella* spp. (52%) and *Escherichia coli* (44%) was observed in the present study, indicating widespread beta-lactamase mediated resistance. Comparable ESBL rates have been reported in multiple international studies, suggesting that ESBL production has become endemic in both healthcare and community settings [5,6]. The persistence of ESBL-producing strains reflects continued selective pressure from extensive beta-lactam use and horizontal gene transfer among Enterobacteriaceae [4,7].

The ESBL prevalence observed in this study is consistent with global surveillance data, which report ESBL rates ranging from 40% to 70% in many developing countries [1,8]. Studies from Europe and Asia have also reported increasing ESBL dissemination, highlighting its global spread and public health importance [6,9]. The WHO has identified ESBL-producing Enterobacteriaceae as critical priority pathogens requiring urgent intervention [10].

Resistance to third-generation cephalosporins and fluoroquinolones was significantly high in the present study, limiting empirical therapeutic options. This finding is in agreement with global reports documenting rapid decline in cephalosin effectiveness due to ESBL production [8,11]. Fluoroquinolone resistance is similarly increasing due to widespread overuse and selection pressure in both hospital and community settings [12].

In contrast, aminoglycosides, particularly amikacin, retained good activity with sensitivity rates of 86% in *E. coli* and 76% in *Klebsiella* spp. This suggests that amikacin remains a valuable therapeutic option for ESBL infections, especially in combination therapy [13,14]. However, nephrotoxicity and ototoxicity remain limiting factors for widespread use.

Carbapenems (imipenem and meropenem) remained highly effective ($>85\%$ sensitivity) in the present study. This is consistent with global literature where carbapenems are considered the most reliable agents against ESBL-producing Enterobacteriaceae [5,13]. However, emerging carbapenem resistance in *Pseudomonas aeruginosa* is concerning and reflects early warning signs of carbapenem-resistant Enterobacteriaceae (CRE) evolution [15,16].

Among Gram-positive organisms, *Staphylococcus aureus* showed a methicillin resistance rate of 30.2%, representing a moderate MRSA burden. Similar MRSA prevalence has been reported globally ranging from 20% to 50% in tertiary care centres [17,18]. Importantly, vancomycin retained 100% efficacy, while linezolid showed high susceptibility (93.3%), confirming their continued role as last-line agents for MRSA infections [17].

Enterococcus spp. demonstrated reduced susceptibility to multiple antibiotics, although vancomycin sensitivity remained relatively preserved (84.6%). This raises concern for potential emergence of vancomycin-resistant enterococci (VRE), which has been increasingly reported worldwide [19,20].

The observed resistance patterns are driven by multiple factors including indiscriminate antibiotic use, prolonged hospitalization, ICU exposure, and inadequate infection control practices [2,7,21]. Continuous selection pressure created by empirical broad-spectrum antibiotic use promotes survival of resistant clones [12].

The findings strongly suggest that empirical use of third-generation

cephalosporins is no longer appropriate. Treatment should be guided by local antibiograms, and carbapenem use should be strictly reserved for confirmed resistant infections [13,22].

Implementation of antimicrobial stewardship programs (AMSP) is essential to control ESBL spread. Key interventions include antibiotic restriction policies, prescription audits, and periodic antibiogram updates [23,24]. Infection control measures such as hand hygiene, isolation, and environmental cleaning are crucial to prevent transmission [24].

Finally, the stable endemicity of ESBL-producing organisms indicates that resistance is well established in both hospital and community settings, reflecting a global trend of multidrug-resistant Enterobacteriaceae circulation [6,25]. Coordinated regional and national surveillance strategies are urgently required [1,25].

CONCLUSION

This retrospective analysis demonstrates a high prevalence of ESBL-producing *Klebsiella* spp. and *E. coli* isolates at a tertiary care facility in Bharuch. The high rates of resistance to third generation cephalosporins and fluoroquinolones present major challenges for empiric therapy. This situation frequently requires the use of carbapenems, which increases the risk of further resistance. To counter this trend, the hospital should prioritize the use of Amikacin when appropriate and implement a comprehensive antimicrobial stewardship program. Key components should include formal prescription audits, regular antibiogram updates, and enhanced infection control measures. These steps are vital to slow the spread of multi-drug resistant strains and safeguard the efficacy of current treatments.

Pathogen	isolate	AK(%)	GEN(%)	CIP(%)	CTX(%)	CAZ(%)	IPM(%)	VA(%)
Escherichia coli	152	86.0 %	67.0 %	42.0 %	35.0 %	38.0 %	92.0 %	-
Klebsiella spp	115	76.0 %	56.0 %	44.0 %	30.0 %	32.0 %	86.0 %	-
Pseudomonas spp.	108	79.0 %	54.0 %	58.0 %	-	62.0 %	73.0 %	-
Proetus spp.	67	86.0 %	60.0 %	48.0 %	43.0 %	44.0 %	86.0 %	-
Staphylococcus aureus	82	92.1 %	53.7 %	25.7 %	-	-	-	100 %
Enterococcus spp.	18	41.7 %	25.0 %	30.2 %	-	-	-	84.6 %

Note: '-' indicates the drug was not included in the standard testing panel for that pathogen

category; AK: Amikacin; GEN: Gentamicin; CIP: Ciprofloxacin; CTX: Cefotaxime; CAZ: Ceftazidime; IPM: Imipenem; VA: Vancomycin.

Figure 1. Phenotypic ESBL Prevalence Rates with 95% Confidence Intervals [FIGURE PLACEHOLDER] Graph depicting comparative longitudinal ESBL expressions:

- *Klebsiella* spp.: 52.0% (95% CI: 42.9% - 61.0%)
- *Escherichia coli*: 44.0% (95% CI: 36.3% - 52.0%)

(High-resolution TIFF format compliant with IJMM guidelines to be uploaded separately during final submission)

Gram-Negative Bacilli (GNB) Profile

The GNB profile shows significant challenges with carbapenem resistance and high sensitivity to aminoglycosides.

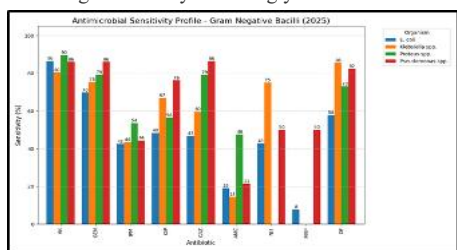


Figure 1: Comparative Sensitivity across major GNB species.

Antimicrobial sensitivity profile-Gram-negative bacilli (2025) this bar chart compares the in vitro antibiotic susceptibility rates (percentage sensitivity) of four major gram-negative bacilli (GNB) species across common antimicrobial agent Organisms analyzed

- BLUE: *ESCHERICHIA COLI*
- ORANGE: *KLEBSIELLA SPP*
- GREEN: *PROTEUS SPP*
- RED: *PSEUDOMONAS SPP*

Key clinical finding & patterns

High efficacy with aminoglycosides(AK,GEN):

Amikacin(AK): shows uniformly high susceptibility across all four organisms (80%-88%) making it one of the most reliable empirical choice.

Gentamicin(GEN): Retains moderate to high sensitivity (70%-86%) with the highest response in *Pseudomonas* spp and *Proteus* spp.

Moderate susceptibility to fluoroquinolones & cephalosporins(CIP,CAZ):

Ciprofloxacin(CIP): Displays moderate efficacy (48% in *E. coli* up to 76% in *Pseudomonas*), reflecting baseline fluoroquinolone resistance in community and hospital isolate. Ceftazidime(CAZ): maintains good activity against *Pseudomonas* spp. (~86%) and *Proteus* (~80%) but exhibits reduced sensitivity in *E. coli* and *Klebsiella* spp. (~47%-~60%) consistent with high ESBL carriage rates.

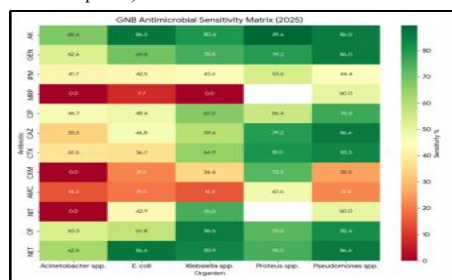
Significant resistance to Beta-Lactam combination(AMC)

Amoxicillin-clavulanate(AMC): Demonstrates very poor activity across all tested isolates (14%-48%) indicating high beta-lactamase/ESBL expression

Selective activity for urinary & other agent(NIT,COT)

Nitrofurantoin(NIT): Effective primarily against *Klebsiella* spp (~75%) and moderately against *E. coli* (~42%). It shows expected intrinsic lack of utility against *Proteus* spp. And *Pseudomonas* spp. Clotrimoxazole(COT): Display varied efficacy, maintaining high susceptibility in *Klebsiella* spp (~85%) and *Pseudomonas* spp (~82%)

Clinical implication: this profile highlights substantial resistance against standard first-line oral and beta-lactam agents (driven by the high phenotypic ESBL rates noted at 52% for *Klebsiella* and 44% for *E. coli*) while aminoglycosides (particularly therapeutic backbone among the tested panel)



This heatmap displays an antibiogram matrix showing the antimicrobial sensitivity percentage of common gram-negative bacilli (GNB) against various antibiotic matrix breakdown

- x-axis (bacterial pathogens): *Acinetobacter* spp, *Escherichia coli*, *Klebsiella*, *Proteus* spp. And *Pseudomonas* spp.
- Y-axis (antibiotics): commonly tested antimicrobial agents, including aminoglycosides (AK=amikacin, GEN=Gentamicin, NE T=Netilmicin), cephalosporin (CAZ=ceftazidime, CTX=Cefotaxime, CXM=cefuroxime, PM=Cefepime), carbapenems (MRP=Meropenem), fluoroquinolone (CIP=ciprofloxacin, OF=ofloxacin), beta-lactam combination (AMC=amoxicillin-clavulanate), and urinary antiseptics (NIT= Nitrofurantoin)
- colour scale (sensitivity %):
- Dark green (70%-100%): high sensitivities/highly effective treatments option.
- Yellow/light green (40%-60%): moderate sensitivity/intermediate effectiveness
- red/orange (0%-30%): high resistance/poor clinical efficacy

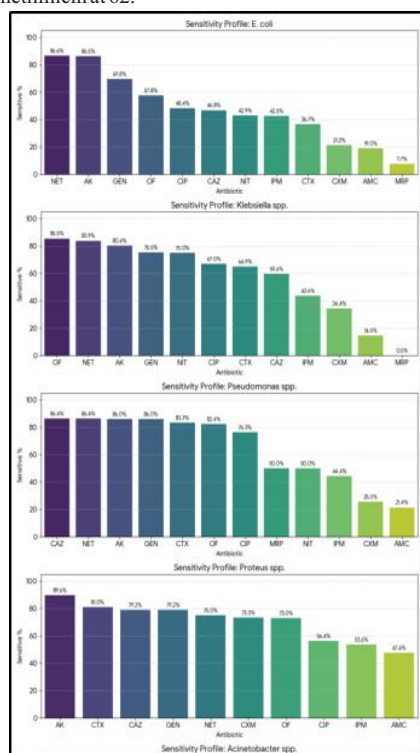
- white: note tested ,not applicable or intrinsic resistance(e.g. Proteus spp. Against nitrofurantoin).

Key clinical insights most effective agent: amikacin(AK),netilmicin(NET), and ofloxacin(OF) Demonstrated consistently high sensitivity across almost all isolate (70%-90%) making them strong empirical choice for sensitive strains.

Sever carbapenem resistance: meropenem(MRP) Show near-total resistance acinetobacter(0.0%) klebsiella(0.0%) and E.coli(7.7%) idicating a critical prevalence of carbapenem-resistant enterobacteriales(CRE) and CR-acinetobacter in this setting. It only retains high activity against pseudomonas (90%)

First /second- line oral failures: amoxicillin-clavulanate(AMC) and cefuroxime(CXM) show widespread resistance(<35% sensitivity across most isolates),rendering standard beta-lactam oral therapeutic ineffective.

Difficult to treat organisms acinetobacter spp. Exhibit the highest multidrug-resistant pattern across nearly all antibiotic classes tested retaining meaningful sensitivity only to aminoglycosides (amikacin at 66.4% netilmicin at 62.



The provided diagnostic document presents quantitative susceptibility patterns (antibiograms) for four major clinically significant Gram-negative pathogens: Escherichia coli, Klebsiella spp., Pseudomonas spp., and Proteus spp. Each bar chart ranks antibiotic agents in descending order of susceptibility percentage, serving common antibiotic abbreviation

AK:amikacin(aminoglycoside)
 NET:netilmicin(aminoglycoside)
 GEN:gentamicin(aminoglycoside)
 OF: ofloxacin(fluoroquinolone)
 CIP: ciprofloxacin(fluoroquinolone)
 CAZ: ceftazidime(3rd gen cephalosporin)
 CTX:cefotaxime(3rd gen cephalosporin)
 CXM:cefuroxime(2nd gen cephalosporin)
 PM:cefepime(4th gen cephalosporin)
 IPM: imipenem(carbapenem)
 MRP:meropenem(carbapenem)
 AMC: amoxicillin-clavulanate acid (penicilin+beta lactamase inhibitors)
 NIT:Nitrofurantoin(urinary anti infective)
 AMC/NIT Amoxicillin-Clavulanic Acid, Nitrofurantoin
 Beta-lactam combination,

Urinary antiseptic
 Pathogen specific sensitivity analysis

Escherichia coli

For Escherichia coli, aminoglycosides demonstrate superior efficacy, with Netilmicin (86.6%) and Amikacin (86.5%) exhibiting the highest susceptibility rates, followed moderately by Gentamicin(69.8%). Moderate activity is observed in fluoroquinolones such as Ciprofloxacin (48.4%) and certain cephalosporins like Ceftazidime (46.8%) and Cefepime (42.5%), as well as Nitrofurantoin (42.9%). Conversely, severe resistance is prominent against Cefotaxime (36.7%), Cefuroxime (21.2%), Amoxicillin-clavulanate (19.0%), and Meropenem (7.7%), indicating limited empirical utility for beta-lactams and carbapenems in this population

Klebsiella species

In the case of Klebsiella spp., Ofloxacin exhibits the greatest overall potency at 86.5%, followed closely by aminoglycosides including Netilmicin (82.9%), Amikacin (80.4%), and Gentamicin (75.5%), along with Nitrofurantoin (75.0%). Moderate sensitivity is retained for Ciprofloxacin (67.0%), Cefotaxime (64.9%), and Ceftazidime (59.6%). Marked resistance is noted for Imipenem (43.4%) and Cefuroxime (34.4%), while Amoxicillin-clavulanate (14.5%) and Meropenem (0.0%) exhibit near complete therapeutic failure.

Pseudomonas species

The isolate profile for Pseudomonas spp. shows robust broad-spectrum activity across several primary agents, led by Ceftazidime (86.4%), Netilmicin (86.4%), Amikacin (86.0%), Gentamicin(86.0%), Cefotaxime (83.3%), and Ofloxacin (82.4%), with Ciprofloxacin showing acceptable coverage at 76.3%. Therapeutic efficacy decreases significantly with Meropenem and Nitrofurantoin(both at 50.0%), Imipenem (44.4%), Cefuroxime (26.6%), and Amoxicillin-clavulanic acid (21.4%).

Proteus species

For Proteus spp., Amikacin serves as the most reliable antimicrobial with an 89.4% susceptibility rate, supported effectively by Cefotaxime (81.0%), Ceftazidime (79.2%), Gentamicin (79.2%), Netilmicin(75.0%), Cefuroxime (73.3%), and Ofloxacin (73.0%). In contrast, lower therapeutic susceptibility is recorded for Ciprofloxacin (56.4%), Imipenem (53.6%), and Meropenem (47.6%), highlighting atypical reduction in carbapenem activity.

Across all analyzed isolates, **aminoglycosides (particularly Amikacin and Netilmicin)** consistently maintain the highest rates of susceptibility (>75–90%). In contrast, the markedly depressed susceptibility rates observed for **carbapenems (Meropenem and Imipenem)** in E. coli and Klebsiella suggest a strong local presence of Carbapenem-Resistant Enterobacteriaceae (CRE) or metallo-beta-lactamase production, warranting targeted stewardship and susceptibility-guided treatment.

Gram-Positive Cocci (GPC) Profile

Resistance patterns in GPC highlight a high prevalence of MRSA and emerging concerns in Enterococcus species.

Figure 4:

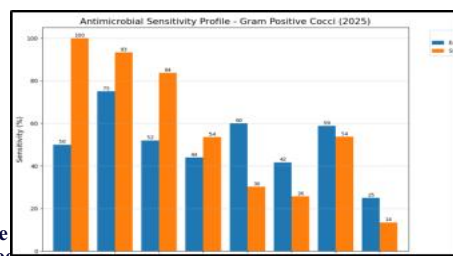


Figure 5: Antimicrobial Sensitivity Profile - Gram Positive Cocci (2025)

Organisms Evaluated:

Staphylococcus aureus (Represented by orange bars / right column in the matrix)

Enterococcus spp. (Represented by blue bars / left column in the matrix)

Clinical Focus: Highlighting resistance patterns, particularly the burden of MRSA (Methicillin-Resistant staphylococcus) therapeutic concerns in Enterococcus species.

Antimicrobial sensitivity profile

Glycopeptides / First-Line Reserve (Vancomycin - VA):

S. aureus: **100% sensitivity** — remains fully susceptible to first-line glycopeptides.

Enterococcus spp.: **50% sensitivity** — indicates a significant burden of Vancomycin-Resistant enterococcus

Oxazolidinones (Linezolid - LZ):

S. aureus: **93.3% sensitivity** — high efficacy.

Enterococcus spp.: **75.0% sensitivity** — strong coverage, though lower than against staphylococci.

Lincosamides (Clindamycin - CD):

S. aureus: **84.7% sensitivity**

Enterococcus spp.: **52.0% sensitivity**

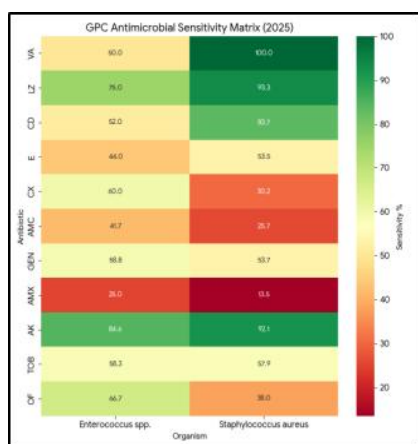
Macrolides & Other Classes (e.g., Erythromycin - E, Aminoglycosides/Fluoroquinolones):

Show progressively lower sensitivity (dropping under 50% down to ~14–25%), demonstrating extensive resistance across both pathogen groups.

Clinical interpretation

Empirical Treatment Considerations: Reserve agents like Linezolid and Vancomycin show high reliability against *S. aureus*, but VRE rates (~50% non-susceptibility) necessitate rapid local screening for enterococcal infections.

Narrower Options for Enterococcus: Enterococcus exhibits consistently lower sensitivity across standard antibiotic classes compared to *S. aureus*, underscoring the need for tailored antimicrobial stewardship.



The 2025 Matrix provides a comprehensive overview of sensitivity patterns for two clinically prominent bacterial pathogens: Enterococcus spp. And Staphylococcus aureus. The data evaluates the effectiveness of eleven widely prescribed antimicrobial agents, spanning glycopeptides, oxazolidinones, aminoglycosides, lincosamides, fluoroquinolones, macrolides, and various β -lactams. In this assessment, sensitivity percentages reflect the proportion of bacterial isolates successfully inhibited or eradicated by standard therapeutic concentrations.

Heatmap matrix(top): display the percentage sensitivities(% of bacterial isolated effectively inhibited or killed) of major pathogen across 11 antibiotic green shades(70-100%): high effectiveness/ drug of choice. yellow shades(50-69%): moderate effectiveness/ intermediate resistance orange to dark red shades(13-49%): high resistance/ low effectiveness

antimicrobial sensitivity profile staphylococcus aureus

Staphylococcus aureus isolates demonstrate the highest susceptibility to targeted reserve anti-Gram-positive agents, led by Vancomycin (VA) with complete 100.0% sensitivity across all tested strains. Linezolid (LZ) and Amikacin (AK) also display exceptional

antimicrobial potency, achieving 93.3% and 92.1% susceptibility respectively. Clindamycin (CD) remains highly effective with an 83.7% sensitivity rate, representing a viable alternative for severe soft tissue and bone infections when oral or parenteral switch therapy is required.

Moderate activity is observed among aminoglycosides and macrolides, where Tobramycin (TOB) achieved 57.9% sensitivity, Gentamicin (GEN) showed 53.7% sensitivity, and Erythromycin (E) recorded 53.5% sensitivity. These values reflect substantial intermediate resistance and limited reliability for empirical monotherapy against *S. aureus*.

In contrast, severe resistance is evident across fluoroquinolones and conventional β -lactam agents. Ofloxacin (OF) exhibited only 38.0% sensitivity. Cefoxitin / Cloxacillin (CX) demonstrated a 30.2% sensitivity rate, confirming a heavy prevalence of Methicillin-Resistant Staphylococcus aureus (MRSA) within this cohort. Further more, combination penicillinase-inhibitor formulations such as Amoxicillin-Clavulanic Acid (AMC) and standard penicillins like Amoxicillin / Ampicillin (AMX) achieved only 25.7% and 13.5% sensitivity, respectively, rendering them ineffective for empiric treatment

Enterococcus Sensitivity

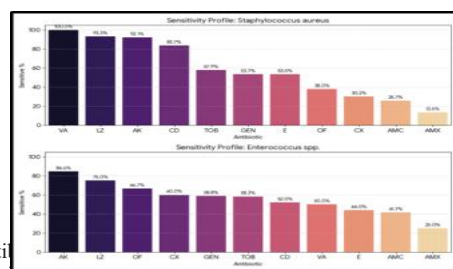
For Enterococcus spp., the highest sensitivity was documented with the aminoglycoside Amikacin (AK) at 84.6%, followed by Linezolid (LZ), which exhibited strong clinical utility with a 75.0% sensitivity rate. Ofloxacin (OF) retained moderate-to-good activity at 66.7% sensitivity, showing markedly higher responsiveness compared to its performance against *S. aureus*.

A critical clinical finding is the performance of Vancomycin (VA) and Cefoxitin (CX), both of which demonstrated exactly 60.0% sensitivity. The reduced Vancomycin susceptibility indicates a notable 40.0% rate of Vancomycin-Resistant Enterococci (VRE), requiring cautious selection of reserve glycopeptides. Aminoglycosides such as Gentamicin (GEN) and Tobramycin (TOB) demonstrated moderate susceptibility at 58.8% and 58.3%, respectively, serving primarily as synergistic agents in combination regimens.

Lincosamides and standard oral β -lactams showed poor-to-marginal efficacy against Enterococcus spp. Clindamycin (CD) achieved only 52.0% sensitivity, while Erythromycin (E) dropped to 44.0%. Profound resistance was observed against Amoxicillin-Clavulanic Acid (AMC) at 41.7% sensitivity and Amoxicillin / Ampicillin (AMX), which recorded the lowest sensitivity at 25.0%.

Clinical interpretation

Comparing both pathogens, Linezolid and Amikacin maintain strong, reliable broad-spectrum coverage exceeding 75% to 93% across both species. While Vancomycin is universally effective (100.0%) against Staphylococcus aureus, its diminished activity (60.0%) in Enterococcus spp. underlines the growing clinical burden of VRE strains conversely, common first-line β -lactam regimens (Amoxicillin, Co-amoxiclav) and macrolides (Erythromycin) exhibit severe failure rates across both organism groups.



An antimicrobial sensitivity profile, or antibiogram, provides a clear overview of how effective various pharmaceutical agents are against specific bacterial pathogens. The vertical axis on each chart represents the percentage of tested bacterial strains or clinical isolates that demonstrate susceptibility to a given antibiotic. A higher percentage indicates that the specific bacterium is vulnerable to the drug, highlighting it as a potentially reliable choice for therapeutic intervention. Conversely, a lower percentage signifies that the bacterial population possesses

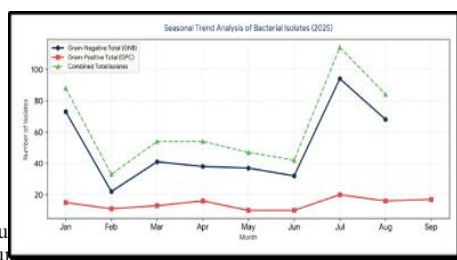
substantial resistance, meaning the drug is unlikely to succeed in clearing the infection.

s.aureus sensitivity profile

The upper chart details the efficacy of a panel of antibiotics against strains of *Staphylococcus aureus*. Leading the profile is Vancomycin (VA) with a 100.0% sensitivity rate, closely followed by Linezolid (LZ) at 93.3% and Amikacin (AK) at 92.1%. These high percentages reflect that the vast remaining majority of tested isolates remain highly vulnerable to these primary agents. Moving down the spectrum, intermediate agents such as CD (83.7%), TOB (57.9%), GEN (53.7%), and E (53.5%) demonstrate moderate clinical effectiveness. On the opposite end of the spectrum, Amoxicillin (AMX) displays the lowest sensitivity rate at just 13.5%, accompanied by Amoxicillin-Clavulanate (AMC) at 25.7% and CX at 30.2%. These lower values indicate a strong level of acquired resistance among the tested *Staphylococcus aureus* strains against these particular drug classes, guiding clinicians away from their empirical use. The lower chart illustrates the sensitivity distribution for *Enterococcus* species across a similar range of compounds. In this profile, Amikacin (AK) emerges as the most effective agent with an 84.6% sensitivity rate, followed by Linezolid (LZ) at 75.0% and OF at 66.7%. Moderate efficacy is observed among agents such as CX (60.0%), GEN (58.8%), TOB (58.3%), CD (52.0%), and VA (50.0%), which hover near or around the midpoint of susceptibility. Similar to the previous organism, Amoxicillin (AMX) demonstrates reduced efficacy against *Enterococcus* species, recording a low sensitivity of 25.0%. Additional lower-tier responses are noted for AMC (41.7%) and E (44.0%), highlighting significant resistance challenges that necessitate careful selection of targeted antimicrobial therapy.

Clinical Interpretation

These comparative graphs serve as crucial tools for medical professionals, enabling them to evaluate and contrast how susceptible a given bacterial infection is across an array of available drugs. Therapeutics positioned on the left side of each chart with darker coloring and higher percentages represent robust treatment options for targeting the respective pathogens. In contrast, those on the right side with lower susceptibility percentages underscore high resistance profiles, emphasizing the necessity of personalized and evidence-based antibiotic stewardship in clinical practice. This report provides an advanced biostatistical evaluation of bacteriological sentinel data collected across clinical departments throughout 2025. The core objective is to map temporal distribution patterns, establish baseline organism frequencies, and identify seasonal surge periods to guide empirical antimicrobial therapy protocols and curb resistance selection pressure.



Longitudinal trend analysis of bacterial isolates over time. A substantial mid-year peak occurs during July ($n = 114$ total isolates), driven predominantly by Gram-negative bacilli ($n = 94$). This pattern strongly correlates with regional environmental transitions (monsoon onset), favoring water and vector-borne pathogen transmission. A secondary minor elevation is observed during January ($n = 88$), reflecting cold-season systemic and respiratory infection burdens.

Clinical & Stewardship Implications

The predictable mid-year surge in Gram-negative pathogens necessitates proactive antimicrobial stewardship measures. Specifically, hospital infection control committees should intensify auditing of broad-spectrum empirical regimens (such as 3rd-generation cephalosporins and fluoroquinolones) preceding and during peak monsoon months. Future iterations of this sentinel program will incorporate unit-specific stratification (SICU versus General Wards) to refine localized antibiograms.

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