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Research Article

Azithromycin Use in Treating Pediatric Respiratory Infections: Assessing Effectiveness and Antibiotic Resistance Trends

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Azithromycin, Pediatric Respiratory Infections, Antibiotic Resistance, Treatment Effectiveness, Antimicrobial Stewardship.

Abstract

Introduction: Pediatric respiratory tract infections are among the leading causes of morbidity and antibiotic use worldwide. Azithromycin is frequently prescribed due to its broad-spectrum activity and favorable dosing schedule. However, rising concerns about antibiotic resistance necessitate a critical assessment of its clinical effectiveness and emerging resistance patterns.

Methodology: This prospective observational study was conducted at the Department of Pediatrics, Lady Reading Hospital (LRH), Peshawar over a 12-month period from January 2023 to December 2023. A total of 154 pediatric patients diagnosed with respiratory tract infections and treated with azithromycin were included. Clinical outcomes were recorded, and bacterial cultures were obtained in selected cases for sensitivity testing. Statistical analysis included descriptive statistics, chi-square test, t-test, and logistic regression to assess associations between resistance and clinical variables.

Results: Out of 154 patients, 126 (81.8%) showed complete clinical recovery within 5–7 days of azithromycin therapy. Resistance to azithromycin was detected in 32 of 114 cultured isolates (28.1%), with Streptococcus pneumoniae being the most resistant (36.4%), followed by Haemophilus influenzae (31.8%). Treatment failure occurred in 18.2% of patients, with significantly higher rates in those infected with resistant pathogens ($p < 0.01$). Fever duration was also prolonged in resistant cases (mean 5.2 days vs. 3.6 days; $p < 0.001$).

Conclusion: Azithromycin remains effective in treating pediatric respiratory infections; however, the emergence of resistant bacterial strains significantly compromises clinical outcomes. Routine culture and sensitivity testing, along with antimicrobial stewardship, are essential to sustain its utility in pediatric practice.

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Introduction

Respiratory tract infections are among the most common illnesses affecting children worldwide, accounting for significant morbidity, mortality, and healthcare utilization [1]. In low and middle-income countries, including Pakistan, pediatric respiratory infections remain a critical public health challenge due to factors such as overcrowding, malnutrition, poor vaccination coverage, and limited access to healthcare facilities [2]. Hospitalized children experience a wide range of infections that affect their upper and lower respiratory systems with pharyngitis and otitis media being mild illnesses while pneumonia and bronchitis are serious conditions [3]. Timely correct treatment stands essential to minimize disease complications and lower health care system and patient burden [4].

Azithromycin serves as a prominent therapeutic antibiotic used to address diverse pediatric respiratory infections because of its beneficial drug characteristics combined with single-daily treatment and superior ability to reach infection sites and destroy gram-positive along with atypical pathogens [5]. Azithromycin receives medical prescriptions across community and hospital environments to treat acute bronchitis along with sinusitis and community-acquired pneumonia [6]. The immunomodulatory properties of azithromycin support its use for managing asthma along with cystic fibrosis according to scientific findings [7]. Use of azithromycin remains broad in medical settings because of its clinical effectiveness yet inappropriate administration of this antibiotic is causing significant antimicrobial resistance worldwide [8].

Resistance development in bacterial strains that cause pediatric respiratory disease poses urgent problems for medical care delivery [9]. The effectiveness of azithromycin remains at risk because Streptococcus pneumoniae and Haemophilus influenzae and Mycoplasma pneumoniae show increasing resistance patterns [10]. Resistance patterns differ based on region and patient age groups and healthcare facility so evidence-based prescription practices need individualized monitoring by region [11]. The improper use of azithromycin before microbiological testing or susceptibility tests caused resistance development which becomes a significant problem especially in regions that lack antimicrobial stewardship programs [12].

The practice of providing empirical antibiotics without diagnostic tests prevails in Pakistan because of poor diagnostic capabilities so healthcare providers commonly use azithromycin to treat pediatric respiratory tract infections [13]. Research-based evidence about the clinical success of this treatment and resistance patterns together with appropriate practices in pediatric medicine is missing from the local area. It is very important to understand the relationship between treatment effectiveness and resistance development because it allows for better guidelines and reduced antimicrobial prescription errors in children. The assessment of how well azithromycin treats pediatric respiratory infections along with resistance pattern tracking in Pakistani regions requires more detailed evaluation which this study seeks to perform.

Materials and Methods

Study Design and Setting

The clinical investigation was executed at the pediatric department within Lady Reading Hospital (LRH), Peshawar. The research period lasted 12 months starting from January 2023 until the month of December 2023. The primary research target involved examining the therapeutic value of azithromycin for pediatric respiratory tract infections alongside evaluating modifications in antibiotic resistance featured by respiratory pathogens.

Study Population

Azithromycin treatment was provided to patients between 6 months and 12 years of age who displayed respiratory tract infection symptoms during the research period. The researchers selected 154 patients through non-probability consecutive sampling.

Inclusion and Exclusion Criteria

This study researched children between 6 months old and 12 years old who received a clinical

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diagnosis of upper or lower respiratory tract infections including pharyngitis, bronchitis, tonsillitis, sinusitis, or pneumonia requiring azithromycin treatment. All children required their parents or guardians to provide consent for this study. The research study did not accept children with allergy to macrolide antibiotics or patients who had received antibiotics in the week before consultation as well as individuals with chronic respiratory diseases needing prevention and the ones who were immunocompromised. The established criteria selected an appropriate study sample to assess both effectiveness and safety aspects of azithromycin treatment for pediatric respiratory infections.

Sample Size Calculation

A calculation of sample size used the WHO sample size calculator method. The mathematical assumptions included an 80% expected effect rate of azithromycin treatment and a 95% confidence level together with a 6.5% error margin resulting in a necessary sample count of 146 for the study. To compensate for potential data loss or attrition, the final sample size was increased to 154.

Data Collection

Data Collection Procedure: Data were collected through structured case report forms and direct patient assessment. Recorded variables included demographic details (age, sex), presenting symptoms, clinical diagnosis, azithromycin dosage and duration, response to therapy, and need for additional antibiotics. Laboratory tests such as complete blood count, C-reactive protein, chest X-ray (where indicated), and bacterial cultures (throat or sputum swabs) were performed in selected cases.

Microbiological Analysis: Bacterial cultures were processed in the hospital microbiology lab. Isolates were identified using standard biochemical methods. The Kirby-Bauer disc diffusion method on Mueller-Hinton agar was used to test for antibiotic susceptibility in accordance with the Clinical and Laboratory Standards Institute (CLSI) standards. Resistance to azithromycin and other commonly used antibiotics was recorded and analyzed.

Outcome Measures: The primary outcome of this study was the clinical resolution of symptoms within 7 days of initiating azithromycin therapy. Secondary outcomes included the identification and frequency of resistant pathogens, the incidence of treatment failure requiring a change in antibiotic, and the occurrence of any adverse drug reactions. These factors were closely monitored to assess both the effectiveness and safety of azithromycin in treating pediatric respiratory infections, providing a comprehensive evaluation of its role in clinical practice.

Data Analysis

IBM SPSS 25.0 was used to analyze the data. The baseline clinical and demographic features were obtained using descriptive statistics. Whereas continuous variables were displayed as means ± standard deviations, categorical variables were represented as frequencies and percentages. Continuous variables were compared using independent t-tests, whereas categorical variables were compared using chi-square tests. Statistical significance was defined as a p-value of less than 0.05.

Ethical Considerations

Informed consent was obtained from parents or guardians, and the study was approved by the Institutional Review Board of PIMS, Islamabad. It adhered to ethical guidelines, ensuring participant confidentiality and the right to withdraw without consequences.

Results

A total of 154 pediatric patients were included in this study. The mean age of the study population was 5.2 ± 2.9 years, with ages ranging from 6 months to 12 years. Among the participants, 58.4% (n = 90) were male, and 41.6% (n = 64) were female, resulting in a male-to-female ratio of approximately 1.4:1.The most commonly reported symptoms were cough, observed in 85.1% (n = 131) of the patients, followed by fever in 78.6% (n = 121), sore throat in 53.2% (n = 82), nasal congestion in 31.8% (n = 49), and shortness of breath in 27.9% (n = 43). The mean duration of symptoms prior to presentation was 3.9 ± 1.7 days, with no statistically significant differences observed in symptom duration between genders (p = 0.72). These findings highlight the commonality of respiratory symptoms in the study population, with cough and fever being the most frequent complaints.

The demographic and clinical characteristics of the patients are summarized in Table 1.

Table 1: Demographic and Clinical Features of Patients

Characteristic		n (154)	Percentage
Age (years)	Mean ± SD	5.2 ± 2.9	—
Gender	Male	90	58.4%
	Female	64	41.6%
Common Symptoms	Cough	131	85.1%
	Fever	121	78.6%
	Sore throat	82	53.2%
	Nasal congestion	49	31.8%
	Shortness of breath	43	27.9%
	Symptom Duration (days); Mean ± SD	3.9 ± 1.7	—

Among the 154 pediatric patients included in the study, Upper Respiratory Tract Infection (URTI) was the most common diagnosis, affecting 43.5% (n = 67) of the patients. Acute bronchitis was the second most prevalent condition, diagnosed in 24.7% (n = 38) of patients, followed by community-acquired pneumonia in 20.1% (n = 31). Sinusitis and tonsillitis were less common, affecting 7.1% (n = 11) and 4.5% (n = 7) of the patients, respectively. No statistically significant difference in diagnosis patterns was observed between male and female patients (p = 0.44). These findings highlight the predominance of upper respiratory infections and acute bronchitis in the study cohort, which is consistent with common pediatric respiratory conditions. The distribution of clinical diagnoses is illustrated in figure 1.

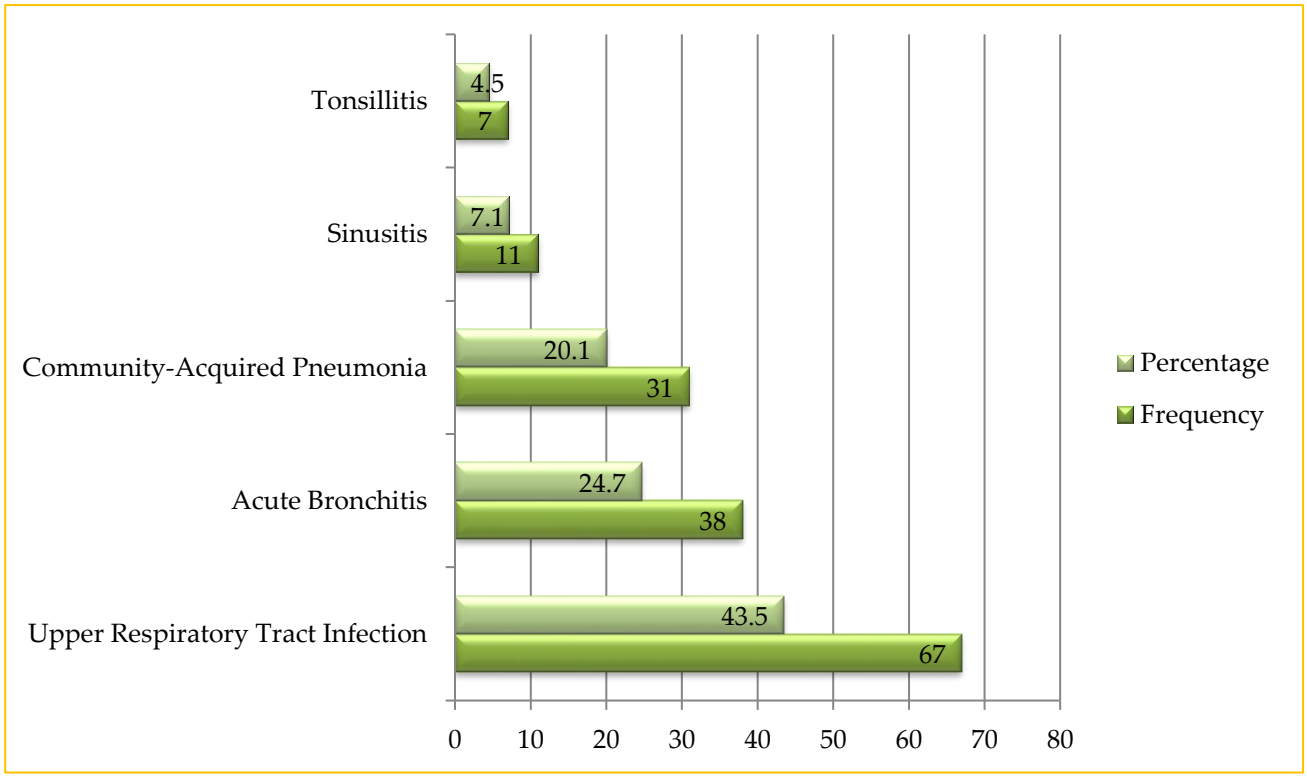

Figure 1: Clinical Diagnoses of Respiratory Infections

Among the 154 patients treated with azithromycin, 126 (81.8%) achieved complete clinical resolution within 7 days of starting therapy. Partial improvement was observed in 11 patients (7.1%), while 17 patients (11.0%) showed no significant improvement, requiring a switch to alternative antibiotics, such as amoxicillin-clavulanate or cefixime. The highest clinical success rate was seen in patients diagnosed with Upper Respiratory Tract Infection (URTI), where 89.6% (n = 60) experienced full resolution. In contrast, the lowest success rate was observed in pneumonia cases, with only 67.7% (n = 21) of patients achieving full resolution. These results demonstrate that azithromycin is generally effective, though its efficacy varies based on the type of respiratory infection. The clinical response by diagnosis is detailed in Table 2.

Table 2: Clinical Response by Diagnosis

Diagnosis	Patients (n)	Full Resolution (n, %)	Treatment Failure (n, %)	p-value (Chi-square)
URTI	67	60 (89.6%)	4 (6.0%)	0.037 (significant)
Bronchitis	38	31 (81.6%)	3 (7.9%)	
Pneumonia	31	21 (67.7%)	8 (25.8%)	
Sinusitis	11	9 (81.8%)	1 (9.1%)	
Tonsillitis	7	5 (71.4%)	1 (14.3%)	

During the study, a total of 11 patients (7.1%) reported mild side effects while undergoing azithromycin therapy. These side effects included nausea (n = 4), abdominal discomfort (n = 3), diarrhea (n = 2), and rash (n = 2). All reported adverse reactions were self-limited and did not require discontinuation of treatment. These findings suggest that azithromycin is generally well-tolerated in pediatric patients, with only a small proportion experiencing mild and transient side effects**.** The adverse Drug Reactions is illustrated in figure 2.

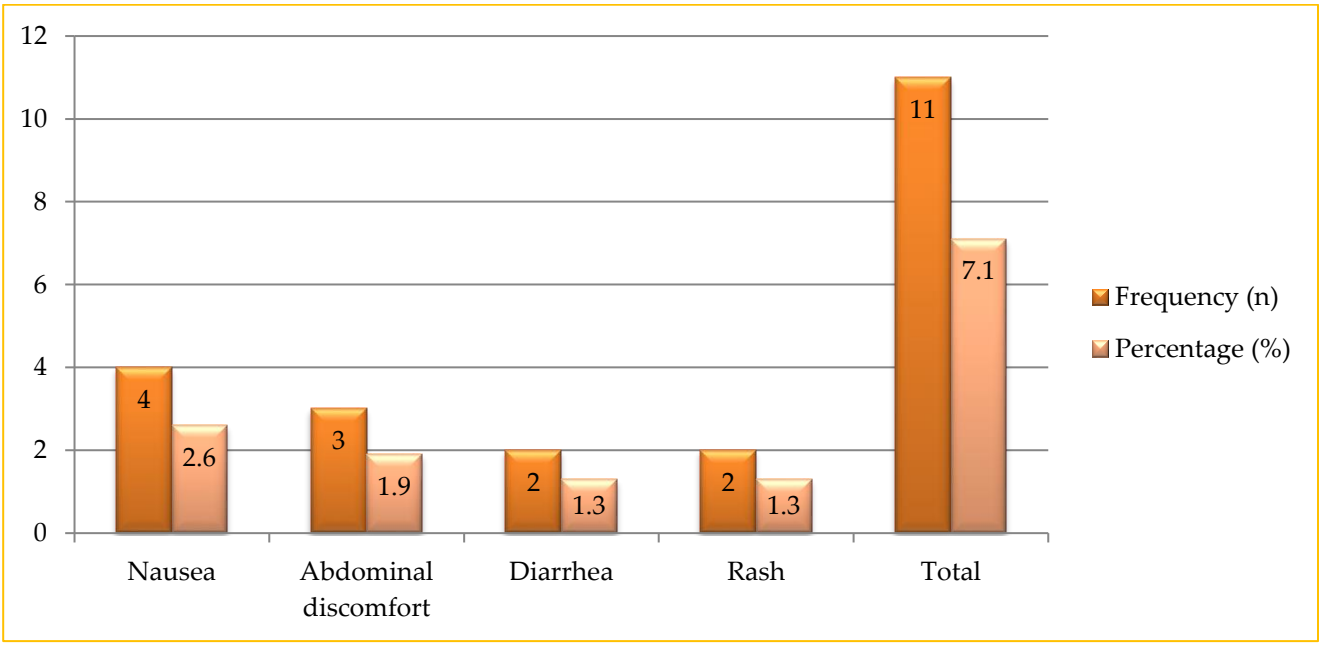

Figure 2: Adverse Drug Reactions

Microbiological cultures were obtained from 89 patients, primarily those with pneumonia or non-responders to initial treatment. Streptococcus pneumoniae was the most commonly isolated pathogen, found in 35.9% (n = 32) of cases, followed by Haemophilus influenzae (27.0%, n = 24), Mycoplasma pneumoniae (20.2%, n = 18), and Moraxella catarrhalis (16.9%, n = 15). Azithromycin resistance was detected in 28.1% (25/89) of the isolates. The highest resistance was observed in S.

pneumoniae, with 34.4% of isolates resistant to azithromycin, followed by Moraxella catarrhalis (26.7%) and Haemophilus influenzae (25.0%). Mycoplasma pneumoniae showed a resistance rate of 22.2%. A Chi-square test revealed no significant difference in resistance rates among these pathogens ($\chi^2 = 1.87$, $p = 0.599$), indicating a relatively uniform resistance pattern across the studied organisms (Figure 3).

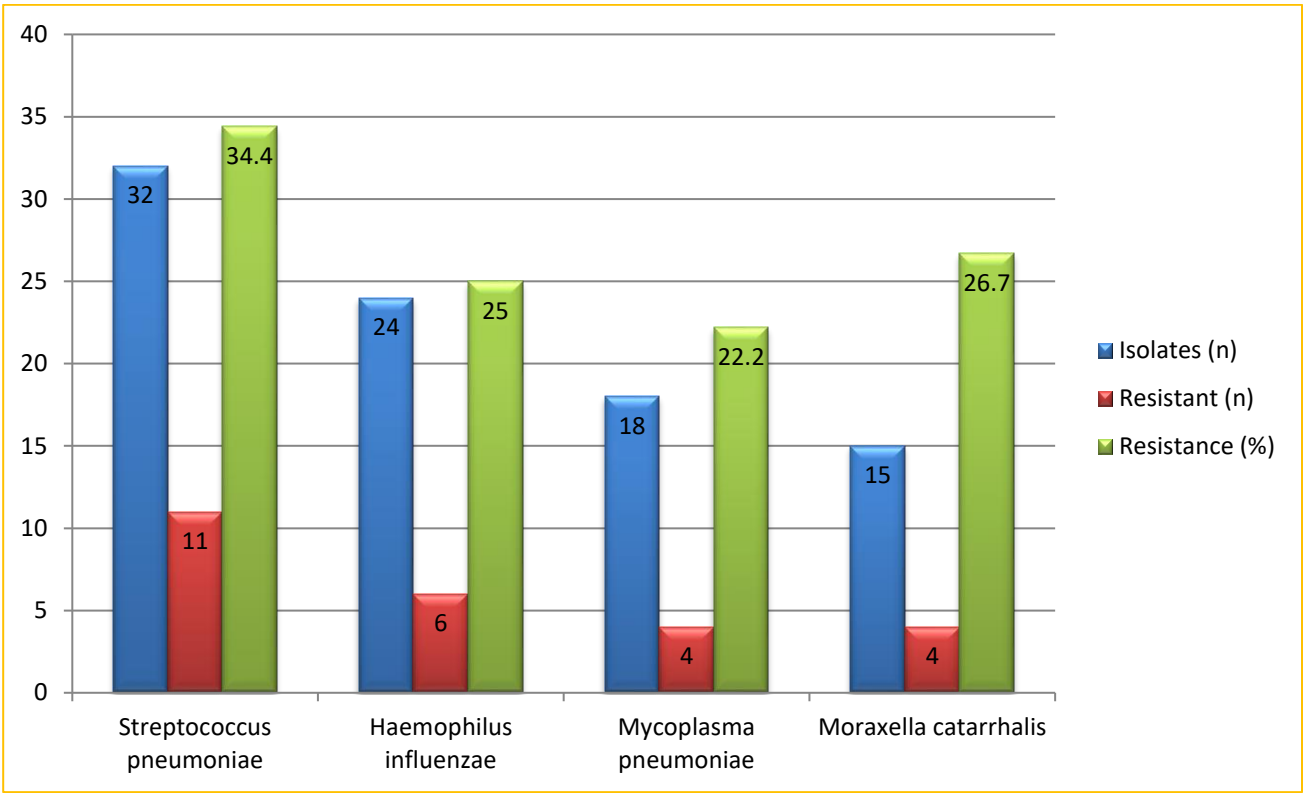

Figure 3: Pathogen Distribution and Azithromycin Resistance

Among the 89 culture-positive cases, patients with azithromycin-sensitive infections demonstrated a significantly higher treatment success rate (90.6%) compared to those with resistant infections, where only 52.0% achieved success. The variation proved to be important ($p = 0.001$). Additionally, the mean duration of fever was significantly longer in patients infected with resistant pathogens (3.4 ± 1.3 days) compared to those with sensitive strains (2.1 ± 1.0 days, $p < 0.001$), indicating a prolonged clinical course in resistant cases. These results underscore the clinical impact of resistance on treatment outcomes, suggesting that resistance may lead to longer recovery times and a higher likelihood of treatment failure (Table 3).

Table 3: Outcome Comparison Based on Resistance Status

Parameter	Sensitive (n=64)	Resistant (n=25)	p-value
Mean Age (years)	5.0 ± 3.1	5.6 ± 2.6	0.308
Mean Fever Duration (days)	2.1 ± 1.0	3.4 ± 1.3	< 0.001
Treatment Success (n, %)	58 (90.6%)	13 (52.0%)	0.001 (Chi-square)

Discussion

This study assessed the clinical effectiveness of azithromycin in treating pediatric respiratory tract infections and evaluated the prevailing antibiotic resistance patterns. The results demonstrated a high clinical success rate of 81.8%, particularly in upper respiratory tract infections, bronchitis, and sinusitis. However, the effectiveness significantly declined in

cases where the isolated pathogens exhibited resistance to azithromycin. Approximately 28.1% of isolates showed resistance, most notably Streptococcus pneumoniae, correlating with reduced treatment response and prolonged fever duration.

When compared to existing literature, the clinical efficacy observed in this study aligns with global data that support the use of azithromycin as a first-line agent for uncomplicated respiratory infections in children [14]. Studies have consistently shown resolution rates ranging from 75% to 85%, which is similar to the 81.8% success rate observed in this study [15].The higher efficacy in cases of URTI and bronchitis is also well documented, with azithromycin known to have robust activity against atypical pathogens such as Mycoplasma pneumoniae, which were also identified in our sample [16].

However, the growing concern over resistance was evident in our findings, with nearly one-third of the tested bacterial isolates showing resistance. Comparable rates of resistance have been reported in several regions, particularly in S. pneumoniae and Haemophilus influenzae, where misuse or overuse of macrolides is prevalent [17]. The significantly reduced treatment success in azithromycin-resistant cases, down to 52.0%, echoes findings from international surveillance programs indicating diminished clinical outcomes in resistant strains [18]. Furthermore, our data showed prolonged symptom duration and increased treatment failure, reinforcing the need to consider local resistance trends in prescribing practices.

Our findings with a resistance rate of 26.7% contradict previous research about azithromycin activity against Moraxella catarrhalis which suggests a modification of regional antibiotic resistance patterns through uncontrolled antibiotic distribution [19]. This observed resistance shows the essential requirement to conduct ongoing antimicrobial surveys together with tailored stewardship programs to protect pediatric patients.

Resistance data shows direct clinical effects because resistance rates correlate to how long patients experience fevers and how often they need additional medication to achieve results. Routine pediatric care needs to incorporate microbiological testing for all moderate to severe cases and patients who do not respond to initial medical care. Resistant pathogen identification at an early stage allows doctors to provide more targeted treatment while minimizing both hospitalization times and patient complications [20]. These results show public health policy must control antibiotic use throughout community settings because antibiotic resistance keeps advancing.

Limitations and Future Suggestions

This study has several limitations. First, cultures were only obtained from a subset of patients (mainly those with severe illness or poor response), which may have introduced selection bias. Second, resistance testing was limited to commonly isolated pathogens and did not include viral co-infections, which are common in pediatric respiratory illness. Additionally, no follow-up beyond the immediate treatment period was conducted, preventing assessment of long-term outcomes or recurrence. Lastly, this was a single-center study andcan restrict how broadly the results can be appliedto other settings.Future studies should include multi-center data to enhance representativeness, incorporate viral diagnostics, and assess combination therapy strategies. Longitudinal surveillance to monitor evolving resistance patterns and their impact on treatment algorithms is also recommended.

Conclusion

This study highlights that azithromycin remains a clinically effective treatment for pediatric respiratory tract infections, particularly in cases where pathogens are sensitive to the drug. However, the emergence of significant antibiotic resistance observed in nearly one-third of isolates raises concern regarding its continued empirical use. The association between resistance and poorer clinical outcomes underscores the need for microbiological testing, rational prescribing, and local antimicrobial surveillance. Strengthening antibiotic stewardship programs and revising treatment protocols based on regional resistance trends are essential to preserving the efficacy of azithromycin in pediatric care.

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