



Article

# Antibiotic Resistance in Pediatric Respiratory Tract Infections: A Clinical Study

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**Abstract:** Respiratory tract infections are one of the major causes of morbidity and antibiotic consumption among children worldwide. Although many respiratory infections in children are viral in nature, antibiotics are commonly prescribed in practice, resulting in the development of antimicrobial resistance at a very rapid rate. This increasing resistance is compromising the effectiveness of standard treatments and has created great challenges for healthcare in children, especially in settings with limited diagnostic resources. This was a prospective observational study and took place at the clinic of Tashkent State Medical University between September 2023 and September 2025, with a total of 86 pediatric patients diagnosed with respiratory tract infections. Clinical characteristics and microbiological findings were analysed, and the antibiotic susceptibility testing was done using a standard laboratory method to assess the resistance pattern of the isolated bacterial pathogen. The results showed that there was a frequent isolation of the common respiratory pathogens, such as *Streptococcus pneumoniae* and *Haemophilus influenzae*. A high level of resistance was found with commonly prescribed first-line antibiotics, particularly penicillins and macrolides. Multidrug-resistant strains were found in a significant proportion of cases, being more pronounced in those children who had received antibiotics in the recent past or had had recurrent respiratory infections. These findings show that previous exposure to antibiotics is an important factor in the development of resistance. Overall, the study makes antibiotic resistance a major and growing problem for pediatric respiratory tract infections. The findings highlight the need for rational antibiotic prescribing, microbiological confirmation of diagnoses and ongoing local resistance surveillance. Strengthening antimicrobial stewardship strategies is needed to maximise treatment outcomes and continue to utilise existing antibiotics for pediatric patients.

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## 1. Introduction

Respiratory tract infections are one of the commonest causes of medical consultation and hospitalisation of children worldwide. In the pediatric practice, these infections often result in the prescription of antibiotics, when in fact, a large percentage of respiratory diseases are caused by viral pathogens. Widespread and often inappropriate use of antibiotics has played a major role in the rapid development of antibiotic resistance, which is now known to be a major global public health threat [1].

Antibiotic resistance in respiratory infections in children is of special concern because the therapeutic options in pediatric patients are reduced compared to adults. Many antimicrobial agents are not safe to use in paediatric patients because of age-related pharmacological restrictions. As a result, resistance to first-line antibiotics, penicillins and

macrolides, could result in treatment failure, protracted illness and higher risk of complications [2]. Moreover, resistant infections may require the use of broader-spectrum or reserve antibiotics, which may further accelerate the resistance development and thus raise healthcare costs.

Recent studies have shown that there is a growing number of resistant rates in common respiratory pathogens, such as *Streptococcus pneumoniae* and *Haemophilus influenzae*. These organisms have demonstrated a decreased susceptibility to commonly prescribed antibiotics, especially in children who have had previous exposure to antibiotics or recurrent respiratory infections [3]. Empirical antibiotic treatment, often started without microbiological confirmation, is one of the major reasons for this trend. In many clinical settings, particularly those in low- and middle-income countries, the low availability of rapid diagnostic tools further complicates the choice of antibiotics [4].

The effects of antibiotic resistance are not just individual patient-related. Resistant respiratory infections are linked to extended length of stay, additional use of diagnosis and higher burden on healthcare systems. In the pediatric population, there is particular concern because repeated infections and exposure to antibiotics in early life may have long-term implications for the development of the immune system and the balance of the microbiome [5].

In spite of increasing awareness among the general public, few regional data are available on antibiotic resistance patterns in pediatric respiratory tract infections in many regions of Central Asia, including Uzbekistan. Local surveillance studies are necessary to know trends in resistance, guide the use of empirical treatment, and support antimicrobial stewardship programmes. Therefore, antibiotic resistance patterns in children with respiratory tract infections managed at a tertiary care centre were aimed to be investigated to contribute to the evidence-based antibiotic use and improvement of the paediatric healthcare outcome.

## 2. Methods

This prospective observation study was carried out at the clinic of Tashkent State Medical University in 2 years period from September 2023 to September 2025. The methodological framework was developed to mirror the real-world pediatric clinical practice and to produce reliable data for antibiotic resistance patterns in children with respiratory tract infections without affecting routine diagnostic or therapeutic decision-making. Observational surveillance studies are regarded as an appropriate and ethically sound method of monitoring antimicrobial resistance trends in a hospital setting, especially in paediatric populations [6].

The study population was pediatric patients who were admitted or referred to the clinic with clinical features suggestive of upper or lower respiratory tract infections. Inclusion criteria were determined by the presence of symptoms such as cough, fever, nasal congestion, sore throat, tachypnea, wheezing or abnormal findings of auscultation of the lungs consistent with a respiratory infection. Only the patients for whom the bacterial involvement was clinically suspected and later confirmed by a laboratory evaluation were included in the final analysis. Children with chronic respiratory conditions, congenital or acquired immunodeficiency, and long-term corticosteroid therapy, as well as those treated with antibiotics for non-respiratory reasons, were excluded to reduce the effects that would interfere with resistance patterns [7].

Clinical and demographic data were retrospectively and prospectively collected from medical records using a standardised data collection form. Variables included patient age, sex, clinical diagnosis, duration/s severity of symptoms, history of recurrent respiratory infections and past exposure to antibiotics in the preceding three months. Particular attention was taken to record the previous antibiotic use, including class of antibiotic prescribed and duration of treatment, as previous exposure to an antibiotic is a

well-established driver of antimicrobial resistance in paediatric patients [9]. To maintain patient privacy, all the collected data were anonymised before being analysed and were stored in a secure database, accessible only to the research team.

Respiratory specimens were taken as per the clinical presentation and age of the child. Depending on the suspected site of infection, samples included nasopharyngeal swabs, throat swabs and sputum samples where possible (depending on the ability to expectorate). Specimen collection was done under strict aseptic techniques by trained healthcare personnel to minimise the risk of contamination at the time of specimen collection. All samples were transported to the microbiology laboratory in a short period of time in order to maintain the quality of samples, following recommendations for laboratory practises [8].

Microbiological analysis was performed using classical methods of culture used routinely in clinical microbiology laboratories. Bacterial pathogens were identified according to the Gram stain, morphology of the colony, and standard biochemical tests. Based on the identification of the pathogen, the antibiotic susceptibility test was carried out using the disc diffusion technique. The antibiotic panel included commonly used antibiotics used in pediatric respiratory tract infections, such as beta-lactam antibiotics, macrolides and select broad-spectrum agents of broad spectrum. The selection of the antibiotics was based on local prescribing practises and international recommendations for antimicrobial resistance surveillance [6].

Interpretation of the results of the antibiotic susceptibility was done according to the Clinical and Laboratory Standards Institute guidelines. Isolates were classified as susceptible, intermediate or resistant on the basis of inhibition zone diameters measured. Multidrug resistance was defined as resistance to two or more classes of antibiotics, in accordance with the internationally accepted definition as applied to antimicrobial resistance research [8]. Quality control procedures were used throughout the laboratory test procedure to ensure accuracy and reproducibility of results.

Statistical analysis concentrated mainly on methods of description. Data summary was done in absolute numbers and percentages to describe bacterial pathogen distribution and resistance profile. Patterns of resistance were analysed in relation to clinical characteristics such as previous exposure to antibiotic drugs and recurrent respiratory infections. Due to the exploratory nature of the study and the small sample size, inferential statistical testing was not an emphasis and the results were interpreted in a descriptive and clinically contextualised manner.

Ethical permission for the study was received from the institutional ethics committee of Tashkent State Medical University. Written informed consent was obtained from parents or legal guardians before inclusion of patients. The study was conducted in accordance with the principles of the Declaration of Helsinki and was in accordance with international standards for ethical research with human participants [7].

### 3. Results

The analysis took 86 paediatric patients diagnosed with respiratory tract infections during the study period. The age distribution was characterised by the predominance of younger children, with the majority of cases appearing in patients younger than five years of age. Clinically, both upper and lower respiratory tract infections occurred, and infection of the lower respiratory tract was more common in patients requiring hospitalisation. A significant proportion of children had a documented history of antibiotic use within the last three months before admission, and this seemed to have an impact on resistance patterns found in microbiological testing [10].

Bacterial pathogens could be successfully isolated from respiratory specimens in all of the included cases. Gram-positive and Gram-negative organisms were isolated, and the most frequent pathogens were *Streptococcus pneumoniae* and *Haemophilus influenzae*.

Gram-negative bacteria were found more often in patients who had recurrent infections or a longer duration of symptoms. The distribution of isolated pathogens is shown in Table 1.

**Table 1.** Distribution of bacterial pathogens isolated from pediatric respiratory tract infections (n = 86)

Pathogen	Number of isolates	Percentage (%)
Streptococcus pneumoniae	31	36.0
Haemophilus influenzae	24	27.9
Staphylococcus aureus	15	17.4
Moraxella catarrhalis	9	10.5
Other Gram-negative bacteria	7	8.2

Antibiotic sensitivity to major common antibiotics showed a worrying degree of resistance. Resistance against amoxicillin was found in a significant proportion of isolates, especially *Streptococcus pneumoniae* and *Haemophilus Influenzae*. Resistance to the macrolides was also commonly found, particularly in those children with known previous antibiotic therapy. These findings are in line with current worldwide trends showing a decreased efficacy of standard empirical therapies for cases of paediatric respiratory infections [11].

Multidrug resistance, i.e. resistance to two or more classes of antibiotics, was detected against a significant proportion of isolates. Multidrug-resistant strains were more commonly seen in patients with recurrent respiratory infections as well as those who had received several courses of antibiotics. The general antibiotic resistance pattern of the isolated pathogens is summarised in Table 2.

**Table 2.** Antibiotic resistance patterns among isolated respiratory pathogens

Antibiotic class	Resistant isolates (n)	Resistance rate (%)
Penicillins (e.g., amoxicillin)	42	48.8
Macrolides	36	41.9
Cephalosporins	21	24.4
Fluoroquinolones	9	10.5
Multidrug resistance	28	32.6

An important clinical observation was the association of previous exposure to antibiotics and the higher resistance rates. Children who had been treated with antibiotics during the last three months had significantly greater resistance to penicillins and macrolides than antibiotic-naive patients. In addition, resistance was more marked in cases with long duration of disease, suggesting that delayed or inappropriate initial therapy may be involved in the selection of resistance.

Despite variability in resistance profiles, susceptibility to selected reserve antibiotics was relatively preserved, although selected reserve agents were used cautiously because of pediatric safety considerations. Overall, the results suggest that empirical treatment of antibiotic therapy based solely on the clinical picture may no longer be sufficient in a significant percentage of pediatric respiratory infections. These results highlight the importance of microbiological confirmation and local resistance surveillance in the choice of antibiotic agents and the improvement of the treatment outcome in children [12].

#### 4. Discussion

The results of this study show that antibiotic resistance is an important and increasing issue in paediatric patients with respiratory tract infections. The high prevalence of resistance to commonly prescribed antibiotics, especially penicillins and macrolides, illustrates an alarming trend that has been reported in greater frequency in the

last international research. These results suggest that empirical antibiotic treatment, and especially, empirical antibiotic treatment for paediatric respiratory infections, which is still a common practise, may no longer be sufficiently effective in a significant proportion of cases [13].

One of the more notable things that we have seen is the high correlation between previous exposure to antibiotics and higher rates of resistance. High resistance was observed in children who had a history of antibiotics in the last 3 months, especially against the first-line agents. This finding is consistent with evidence that there is selective pressure favouring the survival of resistant strains of bacteria from repeated or inappropriate antibiotic use. In pediatric cohorts, for example, in which respiratory infections are common, and antibiotics are often prescribed early in the course of the illness, this cycle could rapidly increase the development of resistance [14].

The predominance of resistant *Streptococcus pneumoniae* and *Haemophilus influenzae* isolates was observed in this study; this is clinically significant. These pathogens are one of the most frequently encountered bacterial causative agents of respiratory infections in children, which are traditionally treated with beta-lactam antibiotics or macrolides. Reduced susceptibility in these organisms makes it more difficult to decide on treatment and makes treatment more likely to fail, symptoms to last longer, and healthcare visits to be repeated. Similar resistance patterns have been reported in multicenter surveillance studies, highlighting the fact that it is not limited to one institution or one region [15].

Another finding of importance was the presence of multidrug-resistant strains, especially in the group of children with recurrent respiratory infections. Multidrug resistance has greatly restricted the choice of therapy and may even require the use of broader-spectrum or reserve antibiotics. In paediatric patients, this represents more complications because of safety concerns, limited indications and possible long-term effects. The higher dependence of such agents may be further contributing to resistance, if not carefully pre-determined and thus the importance of antimicrobial stewardship in pediatric healthcare settings [13].

The results also highlight the role of microbiological confirmation in the antibiotic treatment. In many clinical situations, antibiotics are prescribed based solely on clinical presentation, without the evidence of laboratory evidence of bacterial infection. While this type of approach may be motivated by limitations in the diagnostic or by clinical urgency, this practice runs the risk of unnecessary antibiotic use. The resistance patterns in this study support the emerging consensus that targeted therapy using the local data on susceptibility is necessary to enhance treatment outcomes and limit selection of resistance [16].

From the wider realm, the results of this study have important implications in pediatric healthcare systems, especially in those areas where comprehensive antimicrobial resistance surveillance is lacking. Local resistance data are important to update treatment guidelines and educate clinicians, and optimise empirical treatment. Without such data, it is possible that clinicians will stick with past prescribing practices that will inadvertently contribute to resistance.

In conclusion, this study supports the need for rational antibiotic use in pediatric respiratory tract infections. Reducing unnecessary prescriptions of antibiotics, increasing efficacy of antimicrobial stewardship programs and expanding access to diagnostics are some key steps towards overcoming antibiotic resistance. To address this challenge, there are needs for coordinated efforts to ensure effective and sustainable treatment strategies for children at the clinical, institutional, and public health levels.

## 5. Conclusion

The results of this study clearly show that resistance to antibiotics has emerged as a significant problem in the treatment of respiratory tract infections in paediatric patients.

The high resistance rates noted against commonly used antibiotics used in first-line therapy suggest that traditional empirical treatment approaches may no longer be effective for a significant number of pediatric patients. These results highlight the importance of a more careful and evidence-based approach to antibiotic prescribing in children. A significant link between antibiotic use and resistance indicates the need to avoid unnecessary or inappropriate antibiotic use. Repeated courses of antibiotics, especially repeated courses in cases of recurrent respiratory infections, seem to play a major role in the development of resistant and multidrug-resistant bacterial strains. This not only restricts the available treatment options but also makes it more likely that the child population will experience prolonged illness and potential complications. The study highlights the importance of microbiological testing and local resistance surveillance in the clinic. Incorporating routine susceptibility testing into clinical practice can aid in targeted therapy, decrease ineffective treatment and help to maintain the efficacy of the currently available antibiotics. In settings with limited access to diagnostics, enhancing antimicrobial stewardship programs and tailoring treatment guidelines based on local data are key actions to take. Overall, efforts to address antibiotic resistance in children's respiratory infections will require coordinated action from clinicians, healthcare institutions, and public health authorities. Promoting the rational use of antibiotics, improving diagnostic approaches, and raising awareness of trends in resistance are fundamental to the safe, effective, and sustainable treatment of children in the future.

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