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FREQUENCY OF EXTENSIVELY DRUG-RESISTANT TYPHOID FEVER AND ASSOCIATED FACTORS AMONG CHILDREN PRESENTING TO A TERTIARY CARE HOSPITAL IN KARACHI, PAKISTAN

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Abstract

Background: *Typhoid fever remains a significant public health challenge in Pakistan, particularly among children. The emergence of extensively drug-resistant (XDR) Salmonella Typhi, which is resistant to first-line antibiotics, fluoroquinolones, and third-generation cephalosporins, has severely limited treatment options and raised concerns about untreatable infections. Local epidemiological data are essential to guide clinical management and public health interventions.*

Objective: *To determine the frequency of extensively drug-resistant (XDR) Salmonella Typhi and Salmonella Paratyphi among clinically suspected pediatric typhoid fever patients presenting to a tertiary care hospital in Karachi, Pakistan.*

Methods: *This descriptive cross-sectional study was conducted in the Department of Pediatrics at Dr. Ruth K.M. Pfau Civil Hospital, Karachi, from February to August 2021. A total of 138 children aged 1 month to 12 years with clinically suspected typhoid fever were enrolled using non-probability consecutive sampling. Blood culture and antimicrobial susceptibility testing were performed, and isolates were classified according to CLSI guidelines. XDR typhoid was defined as resistance to chloramphenicol, ampicillin, trimethoprim-sulfamethoxazole, ciprofloxacin, and ceftriaxone.*

Results: *The mean age of participants was 6.41 ± 2.40 years, with females comprising 51.4% of the sample. Only 30.4% of children had received typhoid vaccination. Blood culture confirmed typhoid fever in all 138 patients, and 74 (53.6%) were identified as having XDR typhoid. Antimicrobial resistance was alarmingly high: ampicillin (91.3%), ceftriaxone (64.5%), chloramphenicol (60.9%), ciprofloxacin (58.7%), and trimethoprim-sulfamethoxazole (53.6%). Significant associations with XDR typhoid included male gender ($p=0.007$), low maternal education ($p<0.001$), poor socioeconomic status ($p<0.001$), lack of immunization ($p<0.001$), tap water use*

(p=0.003), and symptoms of nausea/vomiting, loss of appetite, and cough (p<0.001).

Conclusion: *More than half of pediatric typhoid cases were XDR, reflecting a substantial burden of antimicrobial resistance. Vaccination status, maternal education, socioeconomic conditions, and water source were significantly associated with XDR typhoid. Strengthening vaccine coverage, improving water and sanitation infrastructure, promoting antimicrobial stewardship, and maintaining continuous surveillance are essential to control the spread of resistant typhoid and improve pediatric health outcomes.*

INTRODUCTION

Typhoid fever remains a major public health challenge in many low- and middle-income countries despite substantial advances in sanitation, vaccination, and antimicrobial therapy. The disease is caused primarily by Salmonella enterica serovar Typhi and, less frequently, by Salmonella enterica serovars Paratyphi A, B, and C. Transmission occurs predominantly through ingestion of food or water contaminated with human feces, making the disease closely linked to inadequate sanitation, unsafe water supplies, and poor hygiene practices [1,2]. Although typhoid fever has largely been controlled in high-income countries, it continues to be endemic in South Asia and sub-Saharan Africa, where overcrowding, rapid urbanization, and limited access to safe drinking water facilitate disease transmission [3, 4].

Recent global estimates indicate that typhoid fever causes millions of infections annually, with a disproportionately high burden among children and adolescents in endemic regions [3, 5]. South Asia accounts for a substantial proportion of worldwide cases, and Pakistan continues to rank among the countries with the highest disease burden [6]. Young children are particularly vulnerable because of increased exposure risks, limited immunity, and barriers to timely healthcare access. The disease not only contributes to significant morbidity and mortality but also imposes considerable economic and social costs on affected families and healthcare systems [3, 5].

Clinically, typhoid fever presents with prolonged fever, headache, abdominal discomfort, anorexia, malaise, vomiting, diarrhea, or constipation. In severe cases, complications such as intestinal hemorrhage, intestinal perforation, encephalopathy, septic shock, and death may occur if appropriate treatment is delayed [1,7]. Accurate diagnosis remains challenging because the clinical manifestations overlap with many other febrile illnesses. Although blood culture remains the most commonly used diagnostic method, its sensitivity is limited by factors such as prior antibiotic exposure and low bacterial concentration in the bloodstream [8].

The management of typhoid fever has become increasingly complicated because of the emergence and rapid spread of antimicrobial-resistant strains. Historically, chloramphenicol, ampicillin, and trimethoprim-sulfamethoxazole were highly effective treatments; however, widespread antimicrobial use led to the emergence of multidrug-resistant (MDR) Salmonella Typhi strains resistant to all three first-line agents [9]. Subsequently, fluoroquinolones became the preferred therapeutic option, but resistance to this class also increased dramatically across South Asia, resulting in reduced treatment efficacy and prolonged illness [10].

Of particular concern is the emergence of extensively drug-resistant (XDR) typhoid fever. XDR Salmonella Typhi is characterized by resistance to first-line antibiotics, fluoroquinolones, and third-generation cephalosporins, leaving only a limited number of effective treatment options such as azithromycin and carbapenems [11,12]. The first large-scale outbreak of XDR typhoid was reported in Sindh Province, Pakistan, in 2016 and subsequently expanded rapidly across different regions of the country [11]. Molecular investigations demonstrated that the outbreak strain belonged to the globally disseminated H58 lineage and harbored additional resistance genes that conferred ceftriaxone resistance, a development that significantly narrowed treatment choices and raised concerns regarding the potential emergence of untreatable typhoid fever [11, 13].

The Pakistani XDR outbreak has attracted global attention because it represents one of the most significant examples of antimicrobial resistance among enteric pathogens. Cases associated with travel to

Pakistan have subsequently been reported in several countries, highlighting the international implications of localized antimicrobial resistance outbreaks [14]. The emergence of XDR typhoid also underscores broader concerns regarding inappropriate antibiotic use, inadequate antimicrobial stewardship, and insufficient surveillance systems in endemic settings [12, 15].

Vaccination has emerged as a critical strategy for controlling typhoid fever and reducing the spread of resistant strains. The World Health Organization recommends the use of typhoid conjugate vaccines (TCVs) in endemic regions because of their ability to induce strong and sustained immunity in young children [16]. Pakistan became one of the first countries to introduce TCVs into its national immunization program following the XDR outbreak, representing an important step toward disease prevention and control [17]. Nevertheless, vaccine coverage remains variable, and breakthrough infections continue to occur, emphasizing the need for ongoing surveillance and epidemiological monitoring [16, 17].

Several recent studies from Pakistan have reported an increasing frequency of antimicrobial-resistant and extensively drug-resistant typhoid among pediatric populations [6, 12, 18]. However, resistance patterns may vary across healthcare facilities and geographical settings because of differences in antimicrobial prescribing practices, vaccine uptake, population characteristics, and local transmission dynamics. Consequently, periodic assessment of the burden of XDR typhoid at institutional and regional levels is necessary to guide empirical antibiotic therapy, strengthen infection prevention measures, and support public health decision-making.

Given the substantial burden of typhoid fever among Pakistani children and the continued threat posed by XDR Salmonella strains, local epidemiological data are essential for informed clinical management. Determining the frequency of XDR typhoid in tertiary-care settings can facilitate early recognition of resistant infections, optimize treatment strategies, and contribute to national surveillance efforts aimed at limiting the spread of antimicrobial resistance.

Study Objective

To determine the frequency of extensively drug-resistant (XDR) Salmonella Typhi and Salmonella Paratyphi among clinically suspected pediatric typhoid fever patients presenting to a tertiary care hospital.

Methodology

Study Design

A descriptive cross-sectional study was conducted.

Study Setting

The study was carried out in the Department of Pediatrics, Dr. Ruth K.M. Pfau Civil Hospital, Karachi, Pakistan.

Study Duration

The study was conducted over a period of six months, from February 16, 2021, to August 16, 2021.

Sample Size

The sample size was calculated using the WHO sample size calculator. Assuming a prevalence of extensively drug-resistant (XDR) typhoid of 64.4%, a confidence level of 95%, and an absolute precision of 8%, a total of 138 clinically suspected typhoid fever patients were required for enrollment.

Sampling Technique

A non-probability consecutive sampling technique was employed.

Study Population

Inclusion Criteria

- Children meeting the following criteria were included in the study:
- Age between 1 month and 12 years.

- Either gender.
- Clinically suspected cases of typhoid fever according to the operational definition.
- Patients for whom blood culture and sensitivity testing had been advised.

Exclusion Criteria
- Patients were excluded if:
- Parents or guardians declined to provide informed consent.
- An alternative cause of fever other than Salmonella Typhi or Salmonella Paratyphi was identified.

Data Collection Procedure
The study was initiated after obtaining approval from the Ethical Review Committee (ERC) and the College of Physicians and Surgeons Pakistan (CPSP). Written informed consent was obtained from the parents or guardians of all eligible participants. Children aged 1 month to 12 years who presented to the outpatient department or were admitted to the pediatric ward with clinically suspected typhoid fever were assessed for eligibility. Patients who underwent blood culture and sensitivity testing were enrolled in the study.
Data were collected using a structured proforma that captured demographic characteristics and investigation findings. Blood culture and antimicrobial susceptibility reports demonstrating growth of Salmonella Typhi and/or Salmonella Paratyphi were reviewed according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Cases were classified as XDR typhoid when the isolate was resistant to chloramphenicol, ampicillin, trimethoprim-sulfamethoxazole, ciprofloxacin, and ceftriaxone.

Operational Definitions
Clinically Suspected Typhoid Fever: Patients with documented fever ≥38°C for at least one week and at least one associated symptom, including nausea/vomiting, cough, headache, diarrhea, or loss of appetite/poor oral intake.
Typhoid Fever: Blood culture positive for Salmonella Typhi or Salmonella Paratyphi.
Vaccinated Patient: A child who had received a World Health Organization-approved Typhoid Conjugate Vaccine (TCV).
Extensively Drug-Resistant (XDR) Typhoid: Isolation of Salmonella Typhi or Salmonella Paratyphi resistant to chloramphenicol, ampicillin, trimethoprim-sulfamethoxazole, ciprofloxacin, and ceftriaxone according to CLSI criteria.

Results
A total of 138 children with clinically suspected typhoid fever were included in the study. The mean age of the participants was 6.41 ± 2.40 years, with slightly more than half of the patients (53.6%, n=74) aged ≤6 years. Females constituted 51.4% (n=71) of the study population, while males accounted for 48.6% (n=67). Most participants were residents of urban areas (55.1%, n=76), whereas 44.9% (n=62) belonged to rural communities. A large proportion of children (69.6%, n=96) had not received typhoid vaccination, while only 30.4% (n=42) were immunized. The mean duration of fever before presentation was 9.64 ± 0.98 days, with more than half of the participants (55.1%, n=76) experiencing fever for longer than nine days (Table 1).

Table 1. Baseline characteristics of study participants (n=138)

Variable	n (%)
Age (years	**6.41 ± 2.40**
≤6 years	74 (53.6)
>6 years	64 (46.4)
Gender	
Male	67 (48.6)

Female	71 (51.4)
Residence	
Rural	62 (44.9)
Urban	76 (55.1)
Immunization Status	
Immunized	42 (30.4)
Not immunized	96 (69.6)
Duration of Fever (days)	
Mean ± SD	9.64 ± 0.98
≤9 days	62 (44.9)
>9 days	76 (55.1)

The clinical profile of the study participants is summarized in Table 2. Fever was present in all children by study definition. Nausea and vomiting were the most frequently reported accompanying symptoms, occurring in 79.0% (n=109) of patients. Headache was present in 72.5% (n=100) of cases, followed by loss of appetite in 63.8% (n=88) and cough in 61.6% (n=85). Diarrhea was reported in slightly more than half of the participants (52.2%, n=72). These findings indicate that gastrointestinal manifestations, particularly nausea/vomiting and anorexia, were prominent clinical features among children presenting with suspected typhoid fever.

Table 2: Clinical Characteristics and Presenting Symptoms of Children with Suspected Typhoid Fever (n=138)

Symptom	**n** (%)
Fever	138 (100)
Nausea/Vomiting	109 (79.0)
Headache	100 (72.5)
Loss of appetite	88 (63.8)
Cough	85 (61.6)
Diarrhea	72 (52.2)

The antimicrobial susceptibility pattern of Salmonella isolates demonstrated substantial resistance to commonly used antibiotics (Table 3). Ampicillin exhibited the highest resistance rate, with 91.3% (n=126) of isolates classified as resistant and only 8.7% (n=12) remaining sensitive. Resistance to ceftriaxone, a key third-generation cephalosporin used in typhoid management, was observed in 64.5% (n=89) of isolates. Similarly, high levels of resistance were noted against chloramphenicol (60.9%, n=84), ciprofloxacin (58.7%, n=81), and trimethoprim-sulfamethoxazole (53.6%, n=74). The highest sensitivity was observed for trimethoprim-sulfamethoxazole (46.4%, n=64), followed by ciprofloxacin (41.3%, n=57), chloramphenicol (39.1%, n=54), and ceftriaxone (35.5%, n=49). These findings highlight the considerable burden of antimicrobial resistance among pediatric typhoid cases at the study center.

The frequency of extensively drug-resistant (XDR) typhoid fever is shown in Figure 1. Of the 138 children included in the study, 74 (53.6%) were identified as having XDR typhoid fever, whereas 64 (46.4%) had non-XDR disease. Thus, more than half of all confirmed typhoid cases were resistant to first-line antibiotics, fluoroquinolones, and third-generation cephalosporins, indicating a substantial burden of XDR typhoid within the study population.

Table 3: Antimicrobial Susceptibility Pattern of Salmonella Isolates (n=138)

Antibiotic	Sensitive n (%)	Resistant n (%)
Chloramphenicol	54 (39.1)	84 (60.9)
Ampicillin	12 (8.7)	126 (91.3)
TMP-SMX	64 (46.4)	74 (53.6)
Ciprofloxacin	57 (41.3)	81 (58.7)
Ceftriaxone	49 (35.5)	89 (64.5)

Figure 1 therefore demonstrates that XDR typhoid fever constituted the predominant antimicrobial resistance pattern among the enrolled children, emphasizing the growing challenge posed by resistant Salmonella infections in pediatric practice.

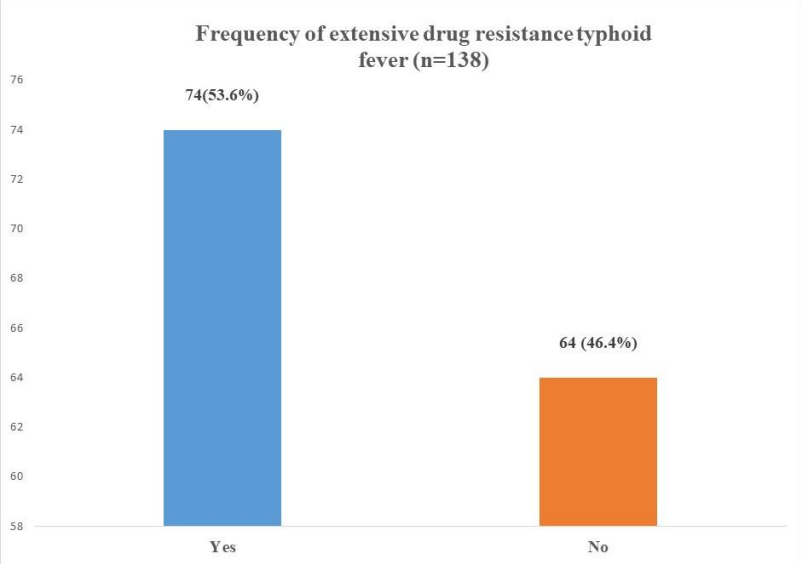


Figure.1 Frequency of extensive drug resistance typhoid fever (n=138)

Comparison of patients with XDR and non-XDR typhoid fever revealed several statistically significant associations (Table 4). Although a higher proportion of XDR cases was observed among children aged ≤6 years (60.8% vs. 45.3%), the association did not reach statistical significance (p=0.069). Similarly, no significant association was found between XDR status and residence (p=0.145), headache (p=0.535), diarrhea (p=0.894), or duration of fever (p=0.933).

Variable	XDR n (%) (n=74)	Non-XDR n (%) (n=64)	p-value
Age Group			0.069
≤6	45 (60.8)	29 (45.3)	
>6	29 (39.2)	35 (54.7)	
Gender			0.007*
Male	46 (62.2)	25 (39.1)	
Female	28 (37.8)	39 (60.9)	
Residence			0.145
Rural	29 (39.2)	33 (51.6)	
Urban	45 (60.8)	31 (48.4)	
Mother			<0.001*

Illiterate	39 (52.7)	6 (9.4)	
Matric	30 (40.5)	34 (53.1)	
Intermediate or above	5 (6.8)	24 (37.5)	
Socioeconomic Status			<0.001*
Low	35 (47.3)	0 (0.0)	
Lower middle	36 (48.6)	42 (65.6)	
Upper middle	3 (4.1)	22 (34.4)	
Immunization Status			<0.001*
Immunized	7 (9.5)	35 (54.7)	
Not immunized	67 (90.5)	29 (45.3)	
Source of Drinking Water			0.003*
Tap water	49 (66.2)	26 (40.6)	
Well water	25 (33.8)	38 (59.4)	
Nausea/Vomiting			<0.001*
Yes	69 (93.2)	40 (62.5)	
No	5 (6.8)	24 (37.5)	
Loss of Appetite			<0.001*
Yes	65 (87.8)	23 (35.9)	
No	9 (12.2)	41 (64.1)	
Headache			0.535
Yes	52 (70.3)	48 (75.0)	
No	22 (29.7)	16 (25.0)	
Cough			0.002*
Yes	55 (74.3)	30 (46.9)	
No	19 (25.7)	34 (53.1)	
Diarrhea			0.894
Yes	39 (52.7)	33 (51.6)	
No	35 (47.3)	31 (48.4)	
Duration of Fever (days)			0.933
≤9	33 (44.6)	29 (45.3)	
>9	41 (55.4)	35 (54.7)	
No	35 (47.3)	31 (48.4)	
Duration of fever, days			
≤9	33 (44.6)	29 (45.3)	0.933
>9	41 (55.4)	35 (54.7)	

Gender was significantly associated with XDR typhoid fever (p=0.007), with males comprising a greater proportion of XDR cases compared with non-XDR cases (62.2% vs. 39.1%). Maternal education also demonstrated a strong association with resistance patterns (p<0.001). More than half of XDR cases had mothers who were illiterate (52.7%), whereas only 9.4% of non-XDR cases belonged to this category. Conversely, children whose mothers had an educational level of intermediate or above were more frequently represented in the non-XDR group.

A significant relationship was also observed between socioeconomic status and XDR typhoid fever ($p<0.001$). Nearly half of the XDR cases belonged to low socioeconomic households, while no non-XDR patient was classified in this category. In contrast, upper-middle socioeconomic status was substantially more common among non-XDR cases than XDR cases (34.4% vs. 4.1%).

Immunization status showed one of the strongest associations with disease resistance patterns ($p<0.001$). Only 9.5% of children with XDR typhoid had received typhoid vaccination, compared with 54.7% of children in the non-XDR group. Conversely, lack of immunization was observed in 90.5% of XDR cases, suggesting a potential protective role of vaccination against resistant typhoid infections.

The source of drinking water was also significantly associated with XDR typhoid fever ($p=0.003$). Children using tap water were more likely to develop XDR infection than non-XDR infection (66.2% vs. 40.6%), whereas the use of well water was more common among non-XDR cases.

Among clinical manifestations, nausea/vomiting, loss of appetite, and cough were significantly associated with XDR typhoid fever. Nausea/vomiting was reported in 93.2% of XDR cases compared with 62.5% of non-XDR cases ($p<0.001$). Similarly, loss of appetite was present in 87.8% of XDR cases versus 35.9% of non-XDR cases ($p<0.001$). Cough was also more frequently observed among patients with XDR typhoid fever (74.3% vs. 46.9%, $p=0.002$). These findings suggest that children presenting with these symptoms may be more likely to harbor resistant organisms.

Overall, the study demonstrated a high burden of XDR typhoid fever among children presenting to a tertiary care hospital. Male gender, lower maternal educational status, poorer socioeconomic conditions, lack of typhoid immunization, use of tap water, and the presence of nausea/vomiting, loss of appetite, and cough were identified as significant factors associated with XDR typhoid fever.

Discussion

The present study evaluated the frequency of extensively drug-resistant (XDR) typhoid fever among pediatric patients presenting to a tertiary care hospital and found that more than half of the enrolled patients (53.6%) had XDR typhoid fever. This finding highlights the substantial burden of antimicrobial resistance among children with typhoid fever and supports growing concerns regarding the widespread dissemination of resistant Salmonella strains in Pakistan and other endemic regions. Similar concerns have been reported in recent studies from Pakistan following the emergence of the XDR outbreak in Sindh, where resistance to first-line antibiotics, fluoroquinolones, and third-generation cephalosporins severely limited available treatment options [19,20].

The mean age of study participants was 6.41±2.40 years, and more than half of the children were aged six years or younger. This finding is consistent with reports indicating that typhoid fever disproportionately affects children in endemic settings, particularly school-aged and younger children who experience greater exposure to contaminated food and water sources [21,22]. Although younger children showed a higher proportion of XDR infection in the present study, the association between age and XDR status did not reach statistical significance. Similar observations have been reported by other investigators who found that antimicrobial resistance affects multiple pediatric age groups rather than being restricted to a specific age category [23].

The current study demonstrated an almost equal gender distribution among participants; however, male children were significantly more likely to have XDR typhoid fever than females. Similar male predominance among typhoid cases has been reported in studies from Pakistan and neighboring countries, possibly reflecting greater environmental exposure and healthcare-seeking patterns among boys [24,25]. Nevertheless, gender-related differences in XDR typhoid have not been consistently reported across studies, suggesting that local sociocultural and environmental factors may influence these findings.

One of the most important findings of the present study was the significant association between lower maternal educational status and XDR typhoid fever. More than half of XDR cases belonged to children whose mothers were illiterate. Maternal education has repeatedly been identified as a key determinant of childhood health outcomes because it influences hygiene practices, food safety behavior, awareness regarding disease prevention, and healthcare utilization [26]. Likewise, children from low socioeconomic households were significantly more likely to develop XDR typhoid. Poor socioeconomic conditions are associated with overcrowding, inadequate sanitation, unsafe drinking water, and limited access to

preventive healthcare, all of which facilitate the transmission of enteric pathogens and contribute to the persistence of typhoid fever in endemic areas [27].

Typhoid immunization status exhibited one of the strongest associations with XDR typhoid in the present study. Only 9.5% of XDR patients had been vaccinated compared with more than half of patients in the non-XDR group. Several recent studies have demonstrated the effectiveness of typhoid conjugate vaccines (TCVs) in reducing laboratory-confirmed typhoid fever, including infections caused by XDR strains [28,29]. Following the introduction of TCV into Pakistan's Expanded Programme on Immunization, significant reductions in XDR typhoid incidence have been reported, emphasizing the critical role of vaccination as a preventive strategy in high-burden settings [28].

The source of drinking water was another significant factor associated with XDR typhoid fever. Children consuming tap water had a significantly higher frequency of XDR infection than those using well water. This finding may reflect contamination of municipal water supplies resulting from deficiencies in sanitation infrastructure and sewage management. Previous outbreak investigations in Pakistan have similarly identified contaminated water supplies as a major contributor to the transmission of drug-resistant Salmonella Typhi [20,30].

Regarding clinical presentation, fever was present in all patients, while nausea/vomiting, headache, loss of appetite, cough, and diarrhea were among the most frequently reported symptoms. These findings are consistent with the typical clinical manifestations of typhoid fever described in the literature [1,31]. Furthermore, nausea/vomiting, loss of appetite, and cough were significantly more common among patients with XDR typhoid. Although these symptoms are not specific for antimicrobial resistance, their higher prevalence in XDR cases may indicate more severe or prolonged illness resulting from ineffective empirical treatment and delayed pathogen clearance.

The antimicrobial susceptibility profile observed in this study is particularly concerning. Resistance rates exceeded 50% for all five tested antibiotics, with ampicillin resistance reaching 91.3%. High resistance rates to chloramphenicol, ciprofloxacin, trimethoprim-sulfamethoxazole, and ceftriaxone were also observed. Similar resistance patterns have been documented in other Pakistani studies, which reported the continuing expansion of the H58 lineage of Salmonella Typhi carrying multiple antimicrobial resistance determinants [19,32]. The high level of ceftriaxone resistance observed in the current study is especially alarming because ceftriaxone remains one of the principal therapeutic agents for severe typhoid fever in many healthcare facilities.

The overall frequency of XDR typhoid fever in this study (53.6%) is lower than some outbreak reports from Sindh that documented very high proportions of ceftriaxone-resistant isolates but remains substantially high from a public health perspective [20]. The persistence of such a high burden several years after the initial outbreak indicates ongoing transmission of resistant strains and highlights the need for strengthened surveillance systems, rational antibiotic prescribing practices, improved sanitation, and expanded vaccination coverage.

The findings of this study should be interpreted in light of certain limitations. Being a single-center study, the results may not be generalizable to all regions of Pakistan. In addition, the cross-sectional design limits causal inference regarding factors associated with XDR typhoid. Nevertheless, the study provides valuable local epidemiological data regarding antimicrobial resistance patterns and factors associated with XDR typhoid fever among children presenting to a major tertiary care hospital.

Conclusion

Extensively drug-resistant typhoid fever constituted more than half of all typhoid cases in the study population, indicating a substantial burden of antimicrobial resistance among pediatric patients. Male gender, low maternal educational status, poor socioeconomic conditions, lack of typhoid immunization, use of tap water, and the presence of nausea/vomiting, loss of appetite, and cough were significantly associated with XDR typhoid fever. Resistance to commonly used antibiotics, including ampicillin, ceftriaxone, ciprofloxacin, chloramphenicol, and trimethoprim-sulfamethoxazole, was alarmingly high. Strengthening typhoid conjugate vaccine coverage, improving water and sanitation infrastructure, promoting antimicrobial stewardship, and maintaining continuous surveillance of resistance patterns are essential to control the spread of XDR typhoid and improve pediatric health outcomes.

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