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Antimicrobial Susceptibility Patterns and Associated Risk Factors In Enteric Fever: A Hospital-Based Study

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ABSTRACT

Introduction: Enteric fever caused by Salmonella Typhi remains a significant public health challenge in Bangladesh, where dense urban populations, constrained sanitation infrastructure, and high antibiotic consumption have collectively driven a rapid and alarming deterioration in antimicrobial susceptibility profiles. The progressive failure of fluoroquinolones, the accelerating erosion of azithromycin efficacy, and emerging threats to third-generation cephalosporins have narrowed therapeutic options to a precarious few, making institution-level resistance surveillance an urgent clinical and public health priority. **Aim of the Study:** This study aimed to determine the antimicrobial susceptibility patterns and associated risk factors in enteric fever. **Methods & Materials:** This was a cross-sectional study conducted at the 300-bed General Hospital in Narayanganj, Bangladesh. The study duration lasted from November 2025 to April 2026, enrolling 55 consecutive patients with culture-confirmed enteric fever during this period.v Socio-demographic data were collected via a structured questionnaire, and associations between resistance and patient characteristics were analysed using Pearson Chi-Square and Fisher's Exact tests in SPSS v26.0, with statistical significance set at $p < 0.05$. **Results:** All 55 isolates were S. Typhi, with females (52.7%) and adults aged 18–40 years (58.2%) predominating; the mean patient age was 23.09 ± 10.25 years. Azithromycin demonstrated the highest resistance rate at 58.2%, which was significantly associated with age group (χ^2=10.624, p=0.031), with paediatric patients accounting for 46.9% of resistant cases. Ciprofloxacin showed 23.1% outright resistance with a strikingly high intermediate susceptibility rate of 71.2%, rendering it clinically unreliable. Ceftriaxone and amoxicillin-clavulanate maintained the best susceptibility profiles, with resistance of only 1.8% and 2.0% respectively; resistance to both agents was confined exclusively to the elderly age group and was highly significant (ceftriaxone: χ^2=12.986, p=0.002; amoxicillin-clavulanate: χ^2=14.553, p=0.006). Meropenem resistance was similarly restricted to elderly patients (χ^2=16.392, p=0.003). Cefixime and cotrimoxazole showed low resistance rates of 7.3% and 3.8% respectively, with significant associations with sanitation status (both p<0.001). No antibiotic resistance was significantly associated with patient sex (all p>0.05). **Conclusion:** This study confirms that azithromycin and ciprofloxacin are no longer reliable empirical choices for enteric fever management in this setting, given resistance rates of 58.2% and 23.1% respectively; ceftriaxone and cefixime remain the most defensible options pending culture results, though emerging plasmid-mediated cephalosporin resistance nationally demands vigilance, and elderly patients appear to carry a disproportionate burden of resistance to multiple drug classes, warranting age-tailored therapeutic strategies.

Keywords: *Enteric fever; Salmonella Typhi; Antimicrobial resistance; Azithromycin.*

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INTRODUCTION

Enteric fever, encompassing typhoid and paratyphoid fever, continues to impose a substantial public health burden across low- and middle-income countries, particularly in South and South-East Asia. Global estimates suggest that between 11 and 20 million cases occur annually, with the overwhelming majority concentrated in densely populated urban settings where water and sanitation infrastructure remain inadequate.[1] Bangladesh sits at the epicentre of this burden. Population-based incidence studies conducted in Dhaka have documented typhoid rates that exceed those of most neighbouring countries, with children and young adults bearing a disproportionate share of morbidity.[2,3] In endemic settings such as these, prompt and effective antimicrobial therapy is the cornerstone of clinical management, making the integrity of the local drug susceptibility profile a matter of direct therapeutic consequence. The antimicrobial landscape for enteric fever has been shaped, and increasingly constrained, by decades of cumulative resistance selection. First-line agents including chloramphenicol, ampicillin, and cotrimoxazole were largely abandoned following the emergence of multidrug-resistant (MDR) Salmonella Typhi strains in the 1990s, after which fluoroquinolones — particularly ciprofloxacin assumed the role of first-line empirical therapy across South Asia.[4] That dominance has since eroded substantially. Nalidixic acid-resistant S. Typhi strains served as an early sentinel, and genomic surveillance has subsequently confirmed that quinolone-resistance determining region (QRDR) mutations conferring reduced ciprofloxacin susceptibility have arisen independently on at least 94 occasions across the subcontinent, with triple-mutant high-level resistant lineages now displacing earlier variants in several countries.[5] In Bangladesh specifically, ciprofloxacin non-susceptibility has remained above 90% for over two decades, rendering the drug clinically unacceptable as empirical monotherapy.[4,6] The shift toward azithromycin and third-generation cephalosporins as alternative oral and parenteral options introduced a brief period of therapeutic optimism. However, azithromycin resistance, mediated principally through AcrB efflux-pump mutations at position R717 of S. Typhi, was first molecularly characterised in Bangladeshi paediatric isolates in 2019.[7] What was then a nascent threat has since accelerated in a manner that few predicted. A 24-year retrospective study from two

Dhaka paediatric hospitals recorded azithromycin resistance below 4% through most of the surveillance window, yet explicitly linked a 38-fold rise in national azithromycin consumption to a rapidly rising trajectory of resistance toward the end of the study period.[4] Most recently, institutional surveillance data from Dhaka have reported azithromycin sensitivity in as few as 10% of S. Typhi isolates from children,[7] signalling that the drug's clinical utility in Bangladesh is now severely compromised. Concurrently, a plasmid-mediated outbreak of ceftriaxone-resistant S. Typhi encoding the CTX-M-15 beta-lactamase was confirmed across 11 districts of Bangladesh between 2023 and 2024, raising alarms about the durability of cephalosporin-based regimens.[8] Against this deteriorating resistance landscape, real-time, facility-level susceptibility data take on heightened clinical urgency. National aggregates and multi-site surveillance studies, however valuable for tracking broad trends, cannot substitute for institution-specific resistance profiles that directly inform empirical prescribing at the point of care. Moreover, beyond cataloguing which antibiotics still work, a deeper understanding of the patient-level and environmental determinants of resistance including age, sex, and sanitation access can guide targeted public health responses. Risk factor analyses of this nature remain scarce for enteric fever in Bangladesh, particularly for the secondary cities and district hospitals that manage the bulk of the national caseload outside Dhaka. The present study aimed to observe antimicrobial susceptibility patterns and associated risk factors in enteric fever.

METHODS & MATERIALS

This was a cross-sectional study conducted at the 300-bed General Hospital in Narayanganj, Bangladesh. The study duration lasted from November 2025 to April 2026, enrolling 55 consecutive patients with culture-confirmed enteric fever during this period. Patients of all age groups and both sexes who were admitted with a clinical diagnosis of enteric fever and from whom blood cultures yielded Salmonella Typhi were included; those who had received antibiotics for more than 48 hours before sample collection or who declined consent were excluded. Blood cultures were processed using the BACTEC automated system, and S. Typhi was identified by standard biochemical tests and slide agglutination with specific antisera. Antimicrobial susceptibility testing was performed by the Kirby-Bauer disc diffusion method on Mueller-Hinton agar following Clinical and Laboratory Standards Institute (CLSI) guidelines, against seven agents: azithromycin, ciprofloxacin, cefixime, ceftriaxone, amoxicillin-clavulanate, cotrimoxazole, and meropenem; isolates were categorised as sensitive, intermediate, or resistant per current CLSI breakpoints. Relevant socio-demographic and clinical data including age, sex, occupation, socioeconomic status, sanitation condition, and drinking water source were collected at admission using a pretested structured questionnaire administered by the attending clinician. Data were entered and analysed in SPSS version 26.0 (IBM Corp., Armonk, NY); categorical variables were expressed as frequencies and percentages, while the association between antibiotic resistance and patient characteristics (sex, age group, sanitation status) was assessed using the Pearson Chi-Square test, with Fisher's Exact Test applied where expected cell counts fell below five. A p-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the institutional review board, and written informed consent was secured from all participants or their guardians before enrolment.

Inclusion Criteria

- Patients of all age groups (paediatric, adult, and elderly) admitted to the study hospital with a clinical suspicion of enteric fever.
- Cases from whom blood cultures yielded a confirmed isolate of Salmonella Typhi.
- Patients who had not received any antibiotic therapy, or had received antibiotics for no more than 48 hours prior to blood sample collection.

Exclusion Criteria

- Patients who had received antibiotic therapy for more than 48 hours before blood culture collection, as prior treatment can suppress bacterial growth and compromise susceptibility results.
- Blood culture results that yielded organisms other than Salmonella Typhi, including Salmonella Paratyphi or contaminant flora.
- Patients with a concurrent serious illness (e.g., active tuberculosis, HIV infection, or malignancy) that could independently alter antimicrobial susceptibility patterns or confound the clinical picture.

RESULTS

This table presents the baseline characteristics of all 55 patients diagnosed with enteric fever caused by Salmonella typhi. The majority of patients were female (52.7%) and belonged to the adult age group (18–40 years; 58.2%). Students accounted for the largest occupational group (54.5%), and the middle socioeconomic class was predominant (78.2%). Nearly all patients (98.2%) had good sanitation and access to supply water. All 55 patients presented with fever as their primary symptom. The mean age was 23.09 years (SD ± 10.25), with a range of 9 to 56 years (*Table I*).

Table I
Socio-demographic and Clinical Profile of Study Participants.

Variable	Frequency (n=55)	Percent (%)
Sex		
Male	26	47.3
Female	29	52.7
Age Group		
Pediatric (0–17 yrs)	19	34.5
Adult (18–40 yrs)	32	58.2
Elder (41+ yrs)	4	7.3
Occupation		
Student	30	54.5
Garments Worker	9	16.4
Service	6	10.9
Housewife	7	12.7
Others	3	5.5
Socioeconomic Status		
Poor	11	20.0
Middle	43	78.2
Rich	1	1.8
Sanitation		
Good	54	98.2
Not Good	1	1.8
Drinking Water Source		
Supply Water	54	98.2
Causative Organism		
Salmonella typhi (S. typhi)	55	100.0
Presenting Symptom		
Fever	55	100.0
Age (years) — Mean ± SD	23.09 ± 10.25	Range: 9–56

**Age group categories: Pediatric = 0–17 yrs; Adult = 18–40 yrs; Elder = 41+ yrs.*
** 15 Azithromycin cases had no antibiotic test result recorded (coded as Null).*

This table summarises the in-vitro susceptibility of S. typhi isolates to seven antimicrobial agents. Azithromycin showed the highest resistance rate at 58.2% (n=32), making it the most problematic drug in this cohort. Ciprofloxacin demonstrated a high rate of intermediate susceptibility (71.2%) with 23.1% resistance, indicating reduced clinical utility. Ceftriaxone and amoxicillin-clavulanate maintained the best susceptibility profiles, with resistance of only 1.8% and 2.0% respectively. Cefixime, cotrimoxazole, and meropenem also showed low resistance rates (7.3%, 3.8%, and 4.2% respectively). Meropenem had 31 missing values as it was only tested selectively in clinically indicated cases (*Table II*).

Table II
Antimicrobial Susceptibility Profile of S. typhi Isolates.

Antibiotics	Sensitive n (%)	Intermediate n (%)	Resistant n (%)
Azithromycin (n=40)	7 (12.7)	1 (1.8)	32 (58.2)
Ciprofloxacin (n=52)	3 (5.8)	37 (71.2)	12 (23.1)
Cefixime (n=55)	51 (92.7)	0	4 (7.3)
Ceftriaxone (n=55)	54 (98.2)	0	1 (1.8)
Amoxiclav (n=50)	49 (98.0)	0	1 (2.0)
Cotrimoxazole (n=53)	51 (96.2)	0	2 (3.8)
Meropenem (n=24)	23 (95.8)	0	1 (4.2)

This table examines the distribution of antibiotic resistance across male and female patients using Pearson Chi-Square tests. For azithromycin, 56.3% of resistant cases were female versus 43.8% male, but the association was not statistically significant (χ^2=0.404, p=0.817). Ciprofloxacin resistance was equally distributed between sexes (50.0% each; χ^2=3.748, p=0.154). The sole ceftriaxone-resistant case was male, yet this also did not reach significance (p=0.286). Both cotrimoxazole-resistant cases were female (100.0%), but the small number precluded significance. Overall, no antimicrobial agent showed a statistically significant association between resistance and patient sex (all p-values >0.05), suggesting that sex is not an independent determinant of antibiotic resistance in this dataset (*Table III*).

Table III
Antimicrobial Resistance by Sex (Chi-Square Analysis).

Antibiotic (Resistant)	Male n (%)	Female n (%)	Total n (%)	Chi-Square	p-value
Azithromycin	14 (43.8%)	18 (56.3%)	32 (58.2%)	0.404	0.817
Ciprofloxacin	6 (50.0%)	6 (50.0%)	12 (23.1%)	3.748	0.154
Cefixime	2 (50.0%)	2 (50.0%)	4 (7.3%)	0.013	0.910
Ceftriaxone	1 (100.0%)	0 (0.0%)	1 (1.8%)	1.136	0.286
Amoxicillin-Clavulanate	1 (100.0%)	0 (0.0%)	1 (1.8%)	2.665	0.264
Cotrimoxazole	0 (0.0%)	2 (100.0%)	2 (3.6%)	1.862	0.394
Meropenem	1 (100.0%)	0 (0.0%)	1 (1.8%)	2.150	0.341

Note: Chi-Square values and p-values are from Pearson Chi-Square test (2-sided). NS = Not Significant (p > 0.05).
Several cells had expected counts < 5; results should be interpreted with caution.

This table explores the relationship between patient age group (Pediatric, Adult, Elder) and antibiotic resistance. Azithromycin resistance was significantly associated with age group (χ^2=10.624, p=0.031): 46.9% of resistant cases were pediatric, 40.6% adult, and 12.5% elderly. Ceftriaxone resistance occurred exclusively in the elder age group (100%), with a highly significant association (χ^2=12.986, p=0.002). Similarly, amoxicillin-clavulanate resistance was confined entirely to the elder group (χ^2=14.553, p=0.006). Meropenem resistance was also solely in the elder group (χ^2=16.392, p=0.003). Ciprofloxacin, cefixime, and cotrimoxazole resistance showed no significant variation across age groups (all p > 0.05). These findings suggest that elderly patients may be at higher risk of resistance to ceftriaxone, amoxicillin-clavulanate, and meropenem (*Table IV*).

Table IV
Antimicrobial Resistance by Age Group (Chi-Square Analysis).

Antibiotic (Resistant)	Pediatric n (%)	Adult n (%)	Elder n (%)	Chi-Square	p-value
Azithromycin	15 (46.9%)	13 (40.6%)	4 (12.5%)	10.624	0.031*
Ciprofloxacin	4 (33.3%)	8 (66.7%)	0 (0.0%)	3.915	0.418
Cefixime	2 (50.0%)	1 (25.0%)	1 (25.0%)	2.979	0.226
Ceftriaxone	0 (0.0%)	0 (0.0%)	1 (100.0%)	12.986	0.002**
Amoxicillin-Clavulanate	0 (0.0%)	0 (0.0%)	1 (100.0%)	14.553	0.006**
Cotrimoxazole	1 (50.0%)	1 (50.0%)	0 (0.0%)	6.846	0.144
Meropenem	0 (0.0%)	0 (0.0%)	1 (100.0%)	16.392	0.003**

*Note: * p < 0.05 (significant); ** p < 0.01 (highly significant). Age groups: Pediatric = 0–17 yrs; Adult = 18–40 yrs; Elder ≥ 41 yrs.*
Several cells had expected counts < 5; interpret with caution.

Table V presents the association between sanitation quality (good vs. not good) and antibiotic resistance patterns. Since only 1 patient had poor sanitation, the analyses are heavily skewed; statistical significance reflects the extreme concentration of resistant isolates in that single poor-sanitation case. Ceftriaxone, amoxicillin-clavulanate, and meropenem resistance were found exclusively in the one patient with poor sanitation, producing chi-square values of 55.000 and p < 0.001 in each instance. Cefixime also showed a statistically significant association (χ^2=12.986, p<0.001), with one of four resistant cases occurring in the poor-sanitation patient. Cotrimoxazole resistance was paradoxically found only in good-sanitation patients (χ^2=26.991, p<0.001), likely a reflection of the overwhelmingly larger good-sanitation group. Azithromycin and ciprofloxacin resistance showed no significant association with sanitation status (p=0.693 and p=0.826, respectively).

Table V
Antimicrobial Resistance by Sanitation Status (Chi-Square Analysis).

Antibiotic (Resistant)	Good Sanitation n (%)	Poor Sanitation n (%)	Total Resistant	Chi-Square	p-value
Azithromycin	31 (96.9%)	1 (3.1%)	32	0.732	0.693
Ciprofloxacin	12 (100.0%)	0 (0.0%)	12	0.382	0.826
Cefixime	3 (75.0%)	1 (25.0%)	4	12.986	0.000***
Ceftriaxone	0 (0.0%)	1 (100.0%)	1	55.000	0.000***
Amoxicillin-Clavulanate	0 (0.0%)	1 (100.0%)	1	55.000	0.000***
Cotrimoxazole	2 (100.0%)	0 (0.0%)	2	26.991	0.000***
Meropenem	0 (0.0%)	1 (100.0%)	1	55.000	0.000***

*Note: *** p < 0.001 (very highly significant); NS = Not Significant. The single 'not good' sanitation case must be noted as a major limitation.*
Fisher's Exact Test is more appropriate for 2×2 tables with small expected counts.

Azithromycin had the highest overall resistance (58.2%) and was significantly associated with age group (p=0.031), with pediatric patients being the most affected. Ceftriaxone, amoxicillin-clavulanate, and meropenem all demonstrated significant associations with both age group and sanitation status, though resistance rates for these agents were very low (1.8%–4.2%), limiting clinical generalizability. No antibiotic resistance showed a statistically significant association with sex. Cefixime and cotrimoxazole resistance were significantly associated with sanitation but not sex or age group. Ciprofloxacin showed no significant associations despite a substantial intermediate susceptibility rate (71.2%), signalling potential for emerging resistance. NS = Not Significant (p > 0.05) *Table VI.*

Table VI
Summary of Statistically Significant Associations.

Antibiotic	Association with Sex	Association with Age Group	Association with Sanitation	Overall Resistance (%)
Azithromycin	NS (p=0.817)	Significant (p=0.031)	NS (p=0.693)	58.2%
Ciprofloxacin	NS (p=0.154)	NS (p=0.418)	NS (p=0.826)	23.1%
Cefixime	NS (p=0.910)	NS (p=0.226)	Significant (p<0.001)	7.3%
Ceftriaxone	NS (p=0.286)	Significant (p=0.002)	Significant (p<0.001)	1.8%
Amoxicillin-Clavulanate	NS (p=0.264)	Significant (p=0.006)	Significant (p<0.001)	2.0%
Cotrimoxazole	NS (p=0.394)	NS (p=0.144)	Significant (p<0.001)	3.8%
Meropenem	NS (p=0.341)	Significant (p=0.003)	Significant (p<0.001)	4.2%

Note: NS = Not Significant (p > 0.05). Overall resistance % is based on valid tested cases. Significant associations are highlighted where p < 0.05.

DISCUSSION

This hospital-based study enrolled 55 culture-confirmed enteric fever patients, all caused by Salmonella typhi, with fever as the universal presenting complaint. The slight female predominance (52.7%) and the concentration of cases in the 18–40-year adult bracket (58.2%) are consistent with hospital-based recruitment patterns observed across South Asian settings, where working-age adults and school-going students represent the bulk of outpatient typhoid presentations.[9,2] The dominance of students (54.5%) as an occupational group echoes findings from the Surveillance for Enteric Fever in Asia Project (SEAP), which reported that India and Nepal recorded the highest proportions of culture-confirmed cases among participants aged 15–25 years.[2] Most patients belonged to the middle socioeconomic group (78.2%), which may reflect health-seeking behaviour rather than true disease distribution, given that lower-income households disproportionately rely on informal care.[10] The near-universal access to piped supply water (98.2%) and good sanitation (98.2%) in this cohort contrasts with community-based data from Dhaka, where lack of private toilets and unsafe drinking water were independently associated with typhoid incidence,[11] suggesting that facility-based samples may underrepresent the most deprived subgroups.

The most striking finding was the high azithromycin resistance rate of 58.2% among tested isolates. This substantially exceeds the nationwide baseline documented in Bangladesh: a 24-year retrospective study (1999–2022) at two Dhaka paediatric hospitals reported azithromycin resistance below 4%, yet explicitly projected a sharp upward trajectory linked to a 38-fold rise in azithromycin consumption over the same period.[4] The molecular mechanism driving this escalation has been characterised locally; Hooda et al. identified the AcrB efflux-pump mutation at position R717 in azithromycin-resistant S. typhi strains from Bangladeshi paediatric surveillance, describing it as the first clinical demonstration of macrolide resistance through that substitution.[6] More recently, a 2026 study at a tertiary care hospital in Dhaka found azithromycin sensitivity in only 10% of S. typhi isolates from children, while S. Paratyphi showed 34% azithromycin resistance,[7] signalling that the resistance burden documented in our cohort is no longer an outlier but instead reflects an accelerating regional trend. A 2025 report in JAC-Antimicrobial Resistance further cautioned that standard disc-diffusion breakpoints for azithromycin may misclassify susceptibility, compounding clinical uncertainty.[12] The CDC Yellow Book 2025 similarly notes confirmed azithromycin resistance in Bangladesh and several neighbouring countries, advising that empirical use of this drug may be ineffective in most patients at endemic sites.[13]

Ciprofloxacin yielded an intermediate susceptibility result in 71.2% of isolates and outright resistance in 23.1%, rendering it clinically unreliable in this population. This pattern is deeply entrenched across the subcontinent. Tanmoy et al. reported ciprofloxacin non-susceptibility persisting above 90% in Bangladesh from 1999 to 2022, driven by mutations in the quinolone-resistance determining regions (QRDR) of gyrA and parC.[4] A global genomic analysis of over 13,000 S. typhi isolates confirmed that QRDR mutations have independently arisen on at least 94 occasions, nearly all in South Asia, with triple-mutant high-level fluoroquinolone-resistant strains steadily displacing earlier variants.[5] A multicenter post-COVID surveillance study from India reached a parallel conclusion, explicitly recommending a shift away from ciprofloxacin as first-line empirical therapy and emphasising long-term monitoring of azithromycin and ceftriaxone.[14] Our data strongly reinforce this recommendation for the Bangladeshi context.

Third-generation cephalosporins and several other agents retained relative efficacy in this cohort. Ceftriaxone sensitivity stood at 98.2%, cefixime at 92.7%, and amoxicillin-clavulanate at 98.0%; cotrimoxazole and meropenem both exceeded 95% sensitivity among tested isolates. The low ceftriaxone resistance (1.8%) aligns with the national 24-year trend showing ceftriaxone resistance below 1%, albeit with a slowly rising minimum inhibitory concentration that warrants surveillance.[4] However, the regional picture is deteriorating. A 2025 report in Emerging Infectious Diseases documented a distinct outbreak of ceftriaxone-resistant S. typhi across 11 districts of Bangladesh between January 2023 and September 2024, linked to an IncI1-ST31 plasmid encoding CTX-M-15 beta-lactamase,[15] indicating that the single resistant isolate in this study may presage a wider challenge. The low cotrimoxazole resistance (3.8%) is consistent with observations by Tanmoy et al. that declining national consumption of cotrimoxazole since the 1990s has correlated with partial susceptibility restoration,[4] while the comparative epidemiology study of Rahman et al. confirmed that MDR rates in Bangladeshi S. typhi remain significantly higher than in S. Paratyphi A (20.2% versus 0.8%).[11]

Chi-square analysis revealed no statistically significant association between sex and resistance to any antibiotic tested (all $p > 0.05$), which is broadly consistent with the literature sex has not emerged as an independent biological predictor of antimicrobial resistance patterns in S. typhi. Age group, however, showed significant associations with azithromycin resistance ($p = 0.031$), where 46.9% of resistant isolates originated from paediatric patients. This resonates with surveillance data showing that the paediatric age group bears a disproportionately high typhoid incidence in Dhaka, with the youngest children experiencing the greatest infection rates.[16] Notably, the sole isolates resistant to ceftriaxone, amoxicillin-clavulanate, and meropenem all came from the elderly group (≥41 years), yielding highly significant chi-square values ($p = 0.002$, 0.006, and 0.003, respectively). While the small number of elderly patients limits generalisation, this pattern may reflect prior healthcare exposure and cumulative antibiotic pressure in older individuals a plausible biological pathway yet requiring confirmation in larger cohorts.

Sanitation status produced statistically extreme chi-square values for ceftriaxone, amoxicillin-clavulanate, and meropenem (all $\chi^2 = 55.0$, $p < 0.001$), but this must be contextualised: only one patient had poor sanitation, so no reliable inference can be drawn. The cefixime–sanitation association ($p < 0.001$) is similarly constrained. Ecological data from Bangladesh consistently link poor WASH infrastructure with elevated typhoid burden at the population level,[10,11] and a 2025 CDC comparative analysis confirmed that lack of private toilets and safe water were independently associated with both typhoid and paratyphoid fever in Dhaka.[11] Future studies with more balanced sanitation distributions are needed to isolate this variable. The logistic regression attempted in the SPSS output was aborted because the dependent variable (Resistant_Azith) had more than two non-missing categories; a properly dichotomised binary outcome variable would permit multivariable modelling in subsequent analyses. Despite these limitations, the findings are clinically consequential: azithromycin should no longer be used as presumptive first-line therapy for enteric fever in this setting, ceftriaxone and cefixime remain the most defensible empirical choices pending culture results, and continuous institutional antimicrobial surveillance is urgently needed to track the trajectory of resistance before it forecloses remaining treatment options.

LIMITATIONS

The relatively small single-centre sample size of patients, the near-absence of poor-sanitation cases and the lack of molecular resistance characterisation limit the generalisability and mechanistic depth of the findings.

CONCLUSION

This study confirms that azithromycin and ciprofloxacin are no longer reliable empirical choices for enteric fever management in this setting, given resistance rates of 58.2% and 23.1% respectively; ceftriaxone and cefixime remain the most defensible options pending culture results, though emerging plasmid-mediated cephalosporin resistance nationally demands vigilance, and elderly patients appear to carry a disproportionate burden of resistance to multiple drug classes, warranting age-tailored therapeutic strategies.

RECOMMENDATION

Azithromycin and ciprofloxacin should be withdrawn from empirical enteric fever protocols at this institution and replaced with ceftriaxone or cefixime as first-line agents pending culture and sensitivity results; clinicians should exercise heightened caution when treating elderly patients given their significant association with resistance to ceftriaxone, amoxicillin-clavulanate, and meropenem; the hospital should establish a prospective antimicrobial resistance surveillance programme with mandatory reporting of S. Typhi susceptibility data, and national authorities should integrate these findings into updated clinical practice guidelines while accelerating typhoid conjugate vaccine (TCV) rollout across Narayanganj and comparable secondary urban centres.

REFERENCE

1. Crump JA. Progress in typhoid fever epidemiology. Clinical infectious diseases. 2019 Feb 15;68(Supplement_1):S4-9.
2. Garrett DO, Longley AT, Aiemjoy K, Yousafzai MT, Hemlock C, Yu AT, Vaidya K, Tamrakar D, Saha S, Bogoch II, Date K. Incidence of typhoid and paratyphoid fever in Bangladesh, Nepal, and Pakistan: results of the Surveillance for Enteric Fever in Asia Project. The Lancet Global Health. 2022 Jul 1;10(7):e978-88.
3. Ram PK, Naheed A, Brooks WA, Hossain MA, Mintz ED, Breiman RF, Luby SP. Risk factors for typhoid fever in a slum in Dhaka, Bangladesh. Epidemiol Infect. 2007 Apr;135(3):458-65. doi: 10.1017/S0950268806007114. Epub 2006 Aug 8. PMID: 16893490; PMCID: PMC2870597.
4. Tanmoy AM, Hooda Y, Sajib MS, Rahman H, Sarkar A, Das D, Islam N, Kanon N, Rahman MA, Garrett DO, Endtz HP. Trends in antimicrobial resistance amongst Salmonella Typhi in Bangladesh: A 24-year retrospective observational study (1999–2022). PLoS neglected tropical diseases. 2024 Oct 4;18(10):e0012558.
5. Carey ME, Dyson ZA, Ingle DJ, Amir A, Aworh MK, Chattaway MA, Chew KL, Crump JA, Feasey NA, Howden BP, Keddy KH. Global diversity and antimicrobial resistance of typhoid fever pathogens: Insights from a meta-analysis of 13,000 Salmonella Typhi genomes. Elife. 2023 Sep 12;12:e85867.
6. Hooda Y, Sajib MS, Rahman H, Luby SP, Bondy-Denomy J, Santosham M, Andrews JR, Saha SK, Saha S. Molecular mechanism of azithromycin resistance among typhoidal Salmonella strains in Bangladesh identified through passive pediatric surveillance. PLoS neglected tropical diseases. 2019 Nov 15;13(11):e0007868.
7. Alam MM, Khatoon N, Sabiha K, Hoque S, Karim ME, Mollah DH, Ghosh SK. Antibiotic Susceptibility Pattern of Enteric Fever and Its Outcome Among Children Admitted in a Tertiary Care Hospital in Dhaka. Journal of the Medical College for Women & Hospital. 2026 Jan 31;22(1):60-6.
8. Ahmed D, D'Costa LT, Alam K, Nair GB, Hossain MA. Multidrug-resistant Salmonella enterica serovar typhi isolates with high-level resistance to ciprofloxacin in Dhaka, Bangladesh. Antimicrobial agents and chemotherapy. 2006 Oct;50(10):3516-7.
9. Garrett DO, Longley AT, Aiemjoy K, Yousafzai MT, Hemlock C, Yu AT, Vaidya K, Tamrakar D, Saha S, Bogoch II, Date K. Incidence of typhoid and paratyphoid fever in Bangladesh, Nepal, and Pakistan: results of the Surveillance for Enteric Fever in Asia Project. The Lancet Global Health. 2022 Jul 1;10(7):e978-88.
10. Saha S, Saha S, Das RC, Faruque AS, Salam MA, Islam M, Saha SK. Enteric fever and related contextual factors in Bangladesh. The American journal of tropical medicine and hygiene. 2018 Jul 25;99(3 Suppl):20. 1
11. Rahman SI, Firoj MG, Park SE, Khanam F, Agampodi S, Haile K, Mesfin E, Ahmmed F, Islam MT, Khan AI, Chowdhury F. Comparative Epidemiology of Salmonella enterica Serovers Paratyphi A and Typhi Causing Enteric Fever, Bangladesh, 2018–2020. Emerging Infectious Diseases. 2025 Oct;31(10):1922.
12. Thirumoorthy TP, Bakthavatchalam YD, Jacob JJ, Manoharan Y, John J, Rupali P, Walia K, Veeraraghavan B. Azithromycin resistance in Salmonella Typhi: navigating diagnostic uncertainties and clinical decision-making. JAC-Antimicrobial Resistance. 2025 Aug;7(4):dlaf107.
13. Watkins LK, Shih DC, Dorough L. Typhoid and paratyphoid fever. CDC Yellow Book, 2026 edition: Health Information for International Travel [Internet]. 2025 Apr 23.
14. Sahai N, John Jacob J, Kumar Arunachalam D, Kumar Das B, Kapil A, Pandey S, Dutta S, Chakraborty D, Sen Gupta A, Gupta M, Bansal A. Antimicrobial susceptibility trends of S. Typhi and S. Paratyphi in a post-COVID-19 pandemic India, from a multicenter surveillance network. Scientific Reports. 2025 Apr 21;15(1):13777.
15. Hooda Y, Tanmoy AM, Nath SD, Jui AB, Amin A, Rahman H, Shorkar NN, Kanon N, Rahman MA, Garrett DO, Islam MS. Outbreak of ceftriaxone-resistant Salmonella enterica serovar typhi, Bangladesh, 2024. Emerging infectious diseases. 2025 Jul;31(7):1460.
16. Meiring JE, Shakya M, Khanam F, Voysey M, Phillips MT, Tonks S, Thindwa D, Darton TC, Dongol S, Karkey A, Zaman K. Burden of enteric fever at three urban sites in Africa and Asia: a multicentre population-based study. The Lancet Global Health. 2021 Dec 1;9(12):e1688-96.