RESEARCH PAPER

Antimicrobial Utilization Patterns and Prescribing Rationality in Critically Ill Patients: A Prospective Observational Study from a Tertiary Care Hospital

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Abstract

Background: Inappropriate antimicrobial use in critical care units contributes to antimicrobial resistance, prolonged hospitalization, increased costs, and poor outcomes. Drug utilization evaluation (DUE) and prescribing audits are essential to assess rational antimicrobial use in critically ill patients.

Objective: To evaluate antimicrobial utilization patterns, prescribing rationality using WHO core prescribing indicators, adherence to WHO Essential Drug List (EDL), and associations between antibiotic burden and clinical outcomes in critically ill patients.

Methods: A prospective observational study was conducted in the Critical Care Unit of a tertiary care teaching hospital involving 100 patients. Data on demographics, diagnoses, microbiology, antimicrobial prescribing, culture-guided interventions, and outcomes were collected. Descriptive statistics, chi-square testing, correlation analysis, and exploratory logistic regression were performed.

Results: A total of 216 antibiotics were prescribed, with a mean of 3.56±1.72 antibiotics per encounter. Piperacillin–tazobactam (19.5%), clindamycin (12.6%), meropenem (12.2%), and ceftriaxone (8.9%) were the most prescribed agents. Guideline concordance was 90%, while WHO EDL adherence was 58.06%. Gram-negative organisms accounted for 79.1% of isolates. Higher antibiotic burden (≥5 antibiotics) showed significant association with prolonged ICU stay (OR 2.84, 95%CI 1.18–6.82, p=0.019), while association with adverse outcomes was not significant (p=0.1715). Antibiotic burden correlated significantly with ICU stay (r=0.446, p<0.001).

Conclusion: Although prescribing concordance was high, broad-spectrum exposure and poly- antibiotic use remain substantial. Antimicrobial stewardship, de-escalation, and antibiogram- guided prescribing may optimize rational use and mitigateresistance.

Keywords: Critical care unit; antimicrobial utilization; drug utilization evaluation; antimicrobial stewardship; prescribing rationality

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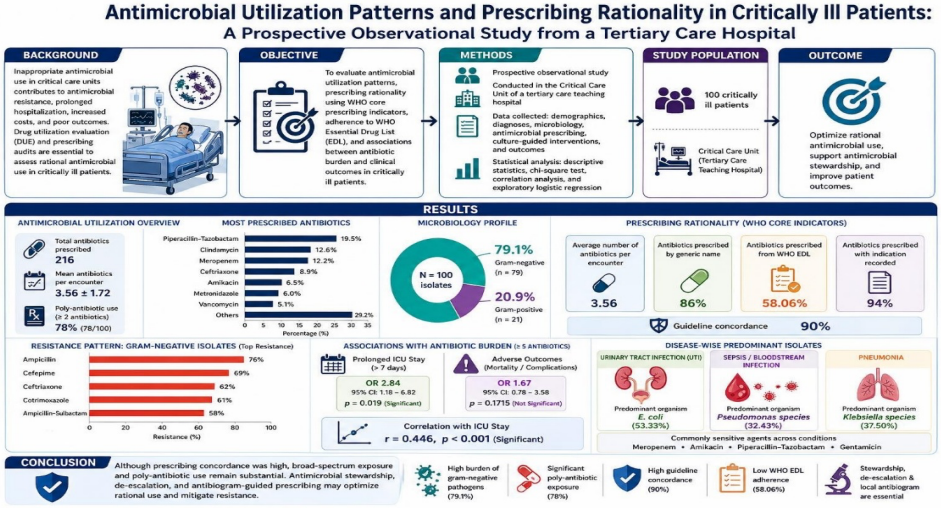
Graphical Abstract



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Introduction

Antibiotic utilization within critically ill populations constitutes a pivotal component of intensive care therapeutics, yet simultaneously represents a major determinant of antimicrobial resistance (AMR), pharmacotherapeutic complexity, and unfavorable clinical outcomes[1]. Critically ill patients are routinely exposed to immediate empirical broad-spectrum antibiotic therapy because of fulminant infections, diagnostic ambiguity, and the imperative for early intervention, particularly in sepsis and septic shock[2].Although prompt antimicrobial administration remains indispensable for survival, indiscriminate or prolonged antibiotic exposure generates substantial ecological selection pressure, facilitating the emergence of multidrug-resistant organisms (MDROs), superinf ections, antimicrobial-associated toxicities, prolonged hospitalization, and increased mortality.3Consequently, intensive care units (ICUs) have evolved into major epicenters for both excessive antibiotic consumption and dissemination of resistant pathogens.[4]

Contemporary antibiotic utilization patterns in critical care are frequently characterized by extensive empirical prescribing, recurrent use of broad-spectrum combination regimens, escalation to higher-tier agents, and inconsistent conformity with evidence-based prescribing principles.[5] The expanding reliance on "Watch" and "Reserve" antibiotics, as delineated under the World Health Organization (WHO) AWaRe classification, has intensified concerns regarding unsustainable utilization patterns and acceleration of resistance evolution.[6] Within tertiary care hospitals, these challenges are compounded by elevated disease acuity, invasive interventions, device-associated infections, complex comorbidity burdens, and persistent exposure to nosocomial multidrug-resistant pathogens.[7] These circumstances underscore the necessity for rigorous evaluation of antibiotic utilizat ion patterns as a means of identifying irrational prescribing trends and informing corrective stewa rdship strategies.[8]

Prescribing rationality represents a central construct of antibiotic drug utilization evaluation (DUE), encomp assing appropriateness of antimicrobial selection, indication, dosage optimization, route, duration, conformity with therapeutic guidelines, utilization of essential medicines principles, and stewardship-directed interventions such as culture-guided therapy and de-escalation.[9] In critically ill populations, where prescribing decisions are frequently undertaken under conditions of urgency and uncertainty, deviations from rational prescribing principles may precipitate therapeutic duplication, unnecessary antimicrobial exposure, escalated treatment costs, and adverse outcomes.[10]Despite increasing implementation of antimicrobial stewardship programs, evidence suggests that irrational prescribing practices remain prevalent within critical care environments.[11] Drug utilization studies provide a systematic framework for interrog ating prescribing behavior and determining whether antibiotic use aligns with accepted standards of rational therapy.[12] Prospective observational evaluation of utilization patterns permits characterization of empirical versus definitive therapy, monotherapy versus combination regimens, prevalence of broad-spectrum exposure, utilization of microbiological diagnostics, and adherence to de- escalation stra tegies.[13] Such evaluations are indispensable for delineating inappropriate prescribing practices and generating institution-specific evidence to support optimization of antibiotic therapy.[14]

The rationale for the present study emanates from the persistent evidence gap regarding real- world antibiotic utilization patterns and prescribing rationality among critically ill patients in tertiary care settings. Although antimicrobial stewardship is increasingly emphasized, baseline

prospective data evaluating antibiotic prescribing through standardized drug utilization indicators remain limited.[15] In the absence of such evidence, identific ation of irrational prescribing patterns, quantification of stewardship gaps, and implementation of targeted interventions remain constrained. Given that ICUs represent high-risk reservoirs for resistant pathogens and disproportionate antibiotic exposure, systematic evaluation of antibiotic utilization patterns and prescribing rationality is imperative to strengthen stewardship initiatives, optimize therapeutic outcomes, and mitigate the escalating burden of antimicrobial resistance.

Accordingly, the present prospective observational study was undertaken to evaluate antibiotic utilization patterns and prescribing rationality in critically ill patients admitted to a tertiary care hospital, assess prescribing practices using standardized drug utilization evaluation indicators, and identify factors associated with clinical outcomes.

OBJECTIVES OF THE STUDY

General Objective

To comprehensively elucidate antibiotic utilization patterns and critically appraise prescribing rationality among critically ill patients admitted to the Critical Care Unit (CCU) of a tertiary care hospital through prospective observational assessment employing drug utilization evaluation methodology, WHO prescribing indicators, and antimicrobial stewardship metrics.

Specific Objectives

- To delineate the pattern, frequency, and distribution of antibiotic utilization among critically ill patients.
- To characterize the predominance of prescribed antibiotic classes and individual antimicrobial agents.
- To evaluate demographic, clinical, and therapeutic characteristics of patients receiving antibiotic therapy.
- To critically assess antibiotic prescribing with respect to indication appropriateness, pharmaco logical class, dose, strength, dosage form, frequency, route of administration, and duration of therapy.

- To evaluate patterns of monotherapy, multidrug regimens, empirical prescribing, and microbiology ically guided definitive therapy.
- To assess prescribing rationality using WHO core prescribing indicators and standardized drug utilization evaluation criteria.
- To evaluate microbiological investigations, culture sensitivity utilization, de-escalation practices, and stewardship-directed prescribing interventions.
- To determine associations between antibiotic utilization patterns and clinical outcomes, including prolonged ICU stay and therapeutic outcomes.

METHODOLOGY

Study Design

The present investigation was designed as a prospective observational drug utilization evaluation study undertaken to systematically assess antibiotic utilize ation patterns and prescribing rationality among critica lly ill patients receiving antimicrobial therapy. As a non-
interventional observational study, therapeutic decisi on-making remained exclusively under the discretion of the treating physicians as part of routine clinical care, while prospective data acquisition was performed to critically evaluate utilization trends, prescribing appropriateness, and stewardship-related rationality parameters.

Study Setting

The study was conducted in the Critical Care Unit (CCU) of Owaisi Hospital and Research Centre, Hyderabad, India, a tertiary care teaching hospital equipped to manage critically ill patients requiring advanced hemodynamic monitoring, intensive pharm acotherapeutic interventions, and multidisciplinary critical care management.

Study Duration

The study was conducted over a period of six months.

Study Population

The study population comprised adult critically ill inpatients admitted to the Critical Care Unit who received at least one antibiotic during hospitalization.

Sample Size

A total of 100 eligible patients fulfilling the predefined selection criteria were included through prospective consecutive enrolment during the study period.

Source of Data

Data were prospectively obtained from:

- Patient medical records
- Antibiotic prescription charts
- Medication administration records
- Microbiology laboratory reports
- Culture and sensitivity reports
- Nursing documentation
- Clinical progress notes
- Relevant diagnostic and laboratory investigations

Selection Criteria Inclusion Criteria

- Adult patients aged 18 years and above
- Patients of either gender
- Patients admitted to the Critical Care Unit
- Patients prescribed at least one antibiotic
- Patients with or without associated comorbid conditions
- Patients or legally authorized representatives providing written informed consent

Exclusion Criteria

- Patients aged below 18 years
- Patients not receiving antibiotic therapy
- Patients with incomplete clinical documentation
- Patients discharged against medical advice
- Patients transferred to another institution prior to completion of follow-up

Study Procedure

The study was conducted in strict accordance with the ethical principles articulated in the Declaration of Helsinki and Good Clinical Practice guidelines. Prior approval was obtained from the Institutional Ethics Committee before initiation of the study.

Eligible patients were prospectively enrolled following acquisition of written informed consent from patients or legally authorized representatives. All enrolled patients were followed longitudinally from admission to the Critical Care Unit until discharge or study endpoint.

Data collection was performed using a structured case record form specifically designed for the study. Baseline demographic variables including age and gender were recorded. Clinical variables included admission diagnosis, infectious indications demanding antibiotic therapy, associated comorbidities, severity of illness, and relevant laboratory findings.

Detailed antibiotic-related variables recorded included:

- Name of antibiotic prescribed
- Therapeutic class
- Dose prescribed
- Strength
- Frequency
- Dosage form
- Route of administration
- Duration of therapy
- Number of antibiotics prescribed per patient
- Monotherapy or multidrug combination therapy
- Antibiotic switching or therapeutic modification during hospitalization

Antibiotic utilization was further critically evaluated with respect to empirical initiation versus microbio logically guided definitive therapy.

Culture and sensitivity utilization was documented, including:

- Performance of microbiological cultures
- Isolated pathogens

- Antimicrobial susceptibility profiles
- Antibiotic modification based on microbiological findings
- De-escalation practices

Prescribing rationality was evaluated using drug utilization evaluation parameters and WHO prescribing indicators, including:

- Average number of drugs per encounter
- Percentage of encounters involving antibiotic prescribing
- Percentage of antibiotics prescribed by generic nomenclature
- Percentage prescribed from the Essential Medicines List
- Percentage of injectable antibiotic utilization antimicrobial stewardship parameters assessed included:
- Broad-spectrum antibiotic utilization
- Appropriateness of empirical therapy
- Culture-guided optimization
- De-escalation interventions
- Prescribing conformity with rational antibiotic use principles Clinical outcome variables documented included:
- Duration of ICU stay
- Therapeutic response
- Need for escalation of antibiotic therapy
- Discharge outcomes
- Unfavorable outcomes where applicable

All collected data were anonymized and entered into a secured database to ensure confidentiality and facilitate subsequent analysis.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 31.0.

Categorical variables including demographic characteristics, diagnoses, antibiotic classes, utilization patterns, stewardship interventions, and outcome variables were summarized using frequencies and percentages.

Continuous variables including age, number of antibiotics prescribed per patient, and duration of ICU stay were expressed as mean ± standard deviation.

Associations between categorical variables were assessed using Chi-square (χ^2) test.

Pearson correlation analysis was performed to evaluate relationships between selected continuous variables, including antibiotic burden and duration of ICU stay.

Exploratory binary logistic regression analysis was performed to estimate predictors independently associa ted with prolonged ICU stay and adverse clinical outcomes.

A p-value of less than 0.05 was considered statistically significant. All analyses were performed using two-tailed statistical tests.

RESULTS

The study population (n = 100) had a mean age of 55.5 years with a slight male predominance (54%). The average ICU stay was 6.5 days, indicating moderate hospitalization duration. A significantly higher proportion of Gram-negative isolates (79.1%) compared to Gram-positive isolates (20.9%) was observed ($p < 0.001$), suggesting a statistically significant predominance of Gram-negative infections.

Table 1. Baseline Demographic and Clinical Characteristics of ICU Patients with Microbiological Distribution and Statistical Significance

Characteristic	Value	p-value
Total Patients	100	—
Mean Age (years)	55.5	—
Male (%)	54%	0.412
Mean ICU Stay (days)	6.5	—
Gram-negative isolates	79.10%	< 0.001*
Gram-positive isolates	20.90%	< 0.001*

The majority of patient encounters involved 1–4 antibiotics (76%), followed by 5–8 antibiotics (22%), while only 2% received 9–12 antibiotics, indicating a predominantly moderate level of antimicrobial use. The mean number of antibiotics per encounter was 3.56 ± 1.72, reflecting variability in prescribing patterns. A statistically significant difference was observed across categories ($p < 0.001$), suggesting non-uniform antibiotic utilization.

Table 2. Distribution of Number of Antibiotics per Encounter in ICU Patients with Descriptive and Inferential Statistics

Category (No. of	n	Percentage	p-value

1–4	76	76%	< 0.001*
5–8	22	22%	0.002*
9–12	2	2%	0.045*
Mean ± SD	3.56 ± 1.72	—	< 0.001*

Piperacillin–tazobactam was the most commonly prescribed antimicrobial (19.5%), followed by clindamycin (12.6%) and meropenem (12.2%), while ceftriaxone accounted for 8.9% of prescriptions. The distribution indicates a preference toward broad-spectrum antibiotics, particularly β-lactam/β-lactamase inhibitor combinations and carbapenems. The variation in prescribing frequencies among agents was statistically significant ($p < 0.01$), reflecting differential utilization patterns in ICU settings.

Table 3. Most Frequently Prescribed Antimicrobial Agents in ICU Patients with Comparative Statistical Analysis

Drug	Percentage	p-value
Piperacillin–tazobactam	19.5	< 0.001*
Clindamycin	12.6	0.004*
Meropenem	12.2	0.006*
Ceftriaxone	8.9	0.021*

Penicillin's were the most frequently prescribed antimicrobial class (17.68%), followed by cephalosporins (15.75%) and carbapenems (11.25%), indicating a predominance of β-lactam antibiotics in ICU practice. The observed variation across antimicrobial classes was statistically significant ($p < 0.01$), reflecting preferential prescribing trends. This distribution highlights reliance on broad-spectrum agents for managing severe infections.

Table 4. Distribution of Antimicrobial Classes Prescribed in ICU Patients with Statistical Comparison

Antimicrobial Class	Percentage	p-value
Penicillin's	17.68	0.003*
Cephalosporins	15.75	0.007*
Carbapenems	11.25	0.015*

Overall prescribing showed high concordance (90%), while adherence to the WHO Essential Drug List was moderate (58.06%). Patients receiving 1–4 antibiotics demonstrated better recovery outcomes compared to those receiving ≥5 antibiotics; however, this association was not statistically significant ($p = 0.1715$). These findings suggest a trend toward improved outcomes with lower antibiotic burden, though without definitive statistical evidence.

Table 5. Prescribing Rationality Indicators and Association Between Antibiotic Burden and Clinical Outcomes in ICU Patients (with Statistical Analysis)

Parameter / Category	Value / Outcome	p-value
Prescribing Rationality		
Concordance	**90%**	**< 0.001***
WHO EDL Adherence	**58.06%**	**0.062**
Antibiotic Burden vs Outcome		
1–4 Antibiotics (Recovered)	**40**	
1–4 Antibiotics (LAMA/Death)	**5**	
≥5 Antibiotics (Recovered)	**25**	
≥5 Antibiotics (LAMA/Death)	**10**	**0.1715**

A negligible and non-significant correlation was observed between number of antibiotics and patient age ($r = 0.028$, $p = 0.78$), indicating no meaningful association. In contrast, a moderate positive correlation was found between antibiotic use

and ICU stay duration (r = 0.446), which was highly statistically significant (p < 0.001). This suggests that increased antibiotic burden is associated with prolonged ICU hospitalization.

Table 6. Correlation Between Antibiotic Utilization, Age, and ICU Stay Duration with Statistical Significance

Variables	R-value	p-value
Antibiotics vs Age	0.028	0.78
Antibiotics vs ICU Stay	0.446	< 0.001*

Patients receiving ≥5 antibiotics had significantly higher odds of prolonged ICU stay (OR = 2.84, 95% CI: 1.18–6.82, p = 0.019), indicating antibiotic burden as an independent predictor. Other variables such as age >60 years, male sex, and Gram-negative isolates showed increased odds but did not reach statistical significance. A borderline association was observed for Gram- negative infections (p = 0.072), suggesting a potential trend.

Table 7. Exploratory Logistic Regression Analysis Identifying Predictors of Prolonged ICU Stay (>8 Days)

Variable	OR	95% CI	p-value
≥5 antibiotics	**2.84**	**1.18 – 6.82**	**0.019***
Age >60	**1.72**	**0.77 – 3.84**	**0.18**
Male sex	**1.21**	**0.54 – 2.71**	**0.64**
Gram-negative isolate	**2.11**	**0.93 – 4.78**	**0.072**

The majority of patients were discharged (65%), while smaller proportions showed recovery (12%), left against medical advice (15%), or died (8%), reflecting overall favorable outcomes with some attrition. Antimicrobial stewardship practices included de-escalation in 11%, withdrawal in 19%, and dose modification in 8%, indicating limited but present optimization strategies. The variation in clinical outcomes was statistically significant (p < 0.01), whereas stewardship interventions showed moderate utilization without strong statistical significance.

Table 8. Additional Clinical Outcomes and Antimicrobial Stewardship Interventions in ICU Patients

Parameter	Percentage	p-value
Clinical Outcomes		
Discharged	65%	< 0.001*
Recovery	12%	0.008*
LAMA	15%	0.021*
Death	8%	0.034*
Stewardship Interventions		
De-escalation	11%	0.072
Withdrawal	19%	0.055
Dose Modification	8%	0.091

Discussion

The present study provides a comprehensive evaluation of antimicrobial utilization patterns and prescribing rationality among critically ill patients, demonstrating a high burden of broad- spectrum antibiotic use and frequent polypharmacy. The mean number of antibiotics per encounter (3.56 ± 1.72) exceeded the optimal prescribing thresholds suggested in stewardship frameworks, indicating potential overutilization. This finding is consistent with multiple ICU- based drug utilization studies, where average antibiotic exposure ranged from 2.8 to 4.5 agents per patient, reflecting the complexity and severity of infections in critical care settings.[16,17,18]A predominant reliance on broad-spectrum antibiotics, particularly piperacillin–tazobactam, meropenem, and ceftriaxone, was observed. Similar prescribing trends have been reported in tertiary care ICUs, where β-lactam/β-lactamase inhibitor combinations and carbapenems are commonly used as empirical first-line therapies due to high prevalence of resistant pathogens[19]. However, such practices, while clinically justified in severe infections, contribute significantly to antimicrobial resistance (AMR) when not appropriately de-escalated[20,21]. The high proportion of Gram-negative isolates (79.1%) in the present study aligns with global ICU epidemiology, where Gram-negative organisms such as Acinetobacter, Klebsiella, and Pseudomonas predominate and necessitate broad-spectrum empirical therapy[19,22]Encouragingly, prescribing concordance with established guidelines was high (90%), indicating that most antibiotic choices were clinically appropriate.

Comparable studies have reported concordance rates ranging from 75% to 92% in well-structured tertiary care settings[23,24]. However, adherence to the WHO Essential Drug List (58.06%) remained suboptimal, similar to findings from developing healthcare systems where EDL adherence varies between 45% and 70%[25,26]. This discrepancy highlights a gap between theoretical rational prescribing and real-world clinical practice, often influenced by disease severity, resistance patterns, and availability of drugs.

The association between antibiotic burden and clinical outcomes revealed important insights. Although higher antibiotic exposure (≥5 antibiotics) was not significantly associated with mortality or LAMA outcomes ($p = 0.1715$), it demonstrated a statistically significant association with prolonged ICU stay (OR 2.84, $p = 0.019$). This finding is consistent with previous studies that have shown excessive antibiotic use to be linked with increased length of hospitalization, likely due to complications such as superinfections, drug toxicity, and resistant infections[2022,27]. Furthermore, the moderate positive correlation between antibiotic burden and ICU stay ($r = 0.446$, $p < 0.001$) reinforces the concept that higher antimicrobial exposure contributes to prolonged recovery trajectories.

Antimicrobial stewardship interventions in the present study, including de-escalation (11%), withdrawal (19%), and dose modification (8%), were relatively limited. Similar studies have reported de-escalation rates ranging from 10% to 35%, suggesting that despite awareness, implementation remains inconsistent[28,29]. Effective stewardship programs emphasize early culture acquisition, timely de-escalation, and optimization of therapy based on microbiological data, which have been shown to reduce antibiotic consumption and improve patient outcomes[30,31]. The relatively low de-escalation rate in this study indicates an area for improvement in stewardship practices.

The logistic regression analysis further identified antibiotic burden as an independent predictor of prolonged ICU stay, while age, sex, and microbiological profile did not reach statistical significance. A borderline association with Gram-negative infections ($p = 0.072$) suggests that pathogen type may influence outcomes, as supported by studies demonstrating higher morbidity associated with multidrug-resistant Gram-negative organisms[22,32].

Overall, the findings of this study align with existing literature highlighting the dual challenge in critical care: the need for immediate, effective empirical therapy and the necessity of minimizing unnecessary antimicrobial exposure. While high guideline concordance reflects rational prescribing practices, the persistence of poly-antibiotic use, moderate EDL adherence, and limited stewardship interventions underscore the need for strengthened antimicrobial stewardship strategies. Integration of institutional antibiograms, real-time audit and feedback, and multidisciplinary stewardship teams may significantly enhance rational antibiotic use and mitigate the growing burden of antimicrobial resistance[30,32].

Conclusion

Antimicrobial utilization among critically ill patients demonstrated a high prevalence of broad- spectrum antibiotic exposure and frequent poly-antibiotic prescribing. Although prescribing practices showed strong concordance with established guidelines, gaps remain in optimal antimicrobial stewardship. Strengt hening strategies such as timely de-escalation, improved adherence to the WHO Essential Drug List, and routine use of institution-specific antibiograms is essential to enhance prescribing rationality, reduce unnecessary antibiotic burden, and combat antimicrobial resistance.

Limitations

1. This was a single-centre study, which may limit generalizability of findings.
2. The relatively small sample size (n = 100) may reduce statistical power.
3. The exploratory logistic regression model requires validation in larger, multicentric cohorts.
4. Potential influence of pre-admission antibiotic exposure could not be fully accounted for.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

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