

Original Article

Utilization pattern and outcomes of piperacillin-tazobactam in a multispecialty hospital: A cross-sectional analysis

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ABSTRACT

Objectives: To evaluate the utilization of piperacillin and tazobactam (PTZ) by identifying appropriate and inappropriate use, assessing empirical versus culture-guided use and rationality based on Infectious Diseases Society of America (IDSA) guidelines, analyzing the distribution of infection sites, and examining patient-centered outcomes such as hospital mortality, length of stay, and duration of treatment.

Material and Methods: A 6-month cross-sectional study at Multispecialty Hospital in Chennai, India, involving 245 participants was conducted. Consenting patients were assessed upon admission. The study also assessed antibiotic use based on IDSA recommendations.

Results: In this study, the most frequent indication for piperacillin and tazobactam (PTZ) use was urinary tract infection (26.1%). The most commonly prescribed dosage was 4.5 g every 8 hours, with the most typical treatment duration being 1-5 days. PTZ was primarily prescribed empirically (64%). Mean length of hospital stay (LOS) was 8.56±5.2 days. Appropriate use of the drug was most often observed in cases of urinary tract and respiratory tract infections. Patient outcomes showed improvement in 64.9% of cases, no improvement in 16.8%, and mortality in 18.4% of patients.

Conclusion: The study highlights the extensive utilization of PTZ in a multispecialty hospital, leading to considerable medication exposure among patients. Severity scores for mortality and morbidity were employed to evaluate survivorship bias. The most frequently observed infection leading to inpatient mortality was associated with a short duration of hospital stay for the majority of patients.

Keywords: Antibiotic resistance, Audit, β -lactamase inhibitor, Drug utilization, Piperacillin, Tazobactam, Ureidopenicillin

INTRODUCTION

Infectious diseases are illnesses caused by pathogenic microorganisms or their toxic byproducts and can be transmitted through contact with infected animals or consumption of contaminated food and water.^[1] Vaccination can prevent many infectious diseases, and antibiotics have facilitated advanced medical procedures such as oncology treatments, cardiac surgeries, and organ transplantation, thereby significantly improving life quality and expectancy.^[2] However, the improper use of antibiotics, without adherence to clinical guidelines, has led to the emergence of antimicrobial resistance, rendering infections increasingly difficult or sometimes impossible to treat.^[3] This issue has persisted for decades, complicating the management of both common and critical infections. Piperacillin-tazobactam (PTZ) is a broad-spectrum antibiotic that combines a ureidopenicillin with a beta-lactamase inhibitor.^[4] It exhibits bactericidal activity

against a wide range of gram-positive and gram-negative aerobic and anaerobic bacteria by inhibiting septum and cell wall synthesis.^[5] This combination extends its antibacterial spectrum to include many β -lactamase-producing organisms, such as *Staphylococci*, *Enterobacteriaceae*, *Haemophilus influenzae*, and *Bacteroides* species.^[6] PTZ is frequently utilized in the treatment of intra-abdominal infections, nosocomial infections, community-acquired pneumonia, skin and soft tissue infections, and gynecological infections.^[7] It is contraindicated in patients with known hypersensitivity to any penicillin, cephalosporin, or β -lactamase inhibitor.^[8] To mitigate the development of resistant bacteria and preserve the efficacy of PTZ and other antibacterial agents, it should be prescribed exclusively for confirmed or strongly suspected bacterial infections.^[9] Prescription auditing forms a crucial component of a comprehensive clinical audit aimed at enhancing patient care and clinical outcomes through systematic review of practices against established criteria and

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the implementation of necessary changes.^[10] Routine and timely audits of antibiotic prescriptions can prevent irrational antibiotic use and improve the overall quality of healthcare delivery. PTZ has been widely researched regarding its usage and outcomes in various clinical environments. Studies indicate that educating healthcare providers on alternative treatments can significantly reduce the utilization of PTZ.^[11] Additionally, critically ill adults receiving PTZ did not experience an increased incidence of adverse renal events and exhibited improved neurologic outcomes compared to those treated with anti-pseudomonal cephalosporins.^[12] In patients undergoing open pancreatoduodenectomy, the use of PTZ as perioperative prophylaxis has been shown to decrease the incidence of postoperative surgical site infections, pancreatic fistula, and sepsis, endorsing its application as standard care in this context.^[13] Furthermore, extended infusion of PTZ has been linked to lower mortality rates, reduced incidence of *Clostridium difficile* infections, and cost savings when compared to standard infusion, highlighting its advantages in non-critically ill patients.^[14] Lastly, PTZ has proven to be an effective alternative to carbapenems for treating nosocomial pneumonia caused by extended spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae, with comparable clinical outcomes observed between the two treatments.^[15] The audit of PTZ usage has been the subject of limited studies. In a prospective study conducted at a large urban tertiary care hospital in Canada, the utilization of PTZ was evaluated based on several criteria: adherence to hospital guidelines, appropriateness of antibiotic selection for the

clinical scenario, and proper duration of therapy. The study found that 38.5% of PTZ use was inappropriate, and the cost avoidance associated with appropriate usage was also calculated.^[16] Another study assessed the appropriate use of PTZ in a community health system over 3 months, involving 500 patients across four hospitals. The overall appropriate use rate was 71.5%, with hospitals A and B both demonstrating an 82% appropriateness rate, compared to 64% and 58% for hospitals C and D, respectively. This assessment followed the IDSA guidelines Shah and Ryzner, 2013.^[17] Similarly, a study conducted over four months with 200 patients at a tertiary care teaching hospital found that PTZ was used appropriately in 73.5% of cases, with inappropriate use identified in 26.5% of cases. Another study with a comparable sample size reported a 93.24% rate of appropriate use of PTZ.^[18] The objective of our audit is to monitor and optimize the administration of PTZ in a multi-specialty hospital in Chennai illustrated in Figure 1.

MATERIAL AND METHODS

Study design

Participant enrollment

This cross-sectional study was conducted at Multispecialty Hospital in Chennai, India, over a six-month period. The study population consisted of 245 participants, who were recruited after obtaining informed consent from each subject. Approval for the study was granted by the hospital's institutional ethics committee in May (HMH/IEC/2022/STEA24). All study

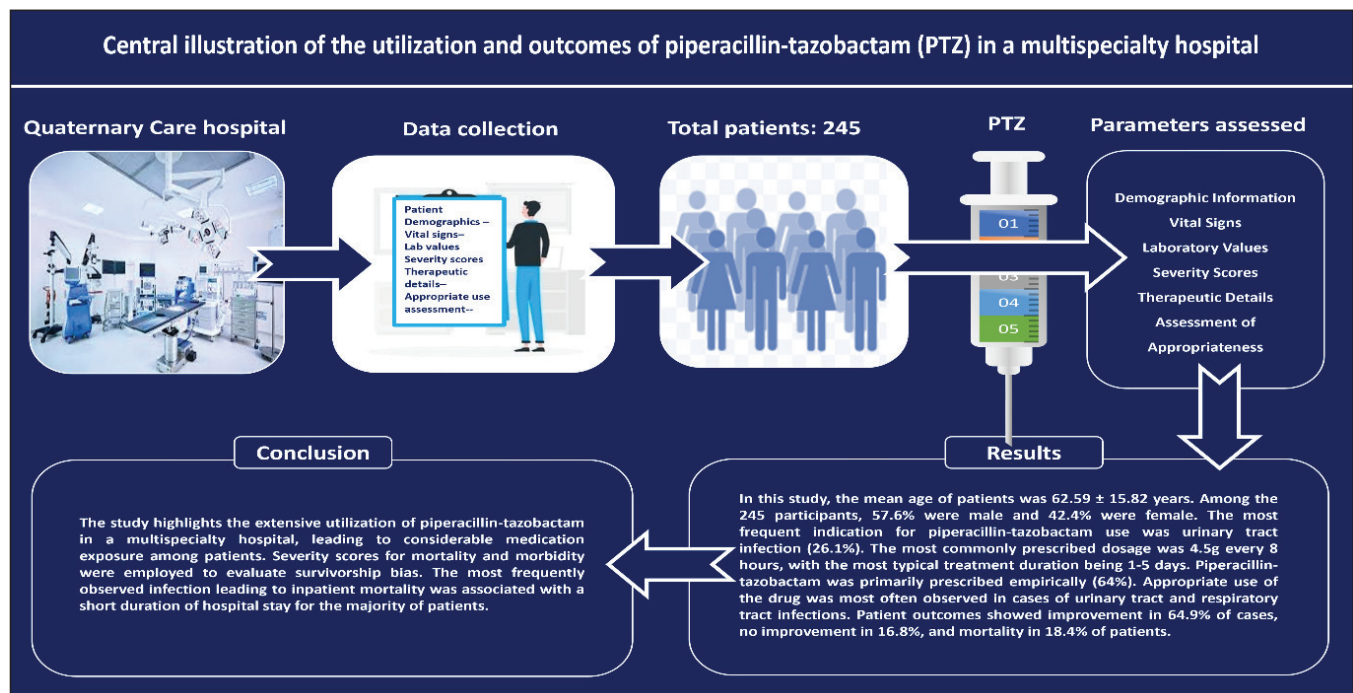


Figure 1: Schematic representation of the piperacillin-tazobactam utilization and outcomes in a multi-specialty hospital.

procedures were performed in accordance with the guidelines outlined in the declaration of Helsinki.

Data collection

The study included all consecutive adult patients aged 18 years and older who had been prescribed and received at least one dose of PTZ. Eligible subjects were enrolled, and the following data were collected: demographic information (age, sex, date of birth, past medical history), vital signs (temperature, height, weight, body mass index, body surface area, blood pressure, pulse rate, respiratory rate, SpO₂, mean arterial pressure), laboratory values (clinical hematology, biochemistry, lipid profile, renal function test, liver function test, clinical pathology, microbiology and infectious disease serology), severity scores (Sequential organ failure assessment [SOFA], Pitt's bacteremia score, Charlson Comorbidity Index, Glasgow Coma Scale [GCS], Acute physiology and chronic health evaluation II [APACHE II score]), calculated using the worst value for each physiological variable recorded within the first 24 hours of hospital admission, therapeutic details (empirical and rational indications for PTZ use, dose and duration of therapy, culture and sensitivity test results, total length of hospital stay-LOS), and an assessment of the appropriateness of PTZ use. Clinical improvement was based on predefined discharge criteria and was linked to at least one scoring metric in the results (for example, a decrease in SOFA/APACHE II from admission to discharge). Patients who were re-hospitalized were excluded from the study. Following the initial assessment, all patients were monitored until discharge or the end of the study period, and data were documented in case report forms (CRFs) from the hospital records.

Criteria for use of PTZ

The appropriateness of PTZ use was determined based on the following criteria: 1) The initial antibiotic selection was evaluated for suitability according to the prescription information or Infectious Diseases Society of America (IDSA) disease-state guidelines. Empirical therapy with PTZ was considered appropriate if it followed these recommendations. 2) The dosage was reviewed to ensure it adhered to the prescribed directions, but only if the empirical therapy with PTZ was initially deemed appropriate. 3) After obtaining culture and sensitivity results, the therapy was re-evaluated and adjusted as needed. If necessary, the treatment plan was modified to reduce the use of PTZ, and if the organism was not susceptible to this antibiotic, an alternative was prescribed.

The IDSA guidelines recommend PTZ use in specific situations:

- Complicated urinary tract infections (UTI)/Urosepsis: When gram-negative rods are suspected in systemically ill or multi-drug resistant patients.

- Sepsis/bloodstream infections: Empirically for suspected sepsis with risk factors for *Pseudomonas* or ESBL-producing organisms, especially in critically ill patients.
- Respiratory tract infections: For, where anaerobes or *Pseudomonas* are likely.
- Intra-abdominal infections: In moderate-to-severe cases, particularly when enteric Gram-negatives and anaerobes are suspected.
- Skin and soft tissue infections: Appropriate for severe diabetic foot infections or necrotizing fasciitis requiring broad-spectrum coverage.
- Surgical prophylaxis: PTZ use was justified if the patient was colonized with resistant pathogens or at high risk for nosocomial infections, in alignment with institutional and IDSA guidelines for surgical prophylaxis in high-risk cases.
- Immunocompromised states (e.g., febrile neutropenia): As part of empirical therapy when gram-negative sepsis is suspected.

Statistical analysis

Data were expressed as mean \pm standard deviation (SD), median with interquartile range, or frequency with percentage. Data normality was assessed via Q-Q plots. Statistical calculations were performed using SPSS Version 16.0 (Chicago, IL).

RESULTS

The study included all patients who were prescribed PTZ and met the inclusion criteria during the study period. Table 1 summarizes the basic information about the 245 eligible patients in the study. Out of these patients, 141 (57.6%) were male, and 104 (42.4%) were female, with a mean age of 62.59 \pm 15.82. The average weight, height, and BMI were 66.61 \pm 14.53, 161.2 \pm 7.31, and 25.47 \pm 5.02, respectively. Around 31% of admissions went to the ICU, and 69% went to the general ward. We documented vital signs on admission, including temperature, oxygen saturation, blood pressure (systolic and diastolic), pulse rate, respiratory rate, and mean arterial pressure. We performed laboratory tests, including blood cell analysis, glucose and lipid levels, and other biochemical markers, when we started PTZ therapy. Most of the reviewed patients were from the general ward, and their hospital stays ranged from 6 to 10 days.

The study included 245 patients, with various co-morbidities observed among them. The most prevalent co-morbidity was diabetes mellitus, affecting 130 patients (53.1%), followed by hypertension, present in 101 patients (41.3%). Other significant co-morbid conditions included heart disease in 36 patients (14.7%), cancer in 13 patients (5.3%), and chronic obstructive pulmonary disease (COPD) in 11

Table 1: Baseline characteristics of the study population with PTZ.

Parameters		PTZ (n=245) (mean±SD)
Age		62.59±15.82
Sex	Male	141 (57.6)
	Female	104 (42.4)
Ward	General	169 (69)
	ICU	76 (31)
Height (cm)		161.20±7.306
Weight (kg)		66.61±14.526
BMI (kg/m ²)		25.470±5.0183
BSA (m ²)		1.719±0.2050
Temperature(°C)		98.470±1.4463
Oxygen saturation (%)		96.12±5.535
Systolic BP (mm/hg)		123.07±23.665
Diastolic BP (mm/hg)		75.59±14.378
Pulse rate (bpm)		94.26±20.532
Respiratory rate (bpm)		22.06±4.107
MAP (mm/hg)		90.91±16.146
Laboratory Characteristics		
RBC (million/mm ³)		3.85±0.91
Haemoglobin (g/dL)		10.73±2.28
Packed cell volume (%)		32.60±6.87
Total Count (cells/ mm ³)		14,700±7912.55
Neutrophils (%)		80.66±11.027
Platelet Count (per microliter)		2.77±1.63
Erythrocyte Sedimentation Rate (mm/hr)		32.49±22.82
Random Blood Sugar (mg/dL)		191.53±108.33
Fasting Blood Sugar (mg/dL)		175.00±85.19
Post Prandial Blood Sugar (mg/dL)		265.69±120.03
Haemoglobin A1c (%)		7.39±2.13
Urea (mg/dl)		45.95±36.78
Creatinine (mg/dl)		1.44±1.79
Blood Urea Nitrogen (mg/dl)		21.45±17.17
Creatinine Clearance (ml/min)		61.68±33.66
Sodium (mEq/L)		133.09±10.38
Potassium (mmol/L)		4.25±1.32
Chloride (mEq/L)		97.85±4.86
Albumin (g/dl)		3.38±0.85
AST (U/L)		140.05±653.58
ALT (U/L)		74.11±244.90
C-Reactive Protein (mg/L)		134.79±144.71
Procalcitonin (ng/mL)		1.51±34.06

(Contd...)

Parameters		PTZ (n=245) (mean±SD)
Length of hospital stay	1-5 Days	87(35.5)
	6-10 Days	99(40.4)
	11-20 Days	49(20.0)
	21-30 Days	7(2.9)
	31-40 Days	3(1.2)
	Mean	8.56 days
Median		8.0 days

PTZ: Piperacillin-tazobactam, BMI: Body mass index, BSA: Bovine serum albumin, BP: Blood pressure, MAP: Mean arterial pressure, RBC: Red blood cells, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, Values in brackets represent percentages, SD: Standard deviation.

patients (4.5%). Acute kidney disease was found in nine patients (3.7%), while chronic kidney disease was observed in seven patients (2.9%). Hypothyroidism and bronchial asthma each affected nine (3.7%) and eight (3.3%) patients, respectively. Cerebrovascular accident and bronchial asthma were each present in eight patients (3.3%). Parkinsonism was noted in six patients (2.4%), and rheumatoid arthritis in five patients (2.0%). Decompensated chronic liver disease was the least common, affecting four patients (1.6%). The study participants reported having at least one comorbidity is 130 (53.1%), and patients reported having two or more comorbidities 101(41.3%).

Overall, the data highlight the diverse range of co-morbidities present in the study population, with diabetes mellitus and hypertension being the most common were illustrated in Table 2.

Table 2: Comorbidities of study participants.

Co-morbidities		Frequency (n=245)
Diabetes mellitus		130 (53.1)
Hypertension		101 (41.3)
Kidney disease	Acute	9 (3.7)
	Chronic	7 (2.9)
Bronchial asthma		8 (3.3)
COPD		11 (4.5)
Heart disease		36 (14.7)
Hypothyroidism		9 (3.7)
DCLD		4 (1.6)
Parkinsonism		6 (2.4)
CVA		8 (3.3)
Rheumatoid arthritis		5 (2.0)
Cancer		13 (5.3)

COPD: Chronic obstructive pulmonary disease, DCLD: Decompensated liver disease, CVA: Cerebrovascular accident, Values in brackets represent percentages.

Table 3: Indications for which PTZ was prescribed.

Infections	Frequency (n=245) (%)
UTI	64 (26.1)
Prophylaxis	63 (25.7)
Sepsis	46 (18.8)
Cellulitis	34 (13.9)
DM foot ulcer	10 (4.1)
Aspiration pneumonitis	15 (6.1)
LRTI	31 (12.7)
COPD	14 (5.7)
Pyelonephritis	12 (4.9)
Intra-Abdominal Infection	15 (6.1)
Hospital acquired pneumonia	11 (4.5)
Febrile neutropenia	1 (0.4)

PTZ: Piperacillin-tazobactam, UTI: Urinary tract infection, LRTI: Lower respiratory tract infection, COPD: Chronic obstructive pulmonary disease, Values in brackets represent percentages.

Table 3 represents the clinical indications for which PTZ was prescribed by physicians. The predominant indication was UTI, representing 26.1% of prescriptions. UTI was followed closely by medical prophylaxis, which constituted 25.7% of the prescriptions. Other significant therapeutic indications included sepsis (18.8%), cellulitis (13.9%), lower respiratory tract infection (12.7%), aspiration pneumonitis (6.1%), and intra-abdominal infection (6.1%). Moreover, PTZ was prescribed for COPD (5.7%), pyelonephritis (4.9%), hospital-acquired pneumonia (HAP) (4.5%), diabetic foot ulcer (4.1%), and febrile neutropenia (0.4%).

These findings underscore UTI and medical prophylaxis as the predominant reasons for PTZ utilization during the study period. Additionally, these results highlight the importance of appropriate antibiotic stewardship practices in healthcare settings. The median LOS for both appropriate and inappropriate hospital admissions was 8.0 days. However, there was a difference in the interquartile range (IQR). The IQR for appropriate admissions (n=242) was 5.0 days, while for inappropriate admissions (n=3), it was 3.75 days. This suggests that while the central tendency of LOS was the same, the spread of data for appropriate admissions was slightly wider.

The majority of PTZ prescriptions were for renal and UTI (32.2%), followed by respiratory infections (25.3%) and skin and soft tissue infections (21.6%). Among the 245 PTZ prescriptions, approximately 18% were for bloodstream infections, 13.5% for surgical site infections, 10.2% for intra-abdominal infections, 2.9% for bone and joint infections,

Table 4: Appropriateness of PTZ by infection type.

Site of infection	PTZ (n=245)
Intra-abdominal	25 (10.2)
Respiratory	62 (25.3)
Blood stream	44 (18.0)
Renal	79 (32.2)
skin & soft tissue	53 (21.6)
Surgical	33 (13.5)
Bone & joint	7 (2.9)
CNS	6 (2.4)

Values in brackets represent percentages, PTZ: Piperacillin-tazobactam, CNS: Central nervous system.

and 2.4% for central nervous system infections has been tabulated in Table 4. The analysis of PTZ microbial profile revealed that urine was the most common source of culture, which accounted for 40.4% of cases, followed by sputum (9.8%), pus (9.0%), tissue (2.9%), blood (0.8%), tracheal (0.4%), and pleural (0.8%) cultures. Most of the isolated organisms were gram-negative (29.0%), a few were gram-positive (0.4%), and no organisms grew in 28.2% of cases. The antibiogram results indicated that 8.2% of the organisms responded well to PTZ, 1.2% had moderate response, and 4.9% were not responsive. Notably, 85.7% of cases lacked antibiogram data.

Table 5: Microbial profile of the study population.

Parameters	PTZ (n=245)	
Source of culture	Urine	99 (40.4)
	Sputum	24 (9.8)
	Pus	22 (9.0)
	Tissue	7 (2.9)
	Blood	2 (0.8)
	Tracheal	1 (0.4)
	Pleural	2 (0.8)
Organisms	Gram positive	1 (0.4)
	Gram negative	71 (29.0)
	No organism grown	69 (28.2)
Antibiogram	Susceptible	20 (8.2)
	Intermediate	3 (1.2)
	Resistant	12 (4.9)
	Nil	210 (85.7)

Values in brackets represent percentages.

This emphasizes the prevalence of urine cultures and gram-negative organisms, underscoring the crucial role of culture and sensitivity testing in directing effective antibiotic treatment has been shown in Table 5.

In this study, we assessed the appropriate use of PTZ based on the IDSA guidelines we found that PTZ was used appropriately with a percentage of 98.8. This study also calculated the therapeutic approach of PTZ, results indicated that empirical use was 63.7% followed by rational (18%), and 18.4% were treated surgically. This standardized approach highlights the consistent administration practices of PTZ in clinical settings. The drug regime of PTZ was tabulated in Table 6.

Over the study period, lincosamide and macrolides were the two most commonly selected antibiotics, along with PTZ, being prescribed on average 12.7% and 4.5% of occasions, respectively. Whereas rarely prescribed antibiotics include nitroimidazole, tetracycline, and fluoroquinolones, as shown in Table 7. The outcomes of 245 cases treated with PTZ were analyzed based on infections caused by *E. coli*, *Klebsiella*, *Pseudomonas*, *Enterococcus*, and *Achromobacter*. Overall, 64.9% of cases improved, 16.8% did not improve, and 18.4% resulted in death. Specifically, for *E. coli* infections, 65.7%

Table 6: Drug regimen of PTZ.

Parameters	PTZ (n=245)	
Therapeutic approach	Empirical	156 (63.7)
	Rational	44 (18.0)
	Surgical Prophylaxis	45 (18.4)
Based on IDSA guidelines	Appropriate	242 (98.8)
	Inappropriate	3 (1.2)
Dose	4.5 g	192 (78.4)
	2.25 g	53 (21.6)
Frequency	BD	37 (15.1)
	TDS	198 (80.8)
	Q6Hrs	10 (4.1)
Duration of treatment	1-5	156 (63.7)
	6-10	77 (31.4)
	11-15	12 (4.9)
Total dose prescribed	1-5	66 (26.9)
	6-15	108 (44.1)
	16-25	57 (23.3)
	26-35	9 (3.7)
	36-50	5 (2.0)

PTZ: Piperacillin-tazobactam, IDSA: Infectious disease society of America, BD: Twice daily, TDS: Thrice daily Values in brackets represent percentages.

Table 7: Combination antibiotic therapy along with piperacillin-tazobactam.

Other antibiotics	PTZ (n=245)
Lincosamide	31 (12.7)
Macrolide	11 (4.5)
Nitro-Imidazole	10 (4.1)
Tetracycline	9 (3.7)
Fluoro-quinolone	9 (3.7)
Others	24 (9.8)

PTZ: Piperacillin-tazobactam, Values in brackets represent percentages.

improved, 14.4% did not improve, and 20% expired. *Klebsiella* infections showed a 46.4% improvement rate, 14.3% did not improve, and 39.3% expired. *Pseudomonas* infections had a high improvement rate of 90.9%, with 9.1% not improving and 9.1% expiring.

Enterococcus infections showed no improvement, with 100% of cases either not improving or expiring. Similarly, *Achromobacter* infections showed no improvement, with 100% of cases not improving. The data highlights the observed improvement high efficacy of PTZ in treating *Pseudomonas* infections, while infections caused by *Enterococcus* and *Achromobacter* had poor outcomes, were demonstrated in Table 8.

The mortality among patients, the most important reasons were septic shock (19), cardiogenic shock (10), Covid 19 pneumonia (5), at the end of the treatment with PTZ shown in Table 9.

Table 10 describes the predictors of mortality among study participants. The outcome measure includes GCS Score (13.45±3.26), Apache II (17.78±6.59), SOFA Score (3.30±2.05), and pitt Bacteraemia Score (1.29±2.46) to account for a survivorship bias.

The dosage of PTZ used varies according to the clinical indication; the most common dose prescribed was 4.5 g every 8 hours in 81.2% (156/192) of the patients. In terms of duration of treatment, most of the patients (121/192) (63%) received PTZ for 1-5 days. Table 11 shows the dosage regimen of PTZ used.

Among the 245 patients, outcomes were assessed based on age categories as detailed in Table 12. Of the 159 patients who showed improvement, 56 were in the 65-79 years age group. For the 45 patients who did not improve, 16 were in the 50-64 years age range. Additionally, of the 27 patients who expired, the majority were in the 65-79 years age group, as illustrated in Table 12. In this study, the culture samples were obtained from 157 patients, as detailed in the table.

Table 8: Outcome at the end of treatment with PTZ based on Infectious organisms.

Status	Total	<i>E. coli</i>	<i>Klebsiella</i>	<i>Pseudomonas</i>	<i>Enterococcus</i>	<i>Achromobacter</i>
Improved	159 (64.9)	23 (65.7)	13 (46.4)	10 (90.9)	-	-
Not improved	41 (16.8)	5 (14.4)	4 (14.3)	1 (9.1)	1 (100)	1 (100)
Expired	45 (18.4)	7 (20.0)	11 (39.3)	1 (9.1)	1 (100)	-

PTZ: Piperacillin-tazobactam, Values in brackets represent percentages.

Table 9: Reason for death at the end of the treatment with PTZ based on infectious organisms.

Reason for death	Total (n=46)	<i>E. coli</i> (n=8)	<i>Klebsiella</i> (n=11)	<i>Pseudomonas</i> (n=1)	<i>Enterococcus</i> (n=1)	<i>Achromobacter</i> (n=0)
Septic shock	20 (8.2)	3 (8.6)	6 (21.4)	-	1 (100)	-
Cardiogenic shock	9 (3.7)	1 (2.9)	4 (14.3)	-	-	-
Covid 19 pneumonia	5 (2.0)	2 (5.7)	1 (3.6)	-	-	-
Brain stem dysfunction	3 (1.2)	1 (2.9)	-	-	-	-
Severe metabolic acidosis	1 (0.4)	1 (2.9)	-	-	-	-
Bradycardia	1 (0.4)	-	-	1 (9.1)	-	-
Others	7 (2.8)	-	-	-	-	-

PTZ: Piperacillin-tazobactam, Values in brackets represent percentages.

Table 10: Predictors of mortality among study participants.

Scores	PTZ (n=245) (mean ± SD)
GCS	13.45±3.267
APACHE II	17.78±6.591
SOFA	5.44±3.713
Charlson co-morbidity	3.30±2.057
Pitt bacteremia	1.29±2.463

PTZ: Piperacillin-tazobactam, GCS: Glasgow coma scale, SOFA: Sequential organ failure assessment, APACHE: Acute physiology and chronic health evaluation, SD: Standard deviation.

Table 11: Dosage regimen of PTZ received by the study.

Parameters		4.5 g (n=192)	2.25 g (n=53)
Frequency	BD	31 (16.1)	6 (11.3)
	TDS	156 (81.2)	42 (79.2)
	Q6Hrs	5 (2.6)	5 (9.4)
Treatment duration	1-5	121 (63)	35 (66)
	6-10	62 (32.3)	15 (28.3)
	11-15	9 (4.7)	3 (5.7)

PTZ: Piperacillin-tazobactam, BD: Twice daily, TDS: Twice daily, Values in brackets represent percentages.

Pathogens were identified in 72 of these cases (29.4%). The most frequently identified pathogen was *E. coli*, found in 35 patients, followed by *Klebsiella* in 28 patients,

Table 12: Status of patients based on age-wise distribution.

Age category	PTZ (n=245)	Improved (n=159)	Not-improved (n=41)	Expired (n=45)
18-29	10 (4.1)	9 (90.0)	1 (10.0)	-
30-49	35 (14.3)	26 (74.3)	8 (22.9)	1 (2.9)
50-64	70 (28.6)	51 (72.9)	16 (22.8)	3 (4.3)
65-79	93 (38.0)	56 (60.2)	10 (10.8)	27 (29.0)
>80	37 (15.1)	17 (45.9)	6 (16.2)	14 (37.8)

PTZ: Piperacillin-tazobactam, Values in brackets represent percentages.

Pseudomonas in 11 patients, and both *Enterococcus* and *Achromobacter* in 1 patient each. gram-negative organisms were predominant, comprising a total of 71 cases (29%) shown in Figure 2.

The antibiogram results highlight the varying levels of effectiveness of different antibiotics against a bacterial strain. High susceptibility is observed with colistin, amikacin, imipenem, and netilmicin, each showing over 99% effectiveness. Conversely, high resistance is noted with cefazolin, cefuroxime, ceftriaxone, ceftazidime, and cefepime, each exhibiting over 68% resistance. Antibiotics like amoxicillin-potassium clavulanic acid, tetracycline, and trimethoprim-sulphamethoxazole show moderate effectiveness, with significant portions of the strain being resistant. In Figure 3, the above data underscores the importance of selecting appropriate antibiotics based on susceptibility patterns to effectively treat infections and minimize resistance development.

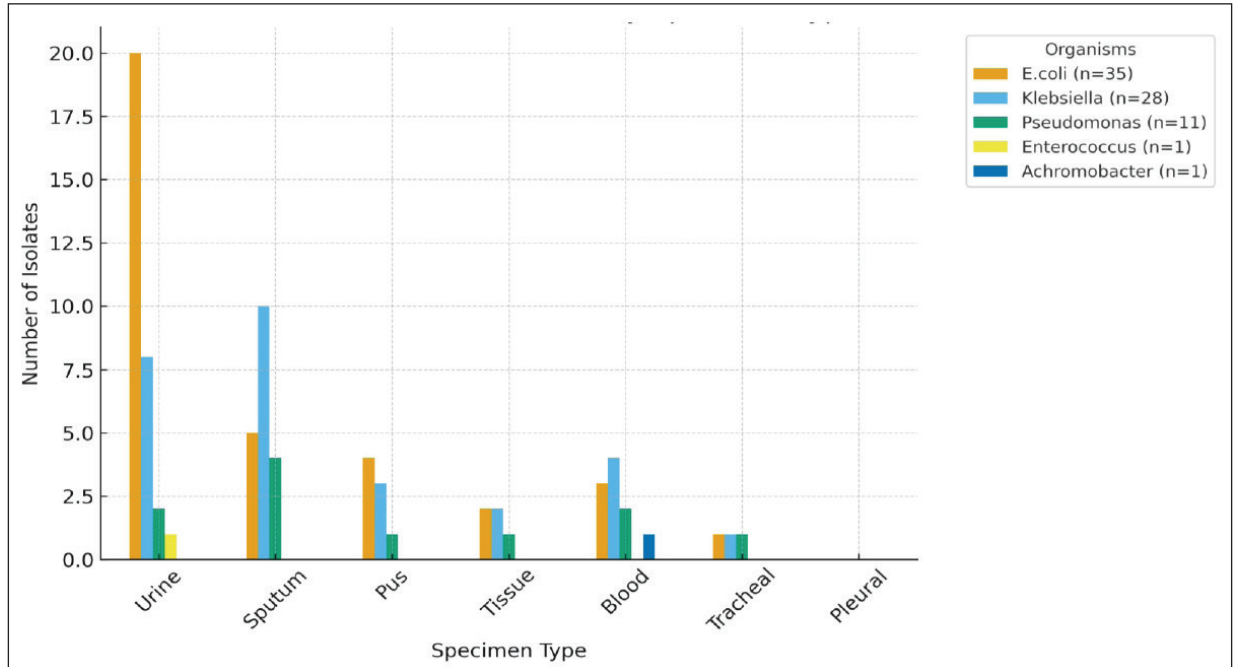


Figure 2: Types of infectious organisms identified from culture.

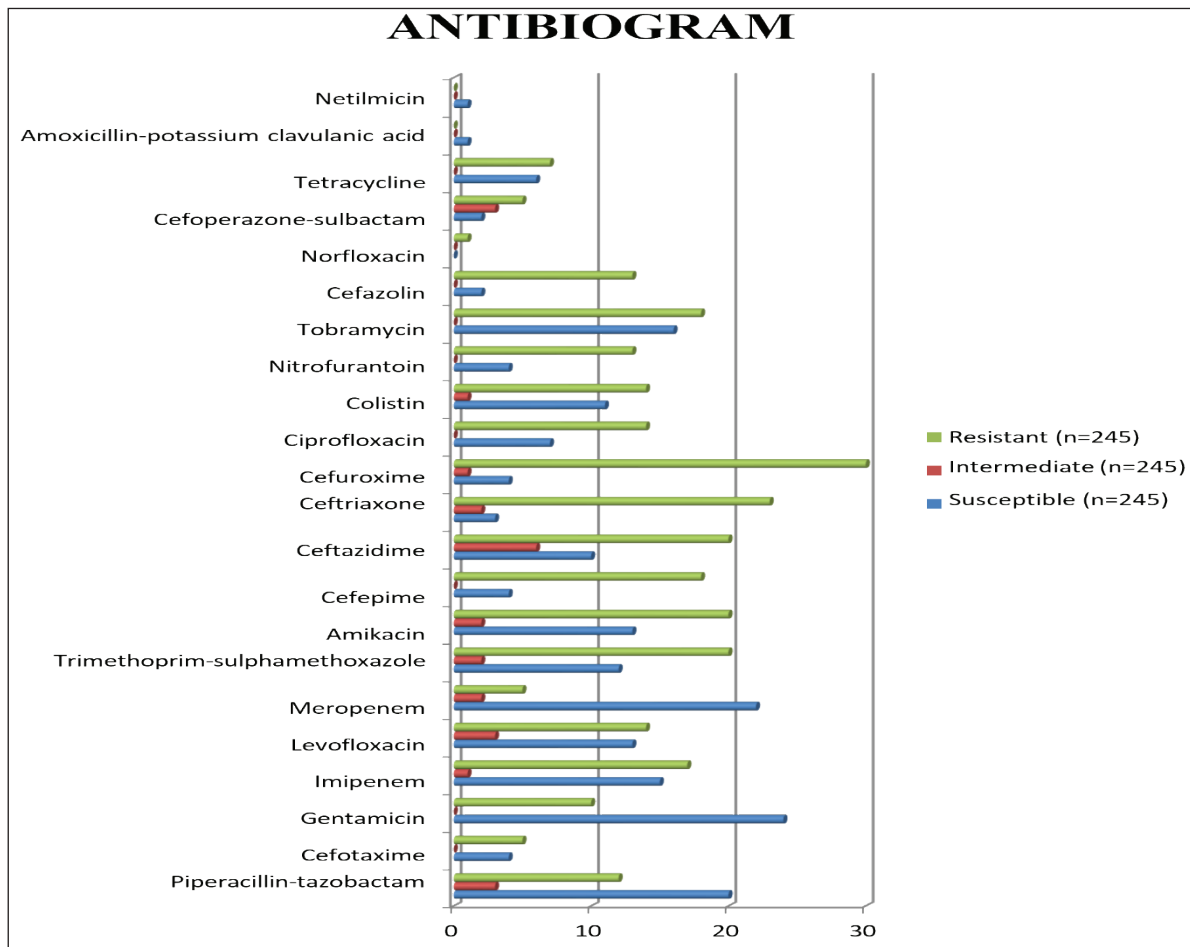


Figure 3: Overall antibiotic sensitivity test performed in the study population.

DISCUSSION

PTZ is recognized as a potent antibiotic capable of treating a broad spectrum of bacterial infections, encompassing both gram-positive and gram-negative, as well as aerobic and anaerobic bacteria.^[5] PTZ was identified as the second most commonly prescribed antibiotic for infections in critically ill patients, comprising 2.5% of all antimicrobial treatments in this group, and ranked among the top five antibiotics for non-critically ill patients.^[19] In this study, we examined the utilization of PTZ in a multi-specialty hospital over the past 6 months, using aggregated data. The research was conducted in the general in patients ward and intensive care unit (ICU), with a higher proportion of patients (69%) admitted to the general ward compared to 31% in the ICU.^[20-22] Eligible participants included patients aged 18 years or older who were admitted to either ward and received any dose of PTZ. The mean age of the patients was 62.59 ± 15.82 years, with 57.6% being male.^[23-25] Baseline characteristics and vital parameters were recorded on a pre-prepared CRF based on medical records. The suspected source of infection was determined through microbiological results from culture samples collected up to 48 hours before treatment initiation. These samples included 99 urine, 24 sputum, 22 pus, seven tissue, two blood, two pleural, and one tracheal sample. The identified pathogens included *E. coli* (35 cases) from urine, sputum, pus, and tissue cultures; *Klebsiella* (28 cases) from all mentioned cultures except tissue; and *Pseudomonas* (11 cases) from the same samples as *E. coli*. *Enterococcus* and *Achromobacter* were each isolated from urine samples.^[22] Cultures were performed for approximately half of the patients, with *P. aeruginosa*, *E. coli*, and *S. aureus* being the most commonly isolated bacteria.^[26,27] In our study, gram-negative bacteria predominated, with *E. coli* being the most frequently isolated pathogen. PTZ was most commonly prescribed for renal infections (32.2%), followed by respiratory infections (25.3%) and skin and soft tissue infections (21.6%), differing from other studies' findings for these indications.^[16] PTZ was frequently used for empiric therapy, primarily prescribed upon admission for suspected respiratory tract infections (29%) and urinary tract infections (26.1%), consistent with the findings of Remesh *et al.*, 2013.^[28] Whereas^[29] observed that 31.4% of respiratory infections diagnosed at admission required empirical antibiotic treatment. Our study primarily evaluated the impact of empirical PTZ therapy. While the treatment regimen was adjusted for many patients, empirical therapy remains crucial, especially for bacteremic patients.^[30,31] However, inappropriate use of PTZ was identified in 24 out of 64 UTI patients, four out of 14 COPD cases, and four out of 11 HAP instances.^[32] The primary outcomes of our study included assessing the appropriateness of PTZ use, determined by dose, frequency, and duration of treatment

as per the IDSA guidelines. Previous studies reported a 90% appropriateness rate for PTZ use. This cross-sectional study identifies high appropriateness of PTZ usage (98.8%) aligned with IDSA guidelines and institutional stewardship protocols. The unusually high appropriateness rate compared to other studies (e.g., Beahm and Fryters,^[16] 38.5% inappropriate use) is attributable to real-time clinical pharmacist review, hospital policy enforcement, and predefined protocol adherence.^[33] The appropriateness varied among different indications, with the highest appropriate use in sepsis (26.3%), followed by UTIs (22.4%) and cellulitis (17.3%). The lowest rates of appropriate use were observed in cases of HAP, pyelonephritis, and COPD.^[34] The dosage of PTZ varied based on clinical indications, with 4.5 g every 8 hours being the most frequently prescribed dose, administered to 81.2% of patients. The antibiotic dosage of 4.5 g for every 8 hours, which was consistent with IDSA guidelines for PTZ usage.^[5] The least common treatment duration was between 6 to 10 days, particularly for pyelonephritis. Our hospital did not frequently use the 3.375 g dosage.^[30] The study revealed variability in the duration of antibiotic treatment, with 63% of patients receiving PTZ for 5 days, 32.3% for 10 days, and 4.7% for 15 days. The total number of doses prescribed averaged 11.80 ± 8.26 per patient. Additionally, 94 patients received combination therapy, with lincosamide being the most frequently combined agent (12.7%). While our study did not record any adverse events, previous research has consistently highlighted the total dose and duration of PTZ therapy as significant risk factors for adverse events.^[35-37] Secondary outcomes included the LOS and hospital mortality. To evaluate patient outcomes, such as morbidity, mortality, and illness severity, various scoring systems are utilized in medical intensive care units. In our study, we calculated the mortality rate using the SOFA and APACHE II scores. The mean APACHE II score among patients was 17.78 ± 6.59 .^[23] The Charlson Comorbidity Index, which assesses chronic illness severity, was also calculated, yielding a mean score of 3.30 ± 2.057 . Additionally, the Pitt Bacteremia score, which evaluates the severity of acute conditions, averaged 1.29 ± 2.463 . The overall mortality rate in the study population was 18.4%, with specific rates varying by age category as shown in Table 9.^[21] Microbiological cure rates and treatment outcomes with PTZ varied based on the infecting organisms. For instance, 23 patients with *E. coli* infections improved, followed by 13 with *Klebsiella* infections, and 10 with *Pseudomonas* infections. Due to data limitations, we could not isolate the LOS from the start of PTZ therapy,^[19] so we analyzed the total length of stay, including the period before therapy initiation. The observed improvement rate of 90.9% in *Pseudomonas* infections reflects clinical response, not efficacy in the interventional trial sense. No control or comparator groups were included. A recent

retrospective study indicated an increased risk of mortality in individuals receiving broad-spectrum antimicrobials, including PTZ, as initial monotherapy for community-acquired pneumonia, potentially due to inadequate coverage of atypical pathogens. Clinical cure in our study was defined by patient survival upon discharge, normalization of vital signs, white blood cell count, and temperature, along with the absence of additional antibiotic requirements.^[38]

Limitations

In evaluating the outcomes of our study, several potential limitations should be considered. The appropriateness of PTZ use was assessed based on adherence to established criteria. Quality assurance tools, including specific assessment criteria and scoring systems, were employed to determine the appropriateness of PTZ administration. The lack of a comparator group and the absence of inferential analysis for LOS are major limitations. While many clinicians describe acceptable PTZ usage in similar terms, there is not always uniformity in how these practices are defined and applied.

CONCLUSION

This study evaluates the utilization of PTZ in a multispecialty hospital, revealing that 98.8% of prescriptions adhered to established guidelines. Hospital admissions frequently use PTZ to treat respiratory and urinary tract infections due to its high effectiveness in clinical improvement against a wide range of bacterial infections. We assessed patient outcomes using standardized scoring systems, such as the APACHE II score, which revealed a moderately high severity of illness among the patient cohort. However, the overall mortality rate was 18.4%, highlighting the effectiveness of PTZ for critically ill patients. Patients infected with common pathogens such as *E. coli*, *Klebsiella*, and *Pseudomonas* showed significant clinical improvements, including faster recovery and reduced infection severity, with gram-negative bacteria being the most frequently isolated pathogens. The majority of patients experienced a relatively short hospital stay, indicating a prompt therapeutic response to PTZ treatment that facilitated a quick recovery. However, the study identified survivorship bias, potentially skewing the results by primarily calculating the mortality and morbidity severity scores for patients who survived until discharge. The findings emphasize the critical importance of adhering to empirical use guidelines to optimize clinical outcomes and minimize the risk of adverse events such as treatment failure and drug resistance. Further prospective, controlled studies with appropriate statistical modeling and trial registration are essential to validate these outcomes and assess long-term PTZ effectiveness.

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