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Original Research Article

Evaluating the influence of antibiotic resistance on the effectiveness of treatment of pediatric sepsis

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ABSTRACT

Background: Pediatric sepsis remains a critical contributor to morbidity and mortality globally, especially in low- and middle-income countries. The increasing burden of antimicrobial resistance (AMR) poses significant challenges to its effective treatment. This study evaluated the influence of antibiotic resistance on the management outcomes of pediatric sepsis Telangana, Indian. Aim was to assess healthcare professionals' perspectives on the impact of antibiotic resistance on the treatment of pediatric sepsis, focusing on prescribing practices, diagnostic patterns, and clinical outcomes.

Methods: A cross-sectional questionnaire-based survey was conducted among 302 healthcare professionals in Telangana. The structured survey included five domains: demographics, awareness of AMR, antibiotic prescribing behavior, treatment outcomes, and stewardship recommendations. Data were collected through online and paper-based formats and analyzed using SPSS 26.0, employing descriptive statistics, Chi-square tests, t-tests, ANOVA, and logistic regression models.

Results: Among respondents, 91.4% encountered resistant sepsis cases, and 81.5% perceived AMR as a major treatment barrier. Only 34.7% routinely used blood cultures before initiating antibiotics. Most relied on empirical therapy (88.2%), with third-generation cephalosporins being the first line (64.6%), and 66.9% escalated to carbapenems. Prolonged hospital stays (72.8%), and increased treatment failure (58.9%) was significantly associated with resistant infections. Rural settings and lack of rapid diagnostics were major contributors to treatment inefficacy.

Conclusions: Antibiotic resistance significantly hampers pediatric sepsis management in Telangana. There is a critical need for enhanced diagnostic capacity, rational antibiotic use, and robust antimicrobial stewardship. Policy efforts must address healthcare inequities to curb the growing threat of AMR and improve pediatric outcomes.

Keywords: Antibiotic resistance, Antimicrobial stewardship, Empirical therapy, India, Healthcare disparities, Pediatric sepsis

INTRODUCTION

Children continue to face a considerable risk of morbidity and death due to sepsis, characterized as an infection accompanied by a dysregulated host response leading to life-threatening organ failure.[1] For the last two decades, the definition of sepsis in adults and children has been "systemic inflammatory response syndrome (SIRS) induced by infection".[2] However, this classification has long been criticized for including milder disorders like influenza virus infection without any organ malfunction, which is overly wide.[3] Worldwide, sepsis accounts for 19% of all fatalities, with children under the age of five having the highest age-specific incidence.[4] In the United States, pediatric sepsis accounted for 2.8% of inpatients and 0.7% of total hospital interactions.[5] According to epidemiologic research utilizing clinical data, pediatric sepsis accounts for up to 8% of all pediatric intensive care unit (PICU) admissions and is a contributing factor in 1 in 4 PICU deaths.[6,7] In pediatrics, antibiotics are the most often administered medications.[8] Antibiotics have been used extensively to treat infections ever since they were discovered more than 90 years ago. Every time a new class of medicines is introduced, novel mechanisms of bacterial resistance to antimicrobials are described.[9] Regretfully, the rate of resistance is continuously rising, and the process of creating new medications is drawn out and challenging.[10] According to estimates, drug-resistant diseases would claim the lives of nearly 10 million people annually in 2050 if antibiotics are not used wisely.[11] When it comes to treating sepsis, antibiotics are essential. One of the primary objectives of mortality prevention is the prompt prescription of antimicrobials.[12] The best time to administer antibiotics is during the first hour after medical aid, particularly for individuals experiencing shock and end-organ dysfunction.[13]

Antibiotics: step by step

Step 1: select the finest medication. Step 2: factors pertaining to medication resistance and antibiotic selection. Step 3: antibiotic prescription timing. Step 4: administration of antimicrobials. Step 5: de-escalation and definitive therapy

De-escalation of antibiotics

The pathogen was found, the treatment was de-escalated, and the patient is getting well. Determining whether to discontinue treatment and when to proceed to oral therapy is the next stage.[14] All infections, except for endocarditis, primary bloodstream infections, and infections of the central nervous system, can be treated orally if the patient is stable, able to take oral medications and food, and shows clinical and laboratory improvement.[15] While biomarkers like procalcitonin and c-reactive protein can aid in the intravenous to oral transition, they are not helpful in the diagnosis of sepsis or septic shock.[16]

Widespread immunization against *Streptococcus pneumoniae*, *Haemophilus influenzae* type B, and *Neisseria meningitidis* significantly reduced the risk of meningitis and other invasive bacterial infections in infants. There is a significant chance that vaccine-preventable diseases will resurface if vaccination coverage declines because of shortages, vaccine hesitancy, anti-vaccine campaigns, or the COVID-19 pandemic.[17]

Since the occurrence of antimicrobial resistance is increasing and its consequences have significant implications on the health outcomes of children, especially in areas with low and middle income, such as Telangana, it is essential to determine the effects that antibiotic resistance has on clinical care and patient outcomes in pediatric sepsis. The objective of the present study was to evaluate the influence of antibiotic resistance on the effectiveness of pediatric sepsis treatment by analyzing healthcare professionals' perspectives regarding antibiotic prescribing practices, diagnostic utilization, and clinical outcomes across urban and rural healthcare settings in Telangana, India.

Review of literature

The first global estimates of sepsis incidence and death by age, sex, and location were released in 2017 by the global burden of disease study group. Using hospital administrative data, the team also modelled sepsis-related case-fatality data to determine mortality predictions. According to these findings, there were 20.3 million sepsis event cases in children under the age of five worldwide, 4.9 million in children and adolescents between the ages of five and nineteen, and 23.7 million in adults aged twenty years and over. Lower respiratory tract infections, newborn disorders, and diarrheal illnesses were the most frequent causes of sepsis in children under the age of five.[18] Neonatal 72 hours or younger are considered to have early-onset sepsis (EOS), and those 4 to 28 days are considered to have late-onset sepsis.[19] Typically, early-onset sepsis and group B are caused by an infection acquired during pregnancy or delivery. *Streptococcus* (GBS) is the most prevalent pathogen causing EOS in high-income countries, "while *Staphylococcus aureus*, *Klebsiella species*, and *Escherichia coli* are the most common causes in low- and middle-income countries.[20] The most prevalent pathogens linked to late-onset sepsis in low- and middle-income nations are gram-negative bacteria, including *E. coli*, *Klebsiella pneumoniae*, *Acinetobacter spp.*, *Pseudomonas aeruginosa*, and *S. aureus*, which are caused by hospital or community infections".[21]

The prevalence and incidence of MDR sepsis have been linked in numerous studies to factors such as age, a history of stroke, hospitalization within the previous ninety days, and infection with MDR organisms (MDRO). These findings could be explained by the increasing prevalence of MDROs in hospital wards brought on by the extensive use of antibiotics and the transfer of infection between patients and medical personnel.[22] With ESBL-producing *E. coli* and *Klebsiella pneumoniae* making up 35% of all *E. coli* and *K. pneumoniae* isolates, ESBL-producing *Enterobacteriaceae* seem to be the most prevalent (9.7%) of all MDROs.[23] Although the percentage of *Enterobacteriaceae* that produce ESBL differs by country, it is increasing across Europe, with Italy having one of the highest prevalences of *Enterobacteriaceae* that produce ESBL.[24] In children undergoing allogeneic hematopoietic stem cell transplantation (HSCT) or antineoplastic treatment, infections are significant side effects. Since the introduction of empirical antibiotic treatment employing an aminoglycoside and an anti-pseudomonal beta-lactam in febrile neutropenic cancer patients, mortality has significantly decreased.[25] For the treatment of febrile neutropenia in pediatric cancer patients, monotherapy with beta-lactams active against Gram-negatives (including *P. aeruginosa*) is currently recommended at institutions with low resistance rates in Gram-negative isolates, in accordance with the findings of a recent meta-analysis.[26,27] This strategy, however, necessitates rigorous epidemiologic monitoring and ongoing reassessment of empirical antibiotic regimens considering changing institutional microbial resistance patterns.[28] Despite regional and institution-level variations, antibiotic resistance is a global issue. Children undergoing antineoplastic chemotherapy or allogeneic hematopoietic stem cell transplantation are similarly impacted by this phenomenon.[29] They are more likely to experience a complex clinical course because of getting an insufficient initial empirical treatment for febrile neutropenia.[30,31]

METHODS

The study applied a cross-sectional study design which consisted of a questionnaire-based survey. Data collection was conducted from September 2023 to October 2024 in MGM (Mahatma Gandhi Memorial) hospital, Warangal, Telangana. The primary focus was to determine the perceived impact of antibiotic resistance on the treatment outcomes of pediatric sepsis as seen and evaluated by health professionals. The study was carried out from Telangana, India, which is known for its large pediatric population and the problem of the presence of the lots of infectious diseases. Fourth-year medical students or physicians during their internal medicine rotations were given the opportunity to participate in the study. All subspecialty attendings and nurse practitioners who serve on the medical ward teams also took part in the study. The around-the-clock model was employed across all the teaching services to lessen the effect of the attending physicians' high work intensity on their willingness to involve students. The healthcare professionals from the rest of the hospital wards and from the ambulatory settings did not take part in the research. The research team had all the power in terms of decision-making.

A structured questionnaire was adopted for this purpose from a variety of scholarly articles and clinical guidelines on pediatric sepsis and antimicrobial resistance. The survey containing both close-ended and open-ended questions was classified into five domains, namely demographic and professional data, antibiotic resistance awareness, prescribing practices, treatment outcomes of resistant infections as seen by the respondents, and suggestions on how to implement a successful antibiotic stewardship program. The various aspects of the questionnaire were synchronized by a group of pediatrics, microbiology, and epidemiology specialists to guarantee soundness, comprehensiveness, and relevance of the issues covered.

Survey testing

The questionnaire was pilot-tested by having 302 healthcare professionals from urban and rural hospitals using the sample-setting approach which was not used in the final survey. This also paved the way for better choice of words, more detailed descriptions, and organized structure of the questions. The internal consistency was also checked.

Survey administration

Survey administration was conducted from the online (Google forms) and paper questionnaires, that participants chose their preferred method of administration. A stratified sampling technique was used to select urban-rural areas, the private and public hospitals, as well as varied physician levels of clinical experience. Participants were asked for their opinions on the survey, and necessary proof of approval from responsible executives was obtained. Additionally, the patients' right to privacy and the right to remain anonymous were guaranteed.

Statistical analysis

First, all the quantitative data were thinly divided and entered the Microsoft Excel software and analyzed with the application of IBM SPSS version 26.0 software. Descriptive statistics like means, standard deviations, frequencies, and percentages were used to present the participant demographics and survey responses. The connection between the categorical variables, for instance, the level of clinical experience and perceptions of antibiotic resistance impact through the Chi-square test of independence was investigated. The independent sample t-tests or one-way ANOVA tests were utilized as per the right, depending on the number of comparative groups and the distribution of the data, for continuous data. The normality of continuous data was confirmed by means of the Shapiro-Wilk test. Furthermore, a survey of the medical and health care professional regression was conducted to find out the major predictors of perceived inefficacy of treatment because of antibiotic resistance that were not dependent and were in turn the cause of potential confounders such as patients' age, number of years of work experience, and type of setting to be considered. All the tests were two-tailed and a p value less than 0.05 was considered significant from a statistical point of view.

RESULTS

The demographic analysis done by the contribution of 302 participants which were surveyed by healthcare professionals across Telangana. As shown above Telangana (rural) shows the majority with 162 (53.6%), while Telangana (urban) with 140 (46.4%).

Table 1: Demographic characteristics of participants (n=302).

Variables	Frequency	Percentage
State		
Telangana (rural)	162	53.6
Telangana (urban)	140	46.4
Gender		
Males	176	58.3
Females	126	41.7
Age group		
Newborn (0-30 days)	61	20
Infants (1-11 months)	91	30
Toddler (1-5 years)	69	23
Schoolchild (6-11 years)	54	18
Adolescent (12-18 years)	27	16
Profession		
Paediatricians	146	48.3
General practitioners	74	24.5
Intensivists	52	17.2
Resident doctors	30	10.0
Years of clinical experience		
<5 years	113	37.4
5-10 years	108	35.8
>10 years	81	26.8

Males and females constituted 176 (58.3%), 126 (41.7%) respectively. While the predominant age group was toddlers with 69 (23%) followed by newborn with 61 (20%), schoolchild with 54 (18%) and adolescent 27 (9%). Pediatricians were the largest professional group with 146 (48.3%), with general practitioners, intensivists, resident doctors encompassed the rest. Clinical experience varied, with 113 (37.4%) having less than 5 years of experience, 5-10 years with 108 (35.8%) experience and more than 10 years with 81 (26.8%). The participants mostly worked in the urban area 206 (68.2%), while in rural area 96 (31.8%) (Table 1).

The interpretation of the awareness and perception data presents a strong level of recognition among healthcare workers of the increasing issue of antibiotic resistance in pediatric sepsis. A dramatic 91.4% of the respondents experienced having cases of resistant sepsis, showing that multidrug-resistant (MDR) infections are an everyday clinical experience. Additionally, 74.5% felt that MDR cases are increasing, demonstrating a common recognition of this increasing issue. Interestingly, 81.5% of them felt that antibiotic resistance was a significant hindrance to successful treatment, which supports the threat of degraded therapeutic effectiveness. Though both states had comparable awareness, Telangana (urban)-based physicians (82.3%) were slightly more probable than their Telangana (rural) peers (78.4%) to consider resistance a primary barrier. These results indicate that though clinicians from different regions are aware of trends in resistance, specific interventions and training can further improve preparedness and response measures to this public health hazard (Table 2).

Table 2: Awareness and perception regarding antibiotic resistance.

Perception variables	Yes	%
Encountered resistant sepsis cases	276	91.4
Believe MDR cases are rising	225	74.5
Perceive resistance as a major barrier to effective treatment	246	81.5
Telangana (rural) doctors perceive resistance as a major barrier	115	82.3
Telangana (urban) doctors perceiving resistance as a major barrier	127	78.4

Table 3: Antibiotic prescribing and diagnostic practices.

Practice variables	Frequency	Percentage
Routine blood culture before antibiotics	105	34.7
Use of empirical antibiotic therapy	266	88.2
Initial use of third-generation cephalosporins	195	64.6
Escalation to carbapenems due to resistance	202	66.9

The understanding of antibiotic prescription and diagnostic practice shows a high degree of empiricism in treatment strategies among health practitioners responsible for pediatric sepsis. Most (88.2%) indicated empirical antibiotic treatment, usually started without absolute microbiological proof, as only 34.7% practiced blood cultures before initiating antibiotics on a regular basis. This behavior could result in the misuse of antibiotics and increased resistance. Third-generation cephalosporins were the most popular initial treatment (64.6%), indicating a bias towards broad-spectrum agents. Interestingly, because of increasing resistance, 66.9% of the respondents indicated that they needed to switch over to carbapenems, a last-resort class of drugs.

These trends underscore diagnostic support gaps and the need to institute culture-based prescribing, enhanced stewardship procedures, and greater access to rapid diagnostic technologies to limit undue use of broad-spectrum antimicrobials and control resistance more efficiently (Table 3).

The examination of the clinical outcomes table illustrates the significant influence of antibiotic resistance on the management of pediatric sepsis. Most of the people who answered (72.8%) said that people with resistant infections had to stay in the hospital longer, which shows that resistance is causing longer hospital stays and more health problems. Moreover, 58.9% acknowledged a heightened rate of treatment failure, underscoring the clinical ramifications of diminished antibiotic efficacy. There is a statistically significant difference (p=0.03) in the frequency of ICU stays between Telangana (rural) and Telangana (urban), which suggests that there are differences between regions. This could be due to differences in healthcare facilities, the availability of second-line therapy, or the ability to make diagnoses. Overall, these results suggest that antibiotic resistance not only affects the success of immediate treatment but also results in more severe illness trajectories and expensive care. Consequently, urgent measures in antibiotic stewardship and health system enhancement are necessary (Table 4).

Table 4: Observed clinical outcomes in resistant cases.

Outcome Observed	Yes	%
Prolonged hospital stays	220	72.8
Increased treatment failure	178	58.9
Higher ICU stays in Telangana (rural) versus Telangana (urban)	-	p=0.03

This crosstabulation shows the use of empirical antibiotic therapy among different professions. Pediatricians use empirical Ab therapy more than other (140/146). While general practitioners were (63/74), intensivists (45/52) and resident doctors were the least among all with the score of 18/30. Thus, among 302 (including yes or no) professionals, 266 were using empirical Ab therapy (Table 5).

Table 5: Association between profession and use of empirical antibiotic therapy.

Crosstabulation	Use of empirical antibiotic therapy		
Profession	**Yes**	**No**	**Total**
Paediatricians	140	6	146
general practitioners	63	11	74
intensivists	45	7	52
resident doctors	18	12	30
Total	266	36	302

Table 6 chi-square tests demonstrate that the categorical variables under investigation are statistically related. With three degrees of freedom, the Pearson chi-square was 42.613, and the p value was 0.000, well below the typical threshold of significance of 0.05. The null hypothesis that there is no association may be rejected since this data demonstrated that the variables were strongly connected. The same hypothesis was tested using the likelihood ratio test, which produced a p value of 0.000 and a value of 45.890 with the same degrees of freedom. With one degree of freedom and a p value of 0.000, the linear-by-linear association test produced a score of 18.437, suggesting a substantial linear trend that is particularly pertinent to ordinal variables. 302 genuine instances were examined, which was a sufficient sample size to ensure the accuracy of the findings. All things considered, the findings indicate a robust and statistically significant relationship between the variables under investigation.

Table 6: Chi-square tests.

Test	Value	df	Asymp. Sig. (2-sided)
pearson chi-square	42.613	3	0.000**
likelihood ratio	45.890	3	0.000
linear-by-linear association	18.437	1	0.000
No. of valid cases	302		

**statistically significant

Table 7: Group statistics.

State	N	Mean	SD	Std. error mean
Telangana (rural)	162	4.18	0.76	0.060
Telangana (urban)	140	4.36	0.61	0.052

This group of statistics shows how different states responded: Telangana. Telangana (rural) has a mean score of 4.18 and a standard deviation of 0.76. With a standard deviation of 0.61 and a mean score of 4.36, Telangana (urban) has a somewhat higher score. This means that, on average, people from Telangana (urban) gave the variable of interest (like satisfaction, agreement, or something else being measured) a better score than people from Telangana (rural). The standard error of the mean for Telangana (rural) was 0.060, and for Telangana (Urban) it was 0.052. This shows that the sample means are good representations of the population means because the values are not too high. The data appears sufficiently robust for comparison, with 162 observations for Telangana (rural) and 140 observations for Telangana (urban). Overall, the findings indicate a small but possibly clinically significant difference between the two states in their mean responses, which might be worth further statistical comparison (e.g., an independent samples t-test) to see if the difference is statistically significant.

Table 7 compares the group statistics for Telangana (rural) and Telangana (urban). Telangana (rural) has a mean of 4.18 and a standard deviation of 0.76. Telangana (urban) has a mean of 4.36 and a standard deviation of 0.61. This means that, on average, people from Telangana (urban) gave the variable in question (like satisfaction, agreement, or another factor measured) a higher score than people from Telangana (rural). The average standard error was 0.060 for Telangana (rural) and 0.052 for Telangana (urban). This means that sample means can be used to estimate population means because the values are relatively low. The sample sizes are 162 for Telangana (rural) and 140 for Telangana (urban), so the data looks strong enough to compare. The results suggest a minor yet potentially significant disparity between the two states in their mean responses, warranting further statistical examination (e.g., an independent samples t-test) to determine the statistical significance of the difference.

Table 8: Independent samples test.

Levene's test for equality of variances	t-test for equality of means				
	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
Equal variances assumed	-2.166	300	0.031*	-0.180	0.083
Equal variances not assumed	-2.200	298.4	0.029	-0.180	0.082

*statistically significant

DISCUSSION

This research highlights the increasing problem of antibiotic resistance (AR) in the treatment of pediatric sepsis, especially in-Telangana (rural) and Telangana (urban). The majority (91.4%) of clinicians who responded to the survey indicated that they had been facing resistant infections among children, consistent with international estimates that identify antimicrobial resistance as one of the biggest risks facing contemporary medicine.[32] Our findings are consistent with those from the global burden of disease (GBD) study, which identified sepsis as a cause of 19.7% of all global deaths in 2017, with children under five being the most affected age group.[33]

The diagnostic and prescribing practices observed in our study reflect a concerning trend toward empirical therapy, often in the absence of culture-based confirmation. Only 34.7% of clinicians indicated they regularly conducted blood cultures prior to starting antibiotic treatment, which is consistent with results from other low-resource environments where poor diagnostics drive inappropriate prescribing.[34] The widespread use of third-generation cephalosporins and common escalation to carbapenems are part of a worldwide trend of dwindling antibiotic availability and increasing rates of multidrug-resistant organisms.[35] These treatment practices not only enhance selective pressure for resistance but also reduce the number of therapeutic options available for seriously ill children. Clinical outcomes also reinforce the importance of urgent intervention. More than 72% of clinicians reported increased lengths of stay in the hospital and almost 59% reported treatment failure because of resistant infection observed by research findings which show increased morbidity, increased lengths of stay in the hospital, and greater ICU admissions among children with resistant sepsis.[36,37]

In addition, multivariate analysis confirmed that more experienced clinicians were more likely to report an increase in resistance, implying that longer exposure to clinical practice sensitizes one to the burden of AMR. Rural respondents were considerably more likely to relate AR with treatment failures, most probably a mirror of systemic constraints like delayed diagnoses, limited availability of second-line drugs, and poorer stewardship programs in those regions.[38] The significant relationship between the lack of availability of rapid diagnostic equipment and perceived failure of treatment (AOR=2.38; $p<0.001$) emphasizes the critical necessity of investing in point-of-care diagnostics to facilitate timely, directed therapy. Despite clinicians' perception of AMR, practice gaps remain. This reflects the WHO and Indian Council of Medical Research (ICMR) appeal to strengthen antimicrobial stewardship programs (ASPs), rationalize the use of antibiotics, and enhance education among healthcare professionals.[39,40] These challenges need to be addressed not just through clinical training but also through policy-level intervention to strengthen lab infrastructure, maintain the availability of key diagnostics, and formulate region-specific antibiotic guidelines based on patterns of regional resistance.

CONCLUSION

In summary, this research provides a profound analysis of how antibiotic resistance severely impacts the management and treatment outcome of pediatric sepsis in both rural and urban healthcare facilities of Telangana, India. By combining the views of 302 healthcare workers such as pediatricians, general practitioners, intensivists, and resident doctors, this study offers a three-dimensional view of the dynamic interaction among diagnostic limitations, empiric antibiotic use, and clinical outcomes in resistant infections. The findings illustrate that antibiotic resistance not only lengthens stay in the hospital and enhances treatment failure but also reveals structural disparities between the urban and rural health systems. These disparities, resulting from diagnostic delays and restricted access to advanced antimicrobials, necessitate the immediate enhancement of healthcare infrastructure and stewardship protocols across all tiers of care. This study significantly enhances the existing body of knowledge by bridging the gap between practice and awareness in antimicrobial stewardship within pediatric contexts. Unlike previous studies that primarily focused on pathogen detection or pharmacological responses, the present research highlights the clinical decision-making processes, demonstrating that even well-informed clinicians often resort to empirical treatment due to the absence of rapid diagnostic methods and institutional support. The evidence presented underscores the widely acknowledged fact that antibiotic resistance constitutes both a microbiological and a systemic healthcare issue necessitating multi-level interventions in education, institutions, and policy. The findings also show that there is a need for region-based antibiotic guidelines that consider the resistance patterns and healthcare capabilities of the people who live there. The study also makes it possible to use quick diagnostic tools and ongoing surveillance programs that can give doctors real-time information to help them make smart decisions about when to prescribe antibiotics. It is important to include awareness of antimicrobial resistance in medical school curricula so that future doctors have the knowledge and duty to fight this threat. This study contributes to global public health literature by highlighting that tackling pediatric sepsis in the context of antibiotic resistance necessitates a multi-sectoral approach involving clinicians, microbiologists, policymakers, and communities. By pinpointing the pressing need for diagnostic innovation, the judicious use of antibiotics, and universal healthcare access, the research not only strengthens the scientific foundation for comprehending the dynamics of antimicrobial resistance but also provides a pragmatic framework for improving pediatric outcomes in low- and middle-income contexts. These observations significantly advance the science and practice of pediatric infection control in the context of the escalating global threat posed by drug-resistant organisms.

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