

Antibiotic Sensitivity Pattern of *Salmonella typhi* and *Salmonella paratyphi*: Cross Sectional Study in a Tertiary Care Hospital

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ABSTRACT

Background: Enteric fever caused by *Salmonella typhi* and *Salmonella paratyphi* remains an important public health concern, while increasing antimicrobial resistance threatens effective treatment. Local surveillance of susceptibility patterns is therefore essential for guiding appropriate antimicrobial therapy.

Aim of the study: To determine and compare the antibiotic sensitivity patterns of clinical *S. typhi* and *S. paratyphi* isolates obtained from patients Dhaka, Bangladesh.

Methods: A cross-sectional observational study was conducted among 100 confirmed clinical isolates of *S. typhi* or *S. paratyphi*. Isolates were identified using standard microbiological and serological methods. Antimicrobial susceptibility was determined by the Kirby–Bauer disk diffusion method according to applicable CLSI recommendations for ampicillin, chloramphenicol, cotrimoxazole, ciprofloxacin, cefixime, ceftriaxone, and azithromycin. MDR was defined as resistance to at least one antimicrobial agent in three or more relevant antimicrobial classes. Data were analyzed using SPSS version 26.0, with $p < 0.05$ considered statistically significant.

Result: Overall, susceptibility was highest to ceftriaxone (91.0%) and azithromycin (86.0%), followed by cefixime (72.0%). Resistance was highest to ciprofloxacin (70.0%), followed by ampicillin (52.0%), chloramphenicol (47.0%), and cotrimoxazole (47.0%). *S. paratyphi* showed higher susceptibility than *S. typhi* to all tested antibiotics, although none of the differences were statistically significant. Susceptibility to ceftriaxone was 96.7% among *S. paratyphi* and 88.6% among *S. typhi* ($p = 0.188$), while azithromycin susceptibility was 90.0% and 84.3%, respectively ($p = 0.458$). MDR was identified in 58.6% of *S. typhi* and 46.7% of *S. paratyphi* isolates.

Conclusion: The study identified a substantial burden of antimicrobial resistance among typhoidal *Salmonella* isolates in Dhaka, particularly against ciprofloxacin and traditional first-line agents. Ceftriaxone and azithromycin retained comparatively high activity. Continued local susceptibility surveillance and culture-guided antimicrobial selection are essential to support effective management and antimicrobial stewardship.

Keywords: *Salmonella typhi*; *Salmonella paratyphi*; enteric fever; antimicrobial susceptibility; antibiotic resistance; multidrug resistance; Bangladesh.

I. INTRODUCTION

Typhoid and paratyphoid fever are systemic enteric infections caused by *Salmonella enterica* serovars Typhi and Paratyphi, respectively, and are transmitted predominantly through ingestion of food or water contaminated with human fecal material [1,2]. The infections are characterized by prolonged fever and systemic manifestations and may progress to bacteremia, intestinal complications, and death in severe cases [1,2]. Globally, *Salmonella typhi* accounted for 76.3% of all enteric-fever cases [3]. Globally, *Salmonella typhi* was responsible for 76.3% of enteric-fever cases [3]. In Bangladesh, *S. typhi* represented 86.4% and *S. paratyphi* 13.6% of laboratory-confirmed enteric fever isolates [4]. Effective antimicrobial therapy remains central to the management of enteric fever, and antibiotic sensitivity testing is important for identifying appropriate treatment options when a clinical isolate is recovered [2,5]. Blood culture remains the principal laboratory method for confirming enteric fever and allows identification of the infecting serovar followed by antibiotic sensitivity testing [5]. The traditional first-line agent chloramphenicol, ampicillin, and trimethoprim-sulfamethoxazole have become less reliable because of resistance among *S. typhi* isolates [6]. In addition, reduced susceptibility and resistance to

fluoroquinolones have limited the clinical usefulness of this antimicrobial class for enteric fever treatment [7]. Moreover, antimicrobial resistance patterns may vary by serovar and over time, with persistent fluoroquinolone nonsusceptibility reported among both Typhi and Paratyphi isolates. Such variation emphasizes the need for continued local surveillance and reassessment of empirical treatment recommendations to preserve effective therapeutic options [8,9]. Consequently, determining the antibiotic sensitivity of circulating clinical isolates is important for informing antimicrobial selection and supporting local antimicrobial resistance surveillance. Antimicrobial resistance among typhoidal *Salmonella* in Bangladesh has involved multiple antibiotic classes. *S. typhi* isolates from Bangladesh have demonstrated multidrug resistance involving ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole [6]. Antimicrobial susceptibility investigations have demonstrated reduced fluoroquinolone susceptibility in both *S. typhi* and *S. paratyphi*, together with resistance to multiple antimicrobial agents among clinical isolates [7, 10]. Ceftriaxone-resistant *S. typhi* has also been reported, indicating resistance to a third-generation cephalosporin used for enteric fever therapy [11]. In addition, antimicrobial resistance has been observed in both *S. typhi* and *S. paratyphi*, with distinct susceptibility profiles among the isolates evaluated [7,10,12,13]. Therefore, susceptibility findings from one healthcare setting may not necessarily reflect the resistance patterns of isolates encountered in another. Despite documented antimicrobial resistance among typhoidal *Salmonella* in Bangladesh, comparative data on the antibiotic sensitivity of *S. typhi* and *S. paratyphi* clinical isolates from Dhaka remain limited. Determining whether these two serovars differ in their sensitivity to commonly tested antibiotics may provide clinically relevant local information for antimicrobial selection and resistance surveillance. Therefore, the objective of the study was to determine and compare the antibiotic sensitivity patterns of clinical isolates of *S. typhi* and *S. paratyphi* obtained from patients Dhaka, Bangladesh.

II. METHODOLOGY & MATERIALS

This cross-sectional observational study was conducted in the Department of Medicine of Dhaka National Medical College, Dhaka, Bangladesh, from March 2024- September 2024. A total of 100 clinical isolates identified as *Salmonella typhi* or *Salmonella paratyphi* were included consecutively according to predefined inclusion and exclusion criteria.

Inclusion Criteria

- Clinical specimens yielding confirmed *Salmonella typhi* or *Salmonella paratyphi* isolates.
- Age ≥ 18 years.
- Patients who provided informed consent for participation and use of relevant clinical information.

Exclusion Criteria

- Isolates other than *Salmonella typhi* or *Salmonella paratyphi*.
- Isolates with incomplete microbiological or clinical information.
- Patients who declined participation.

Ethical Considerations

The study protocol was reviewed and approved by the institutional ethics committee of the study hospital. Written informed consent was obtained from eligible participants before enrollment. Patient identities and clinical information were kept confidential and were used solely for research purposes. All microbiological procedures were performed according to standard laboratory bio-safety practices.

Data Collection

Demographic and clinical information was collected using a structured data collection form through patient interviews and review of clinical records. Variables included age, gender, residence, educational status, occupation, duration of fever, presenting symptoms, and history of previous antibiotic use. Clinical symptoms assessed included fever, headache, abdominal pain, diarrhea, vomiting, and constipation.

Clinical specimens were collected aseptically and processed using standard microbiological procedures. *Salmonella* isolates were identified based on colony morphology, Gram staining, relevant biochemical characteristics, and appropriate serological identification methods. Confirmed isolates were classified as *Salmonella typhi* or *Salmonella paratyphi* for subsequent analysis.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the standard Kirby–Bauer disk diffusion method on Mueller–Hinton agar, following applicable Clinical and Laboratory Standards Institute (CLSI) recommendations. The antibiotics evaluated were ampicillin, chloramphenicol, cotrimoxazole, ciprofloxacin, cefixime, ceftriaxone, and azithromycin. After incubation under standardized laboratory conditions, inhibition

zones were measured and interpreted as susceptible, intermediate, or resistant according to the relevant CLSI breakpoints.

Multidrug resistance (MDR) was assessed according to the predefined study criteria, based on resistance to at least one antimicrobial agent in three or more relevant antimicrobial classes. Species-specific susceptibility patterns were subsequently compared between *S. typhi* and *S. paratyphi* isolates.

Statistical Analysis

All collected information was entered into a structured database and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Categorical variables were presented as frequencies and percentages. Antibiotic susceptibility was summarized according to susceptible, intermediate, and resistant categories. Species-wise susceptibility patterns and MDR status were compared between *S. typhi* and *S. paratyphi*. Appropriate tests of association, including the chi-square test or Fisher's exact test where applicable, were planned for categorical comparisons. A two-sided p-value of <0.05 was considered statistically significant.

III. RESULT

Table 1: Sociodemographic characteristics of the study participants (n=100)

Variables	Frequency (n)	Percentage (%)
Age group (years)		
≤20	18	18.0
21–30	32	32.0
31–40	24	24.0
41–50	16	16.0
>50	10	10.0
Gender		
Male	61	61.0
Female	39	39.0
Residence		
Urban	72	72.0
Rural	28	28.0
Educational status		
No formal education	12	12.0
Primary	21	21.0
Secondary	34	34.0
Higher secondary/Graduate	33	33.0
Occupation		
Student	24	24.0
Service holder	20	20.0
Business	18	18.0
Homemaker	25	25.0
Other	13	13.0

The largest proportion of participants belonged to the 21–30 years age group (32.0%), followed by 31–40 years (24.0%) and ≤20 years (18.0%). Participants aged 41–50 years and >50 years accounted for 16.0% and 10.0%, respectively. Males predominated over females (61.0% and 39.0%). Most participants were from urban areas (72.0%), while 28.0% were from rural areas. Regarding educational status, secondary education was most common (34.0%), followed by higher secondary/graduate education (33.0%). Homemakers constituted the largest occupational group (25.0%), followed by students (24.0%), service holders (20.0%), businesspersons (18.0%), and other occupations (13.0%) (Table 1)

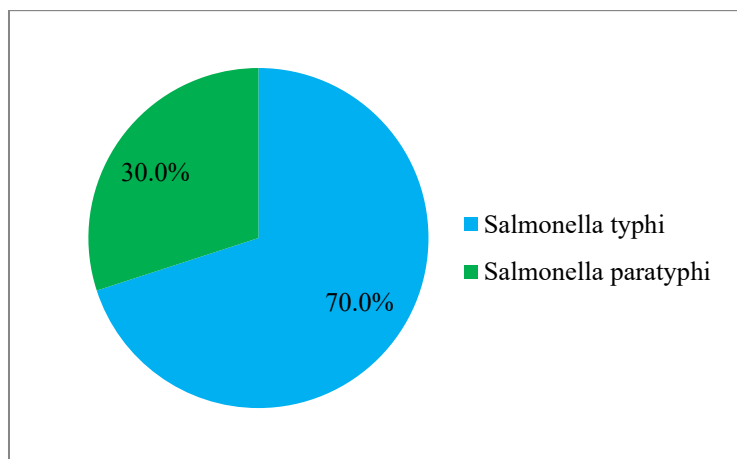


Figure 1: Distribution of *Salmonella* species among the clinical isolates (n=100)

Salmonella typhi was the predominant species among the clinical isolates, accounting for 70.0%, whereas *Salmonella paratyphi* accounted for 30.0% (Figure 1)

Table 2: Clinical characteristics of the study participants (n=100)

Variables	Frequency (n)	Percentage (%)
Total Duration of fever		
≤7 days	42	42.0
8–14 days	39	39.0
>14 days	19	19.0
Presenting symptoms		
Fever	100	100
Headache	63	63.0
Abdominal pain	57	57.0
Diarrhea	45	45.0
Vomiting	29	29.0
Constipation	18	18.0

Regarding clinical characteristics, fever duration of ≤7 days was reported in 42.0% of participants, followed by 8–14 days (39.0%) and >14 days (19.0%). Fever was reported in all participants, while headache, abdominal pain, diarrhea, vomiting, and constipation were present in 63.0%, 57.0%, 45.0%, 29.0%, and 18.0%, respectively (Table 2).

Table 3: Association Antibiotic susceptibility pattern of *Salmonella* isolates (n=100)

Variables	Sensitive		Intermediate		Resistant	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Ampicillin	42	42.0	6	6.0	52	52.0
Chloramphenicol	48	48.0	5	5.0	47	47.0
Cotrimoxazole	46	46.0	7	7.0	47	47.0
Ciprofloxacin	18	18.0	12	12.0	70	70.0
Cefixime	72	72.0	8	8.0	20	20.0
Ceftriaxone	91	91.0	4	4.0	5	5.0
Azithromycin	86	86.0	7	7.0	7	7.0

The antibiotic susceptibility pattern showed that ceftriaxone had the highest susceptibility rate (91.0%), followed by azithromycin (86.0%) and cefixime (72.0%). Susceptibility to chloramphenicol, cotrimoxazole, and ampicillin was 48.0%, 46.0%, and 42.0%, respectively. Ciprofloxacin demonstrated the lowest susceptibility (18.0%) and the highest resistance (70.0%). Ampicillin showed 52.0% resistance, while chloramphenicol and cotrimoxazole each showed 47.0% resistance. Intermediate susceptibility was highest for cefixime (8.0%) and lowest for ceftriaxone (4.0%) (Table 3).

Table 4: Species-wise antibiotic susceptibility pattern of *Salmonella* isolates

Variables	<i>Salmonella typhi</i> (Sensitive)		<i>Salmonella paratyphi</i> (Sensitive)		Chi-square (χ^2)	p-value
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)		
Ampicillin	27	38.6	15	50.0	1.11	0.292
Chloramphenicol	32	45.7	16	53.3	0.46	0.497
Cotrimoxazole	30	42.9	16	53.3	0.94	0.332
Ciprofloxacin	11	15.7	7	23.3	0.82	0.365
Cefixime	48	68.6	24	80.0	1.35	0.245
Ceftriaxone	62	88.6	29	96.7	1.73	0.188
Azithromycin	59	84.3	27	90.0	0.55	0.458

Species-wise analysis showed higher susceptibility among *Salmonella paratyphi* for all tested antibiotics. Susceptibility to ampicillin was 50.0% among *S. paratyphi* and 38.6% among *S. typhi* ($p=0.292$). For chloramphenicol, susceptibility was 53.3% and 45.7%, respectively ($p=0.497$), while for cotrimoxazole it was 53.3% and 42.9%, respectively ($p=0.332$). Ciprofloxacin susceptibility was 23.3% and 15.7%, respectively ($p=0.365$). For cefixime, susceptibility was 80.0% and 68.6%, respectively ($p=0.245$), while ceftriaxone showed susceptibility of 96.7% and 88.6%, respectively ($p=0.188$). Azithromycin susceptibility was 90.0% and 84.3%, respectively ($p=0.458$). None of these differences were statistically significant (Table 4).

Table 5: Multidrug resistance pattern among *Salmonella* isolates according to species (n=100)

Resistance status	<i>Salmonella typhi</i>		<i>Salmonella paratyphi</i>	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Non-MDR	29	41.4	16	53.3
MDR	41	58.6	14	46.7

The MDR pattern showed that MDR was more frequent among *Salmonella typhi* isolates (58.6%) than *Salmonella paratyphi* isolates (46.7%). Conversely, non-MDR isolates were more common among *Salmonella paratyphi* (53.3%) than *Salmonella typhi* (41.4%), indicating a higher MDR proportion among *S. typhi* isolates (Table 5).

IV. DISCUSSION

Antibiotic sensitivity testing is an essential microbiological approach for determining the susceptibility of bacterial isolates to antimicrobial agents and for guiding appropriate antibiotic selection, particularly for clinically important *Salmonella Typhi* and *Salmonella Paratyphi* isolates [14]. The present cross-sectional study evaluated the distribution and antibiotic susceptibility patterns of *Salmonella Typhi* and *Salmonella Paratyphi* isolated from clinical specimens. Regarding sociodemographic characteristics, participants aged 21–30 years constituted the largest age group (32.0%), followed by those aged 31–40 years (24.0%) and ≤ 20 years (18.0%). Males were more frequently represented than females (61.0% vs. 39.0%), while 72.0% of participants were urban residents. The predominance of young adults may be related to greater exposure to contaminated food and water outside the home, occupational or educational mobility, and frequent interaction within densely populated urban environments. The relatively high proportion of students (24.0%) and service holders (20.0%) further supports the possibility of substantial exposure through communal environments [15]. Among the 100 isolates, *S. Typhi* predominated, accounting for 70.0%, while *S. Paratyphi* accounted for 30.0%. This predominance of *S. Typhi* is consistent with the established epidemiology of enteric fever in urban Bangladesh, where typhoid remains an important public health problem. Previous surveillance from Dhaka has also demonstrated a greater frequency of *S. Typhi* compared with *S. Paratyphi* in urban settings [15]. The higher proportion of *S. Typhi* in the present study may reflect the dense population, high population mobility, and persistent challenges related to water, sanitation, and food hygiene. WHO identifies contaminated food and water, inadequate sanitation, and urban overcrowding as important factors facilitating typhoid transmission [16]. Clinically, fever was present in all participants, while headache (63.0%) and abdominal pain (57.0%) were the most frequent accompanying symptoms. Diarrhea was reported in 45.0%, vomiting in 29.0%, and constipation in 18.0%. These findings are compatible with the recognized clinical spectrum of enteric fever, in which prolonged fever, headache, abdominal symptoms, vomiting, constipation, or diarrhea may occur [17]. Most patients had fever for ≤ 7 days (42.0%), whereas 39.0% had fever for 8–14 days and 19.0% had symptoms for > 14 days. Importantly, 38.0% reported previous antibiotic use. Prior antimicrobial exposure may contribute to selection of resistant organisms and may also influence the susceptibility profile of subsequently isolated strains [18]. A major finding of this study was the marked resistance to ciprofloxacin, with only 18.0% of isolates remaining susceptible and 70.0% classified as resistant. This finding is consistent with the long-standing pattern of fluoroquinolone resistance among *S. Typhi* in Bangladesh. A 24-year surveillance study in Bangladesh reported persistent ciprofloxacin non-susceptibility exceeding 90% among *S. Typhi* isolates [19]. Similarly, earlier Dhaka surveillance demonstrated substantially reduced ciprofloxacin susceptibility among *S. Typhi*. Therefore, the very low ciprofloxacin susceptibility observed in the present Dhaka

isolates indicates that fluoroquinolones may have limited value for empirical treatment in this setting [20]. The traditional first-line agents also demonstrated considerable resistance. Ampicillin showed 52.0% resistance, while chloramphenicol and cotrimoxazole each showed 47.0% resistance. However, these findings should be interpreted in light of recent Bangladesh surveillance, which has documented a gradual decline in resistance to these older agents among *S. Typhi*. The relatively high resistance observed in the present study may therefore reflect the local epidemiological characteristics of isolates or differences in study population and sampling period [19]. In contrast, ceftriaxone demonstrated the highest susceptibility (91.0%), followed by azithromycin (86.0%) and cefixime (72.0%). These findings are clinically important because third-generation cephalosporins and azithromycin remain important therapeutic options in settings with substantial fluoroquinolone resistance. WHO recommends ceftriaxone and azithromycin as first-choice options for enteric fever in settings with high fluoroquinolone resistance [21]. Bangladesh surveillance has similarly reported very low ceftriaxone resistance and low azithromycin resistance among *S. Typhi* [19]. However, continued monitoring remains necessary because resistance to these drugs has emerged in different regions and could progressively narrow treatment options [21]. Species-wise comparison showed that *S. Paratyphi* had somewhat higher susceptibility than *S. Typhi* to all tested antibiotics. Ceftriaxone susceptibility was 96.7% among *S. Paratyphi* compared with 88.6% among *S. Typhi*, while azithromycin susceptibility was 90.0% and 84.3%, respectively. Nevertheless, none of these differences reached statistical significance (all $p > 0.05$). This pattern agrees with long-term Bangladeshi surveillance showing that *S. Paratyphi A* has generally remained more susceptible to several conventional antibiotics than *S. Typhi*, with very high susceptibility to ceftriaxone and azithromycin. Thus, the observed species-wise differences may represent an epidemiological trend, although the present sample size may have limited the statistical power to detect significant differences [22]. Finally, MDR was identified in 58.6% of *S. Typhi* isolates compared with 46.7% of *S. Paratyphi* isolates. Although *S. Typhi* showed a higher proportion of MDR, the difference was not statistically evaluated in the presented table. The overall MDR burden remains concerning because multidrug resistance can substantially restrict empirical treatment choices. Nevertheless, recent large-scale surveillance suggests that MDR among *S. Typhi* in Bangladesh has declined over time, emphasizing the importance of continued local surveillance rather than assuming uniform resistance patterns across different hospitals and geographic areas [22].

Limitations of the study: This study has several limitations. Its cross-sectional design and relatively small sample size may limit the generalizability of the findings. Consecutive sampling may also have introduced selection bias. The study evaluated a limited panel of commonly used antibiotics and did not investigate molecular mechanisms or genetic determinants underlying antimicrobial resistance. Clinical outcomes and treatment responses were not systematically assessed. Additionally, information regarding previous antibiotic exposure was partly based on patient-reported history and may therefore be subject to recall bias. The findings should consequently be interpreted within the context of the study population and methodology.

V. CONCLUSION

This study demonstrates substantial antimicrobial resistance among clinical *Salmonella* isolates with particularly high resistance to ciprofloxacin and the traditionally used first-line agents ampicillin, chloramphenicol, and cotrimoxazole. Ceftriaxone and azithromycin demonstrated the highest overall susceptibility, while cefixime showed intermediate activity. Although *S. paratyphi* generally exhibited higher susceptibility than *S. typhi*, none of the species-wise differences reached statistical significance. Importantly, MDR was common in both serovars, underscoring the continuing therapeutic challenge posed by resistant enteric fever. These findings support routine culture-based susceptibility testing, strengthening local antimicrobial resistance surveillance, and judicious antibiotic prescribing to guide effective empirical and definitive treatment of enteric fever in Bangladesh.

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