e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(7); 237-244

Original Research Article

A One-Year Retrospective Study on the Changing Antibiotic Sensitivity Pattern of Salmonella Typhi Isolated from Blood Cultures

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Received: 11-05-2026 / Revised: 19-06-2026 / Accepted: 22-07-2026

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Conflict of interest: Nil

Abstract:

Background: Typhoid fever remains an important public health problem in India, and emerging antimicrobial resistance in Salmonella typhi poses challenges to effective treatment. Local surveillance of antibiotic susceptibility is essential for guiding empirical therapy.

Aim: To evaluate the antibiotic sensitivity pattern of Salmonella Typhi isolated from blood cultures over a one-year period in a tertiary care hospital in Bihar.

Methodology: This hospital-based retrospective observational study was conducted in the Department of Microbiology, Indira Gandhi Institute of Medical Sciences (IGIMS), Patna. A total of 153 blood culture samples from clinically suspected typhoid fever patients were analyzed. Salmonella Typhi isolates were identified by conventional microbiological methods and confirmed using MALDI-TOF MS system. Antimicrobial susceptibility testing was performed using Kirby-Bauer disk diffusion and VITEK 2 AST system according to CLSI guidelines. Data was analyzed using descriptive statistics.

Results: Salmonella Typhi was isolated from 3 of 153 blood culture samples, giving an overall positivity rate of 1.96%. Among the culture-positive cases, the mean age was 17.3 years. All isolates showed 100% sensitivity to ceftriaxone, cefixime, and azithromycin. Ampicillin, cotrimoxazole, and chloramphenicol showed 66.7% sensitivity, while all isolates were resistant to ciprofloxacin and nalidixic acid.

Conclusion: The study showed low Salmonella Typhi blood culture positivity with preserved sensitivity to third-generation cephalosporins and azithromycin. Fluoroquinolone resistance remains a concern, emphasizing the need for continued surveillance, accurate identification, and rational antibiotic use.

Keywords: Salmonella Typhi; Typhoid fever; Blood culture; Antibiotic sensitivity; Antimicrobial resistance; Bihar.

DOI: 10.25258/ijpqa.17.7.33

Introduction

Typhoid fever continues to be a public health problem in many developing countries like India where the environment of poor sanitation, unsafe drinking water, overcrowding and poor hygiene is conducive to the spread of enteric pathogens. Salmonella enterica serovar Typhi (Salmonella Typhi) is a Gram-negative, human-restricted, intracellular pathogen which is transmitted primarily by the faeco–oral route. Although there has been considerable improvement in public health systems and in antimicrobial treatment, typhoid fever remains a major burden for health care systems in developing countries. In the world, it is estimated that there are about 27 million typhoid fever cases per year, with a mortality rate of ~1%, which continues to make it an important disease of public health [1]. Most of these are in the developing countries of Asia where environmental and socio-economic conditions allow for continued disease transmission [2].

India still continues to be one of the countries which has high prevalence rate of typhoid fever, few states have endemic transmission of typhoid fever all year round. Bihar has a high population density, variable access to clean water, lack of sanitation in many rural and peri-urban areas and widespread empirical antibiotic use, creating a conducive environment for persistence and spread of Salmonella Typhi. The persistent presence of typhoid fever in this area highlights the need for ongoing epidemiological surveillance and surveillance of antimicrobial susceptibility that can help direct regional therapeutic and public health measures.

Early diagnosis and prompt effective antimicrobial treatment are crucially important in the successful management of typhoid fever. Traditionally, first-line antibiotics like chloramphenicol, ampicillin, and cotrimoxazole have had excellent clinical efficacy in the treatment of Typhoid fever. But in recent decades the rise and spread of multidrug resistant (MDR) strains have significantly changed the therapeutic landscape [3]. These MDR strains are resistant to all three drugs – chloramphenicol, ampicillin, and cotrimoxazole – leading to treatment failures and more disease burden. As a result, the treatment changed to third generation cephalosporins and, later, fluoroquinolones, and more recently, azithromycin. Interestingly, many Salmonella Typhi isolates are again susceptible to conventional first line antibiotics while there has been a rise in the number of resistances to fluoroquinolones which has become a big clinical challenge. This dynamic evolution of antimicrobial susceptibilities requires ongoing local surveillance to guide the empiric use of antimicrobials and to ensure antimicrobial stewardship [4].

Typhoid fever is sometimes difficult to diagnose clinically owing to its variable, and sometimes non-specific, symptoms. They usually have fever with headache, abdominal pain, loss of appetite, vomiting, diarrhea or constipation, enlarged liver and spleen, and generalized weakness, a combination of symptoms seen in a number of tropical febrile diseases, such as malaria, dengue, leptospirosis and scrub typhus. Therefore, laboratory confirmation is required to make a definitive diagnosis and to appropriately treat the patient with antimicrobial therapy [5]. Despite the availability of other diagnostic techniques, blood culture is still regarded as the "Gold Standard" technique for diagnosis of typhoid fever, as it is the only one that allows definitive isolation of the causative organism and antimicrobial susceptibility testing. Blood culture has a high diagnostic yield in the first week but gradually decreases to about 75%, 60% and 25% in the 2nd, 3rd and 4th weeks of illness, respectively [6]. Thus, collection of samples prior to the initiation of antibiotic therapy significantly enhances the chances of isolating bacteria.

In many resource poor states like Bihar, however, blood culture is poorly used due to lack of laboratory facilities, cost issues, late presentation to hospital and previous antibiotic use prior to hospital admission. All these factors greatly affect culture positivity and the correct microbiological diagnosis. Serological testing like Widal test is still widely performed due to the low cost and availability, but there are issues of sensitivity and specificity, which often leads to false positive and false negative results, affecting the diagnostic reliability. For this reason, empirical antibiotic treatment is often started without microbiological confirmation, which increases the misuse of antibiotics and promotes the development of antimicrobial resistance.

One of the biggest problems in treating typhoid fever is the fast development of antimicrobial resistant Salmonella Typhi strains In the past 20 years, MDR Salmonella Typhi strains, which are resistant to chloramphenicol, ampicillin and cotrimoxazole, have emerged with greater frequency in the world [7]. Later, third generation cephalosporins (3GC) and fluoroquinolones (FQ) emerged as the drugs of choice, but over time, they have built-up resistance, especially to the FQ, which are used indiscriminately and widely [8]. In addition, there is a growing number of isolates with decreased susceptibility to cephalosporins and azithromycin, which further jeopardize the effectiveness of currently available therapeutic options, and underscores the need for antimicrobial surveillance in the region to identify trends in resistance and to guide empirical treatment guidelines.

The antimicrobial susceptibility profile varies in diverse geographical areas, due to differences in prescription habits, availability of antimicrobials, infection control measures, and local epidemiological profile. It is thus important to have periodical regional surveillance to track the evolution of resistance profiles and come up with evidence-based treatment recommendations. Although the incidence of typhoid fever is high in Bihar, little is known about the antibiotic susceptibility pattern of Salmonella Typhi isolated from blood cultures in the region. Local data is important for helping clinicians to make informed therapeutic choices, and also to enhance antimicrobial stewardship efforts to reduce the emergence and spread of resistant strains.

This prompted the present one-year retrospective study of the antibiotic sensitivity pattern of Salmonella Typhi isolated from blood cultures in a tertiary care setting in Bihar, India. The study will also provide valuable regional data on the evolving antimicrobial susceptibility patterns for the study period, which may help in guiding empirical antimicrobial therapy, antibiotic usage policy and help in better management of typhoid fever in this endemic area.

Materials and Methods

Study Design: This study was designed as a hospital-based retrospective observational study to evaluate the changing antibiotic sensitivity pattern of Salmonella Typhi isolated from blood cultures over a one-year period. The study involved retrospective analysis of microbiological laboratory records of patients clinically suspected of enteric fever who underwent blood culture testing. The study primarily assessed blood culture positivity and the antimicrobial susceptibility profile of S. Typhi isolates against commonly used antibiotics.

Study Area: The study was conducted in the Department of Microbiology, Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, Bihar, India.

Study Duration: The study included laboratory records collected over a one-year period.

Sample Size: A total of 153 blood culture samples from patients clinically suspected of typhoid fever were included in the study.

Only culture-positive isolates identified as Salmonella Typhi were included for antimicrobial susceptibility pattern analysis.

Study Population: The study population comprised patients of all age groups and both sexes presenting with clinical features suggestive of enteric (typhoid) fever who underwent blood culture examination at the Department of Microbiology, IGIMS, Patna, during the study period. Blood culture reports and corresponding antimicrobial susceptibility testing records were retrieved from the laboratory database for analysis.

Data Collection: Data were collected retrospectively from the microbiology laboratory records and blood culture registers maintained in the Department of Microbiology. The following information was extracted using a structured data collection format:

- Patient demographic details
- Blood culture results
- Identification of Salmonella Typhi isolates
- Antibiotic susceptibility testing results
- Laboratory accession details

Only complete laboratory records with definitive blood culture reports were included in the analysis. Patient confidentiality was maintained by anonymizing all identifiable information before statistical analysis.

Inclusion Criteria

The following cases were included in the study:

- Patients clinically suspected of typhoid fever whose blood samples were submitted for culture during the study period.
- Blood culture records available with complete microbiological findings.
- Culture-positive isolates confirmed as Salmonella Typhi.
- Cases with complete antimicrobial susceptibility testing results.

Exclusion Criteria

The following cases were excluded from the study:

- Blood culture records with incomplete laboratory information.
- Duplicate blood culture samples from the same patient.
- Blood cultures yielding organisms other than Salmonella Typhi.
- Samples with contaminated cultures or inconclusive microbiological findings.
- Cases lacking antimicrobial susceptibility reports.

Laboratory Procedure: Blood samples collected from clinically suspected enteric fever patients were processed in the Department of Microbiology according to standard laboratory protocols. Blood culture bottles were incubated under appropriate conditions in the BacT/ALERT automated blood culture system and monitored for bacterial growth. Positive blood cultures were subcultured onto MacConkey agar and Salmonella-Shigella (SS) agar and incubated at 37°C for isolation of Salmonella spp.

Identification of Salmonella spp. was carried out using colony morphology, Gram staining characteristics, and standard biochemical reactions routinely employed in the laboratory. Biochemical characterization included catalase test, oxidase test, oxidation fermentation test,indole test,Methyl red test, Voges-Proskauer test, citrate utilization test, urea hydrolysis test and Triple Sugar Iron (TSI) agar testing. The isolates demonstrated a characteristic TSI reaction with an alkaline slant (K) and acid butt (A), along with minimal hydrogen sulphide (H_2S) production producing a distinctive "mustache" or "wisp" appearance and no gas production, findings consistent with Salmonella enterica serovar Typhi (Figure 1).

Figure 1: Triple Sugar Iron (TSI) agar reaction of Salmonella enterica serovar Typhi demonstrating an alkaline slant (K), acid butt (A), absence of gas production, and a characteristic "mustache" (wisp) of hydrogen sulphide (H_2S) production.

Final organism identification was confirmed using matrix-assisted laser desorption ionization–time of flight mass spectrometry (MALDI-TOF MS).

Antimicrobial susceptibility testing (AST) of confirmed Salmonella Typhi isolates was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar and VITEK 2 AST cards, following the Clinical and Laboratory Standards Institute (CLSI) guidelines applicable during the study period. Antibiotics tested included antimicrobial agents for Salmonella spp. available in the laboratory antibiotic panel as per CLSI guidelines . Zone diameters and/or automated minimum inhibitory concentration (MIC)-based results were interpreted as Sensitive (S), Intermediate (I), or Resistant (R) according to CLSI interpretative criteria.

Quality control procedures were performed using recommended American Type Culture Collection (ATCC) reference strains to ensure the accuracy and reliability of organism identification and antimicrobial susceptibility testing throughout the study period.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software (Version 26.0). Descriptive statistics were used to summarize the study findings. Continuous variables, where applicable, were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), while categorical variables were presented as frequencies and percentages. Blood culture positivity rates and antimicrobial susceptibility patterns were calculated as proportions of the total isolates. The distribution of antibiotic sensitivity, intermediate susceptibility, and resistance among Salmonella Typhi isolates was presented using tables and graphical representations. A p-value < 0.05 was considered statistically significant for inferential analyses wherever applicable."

Result

Table 1 presents the gender distribution of the 153 study participants. Overall, males constituted the majority of the study population, accounting for 55.6% (n=85) of cases, while females comprised 44.4% (n=68). Among the 3 culture-positive cases, 66.7% (n=2) were males and 33.3% (n=1) were females. Among the 150 culture-negative cases, 55.3% (n=83) were males and 44.7% (n=67) were females. These findings indicate a slight male predominance among the number of culture-confirmed Salmonella Typhi cases; however, no meaningful gender-based inference can be drawn due to the small number of positive isolates.

Table 1: Gender distribution of cases

Gender	Culture positive cases n (%)	Culture negative cases n (%)	Total number of cases studied n (%)
Male	2 (66.7)	83 (55.3)	85 (55.6)
Female	1 (33.3)	67 (44.7)	68 (44.4)
Total	3 (100.0)	150 (100.0)	153 (100.0)

Table 2 presents the age distribution of the study participants. The mean age of the culture-positive cases was 17.3 years, with a median age of 17 years, indicating that confirmed Salmonella Typhi infection was observed mainly among adolescent and young adult patients in this dataset. Considering the

entire study population, the mean age was 16.2 years, while the median age remained 16 years. Because only three culture-positive cases were detected, age-related trends should be interpreted cautiously.

Table 2: Age distribution of cases		
Cases	**Mean Age (Years)**	**Median Age (Years)**
Culture positive cases	17.3	17
Total number of cases	16.2	16

Table 3 presents the distribution of culture-positive and culture-negative cases according to age group among the 153 study participants. Among patients younger than 15 years (n=31), none were culture positive for Salmonella typhi. In the ≥15 years age group (n=122), 3 patients (2.5%) were culture positive and 119 (97.5%) were culture negative. Overall, Salmonella Typhi was isolated from 3 of 153 blood culture samples, giving an overall culture positivity of 1.96%. This revised positivity rate is within the lower expected range reported for Salmonella isolation from blood cultures in India.

Table 3: Distribution of culture positive cases among total study population			
Age Group (Years)	**Culture Positive Cases N (%)**	**Culture Negative Cases N (%)**	**Total Number Of Cases N (%)**
<15	0 (0.0)	31 (100.0)	31 (100.0)
≥15	3 (2.5)	119 (97.5)	122 (100.0)
Total	3 (1.96)	150 (98.04)	153 (100.0)

Table 4 compares the duration of fever at presentation between culture-positive and culture-negative cases. The mean duration of fever among the 3 culture-positive cases was 8.3 ± 1.5 days, whereas the 150 culture-negative cases had a mean duration of 9.0 ± 2.7 days. Due to the small number of culture-positive isolates, formal comparison has limited interpretability. These findings suggest that duration of fever alone was not sufficient to predict blood culture positivity in the present study.

Table 4: Comparison of duration of fever at presentation in culture positive and negative cases		
Group	**Average duration of fever (days)**	**p-value**
Culture negative cases (n=150)	9.0 ± 2.7	Not emphasized
Culture positive cases (n=3)	8.3 ± 1.5	—

Table 5 presents the antibiotic sensitivity pattern of Salmonella Typhi isolates among the 3 culture-positive cases. All three isolates were sensitive to ceftriaxone, cefixime and azithromycin. Ampicillin, cotrimoxazole and chloramphenicol showed sensitivity in 2 of 3 isolates (66.7%) and resistance in 1 of 3 isolates (33.3%). In contrast, all isolates were resistant to ciprofloxacin and nalidixic acid. Although interpretation is limited by the small isolate count, these results support the continued usefulness of third-generation cephalosporins and azithromycin and highlight the concern of fluoroquinolone resistance.

Table 5: Pattern of antibiotic sensitivity of S. Typhi among culture positive cases (n = 3)			
Drug sensitivity pattern	**Sensitive N (%)**	**Resistant N (%)**	**Total**
Ampicillin	2 (66.7)	1 (33.3)	3
Cotrimoxazole	2 (66.7)	1 (33.3)	3
Chloramphenicol	2 (66.7)	1 (33.3)	3
Azithromycin	3 (100.0)	0 (0.0)	3
Cefixime	3 (100.0)	0 (0.0)	3
Ceftriaxone	3 (100.0)	0 (0.0)	3
Ciprofloxacin	0 (0.0)	3 (100.0)	3
Nalidixic acid	0 (0.0)	3 (100.0)	3

Table 6 shows the distribution of prior empirical antibiotic use among culture-positive and culture-negative cases. Among the 3 culture-positive cases, 1 patient (33.3%) had received prior empirical antibiotic therapy, whereas 2 patients (66.7%) had not received antibiotics before blood culture collection. Among the 150 culture-negative cases, 92 patients (61.3%) had received prior empirical antibiotic therapy and 58 (38.7%) had not. Prior antibiotic exposure was more frequent among culture-negative cases, suggesting that antibiotic administration before sample collection may have contributed to

reduced culture yield; however, this observation should be interpreted cautiously because of the small number of positive isolates.

Table 6: Use of prior antibiotic among culture positive and negative cases

Category	Culture Positive Cases N (%)	Culture Negative Cases N (%)
Cases who had received prior empirical antibiotic therapy	1 (33.3)	92 (61.3)
Cases who had not received prior empirical antibiotic therapy	2 (66.7)	58 (38.7)
Total	3 (100.0)	150 (100.0)

*Because only three Salmonella Typhi isolates were recovered, inferential statistical testing for prior antibiotic exposure was not emphasized; descriptive interpretation was preferred.

Discussion

The present one-year retrospective study was aimed at studying the changing antimicrobial susceptibility pattern of Salmonella Typhi isolated from blood culture along with its demographic profile and clinical characteristics. Of the 153 clinically suspected cases included in the study, Salmonella Typhi was isolated from 3 blood culture samples, giving an overall culture positivity of 1.96%. This revised positivity rate falls within the lower reported range of Salmonella isolation from blood cultures in India and reflects the low yield that may be observed in routine hospital-based surveillance, particularly in settings where prior empirical antibiotic use, delayed presentation, and variable blood culture utilization are common. Among the total study population, males constituted 55.6% and females 44.4%. Among the three culture-positive cases, two were males and one was female, showing a slight male predominance. However, because of the small number of positive isolates, no definite gender-based association can be inferred. Similar male predominance has been reported in previous studies, where about 52% of typhoid cases were male in Karachi, Pakistan [9], and almost 58% of culture-positive cases were male in Nigeria [10]. This male predominance may be related to greater environmental exposure, occupational exposure, food and water consumption habits outside the home, or health-seeking behaviour rather than true biological susceptibility."

The age distribution of the current study showed that the mean age of culture-positive patients was 17.3 years, with a median age of 17 years, while the overall mean age of the study population was 16.2 years. All three culture-confirmed cases were observed in the ≥15 years age group, whereas no culture-positive case was detected among patients younger than 15 years. However, because only three isolates were recovered, age-wise distribution should be interpreted cautiously and should not be considered representative of the true community burden of typhoid fever. The results differ from Siddiqui et al., who reported that almost half of the cases (49.6%) were aged 1–5 years and 23.8% were aged 5–10 years, suggesting a younger age group involvement in Pakistan. Likewise, Marks et al. [11] from Ghana found the highest incidence of culture-proven typhoid fever in children under 2 years. The relatively higher age of culture-positive patients in the present study may be due to differences in endemicity, sanitation, healthcare access, prior immunity, sample size, and local epidemiological patterns, indicating that the age distribution of typhoid fever may vary considerably across different geographical settings.

In the present study, the duration of fever before presentation was broadly comparable between culture-positive and culture-negative patients. The mean duration of fever among culture-positive cases was 8.3 ± 1.5 days, while culture-negative cases had a mean duration of 9.0 ± 2.7 days. Due to the very small number of culture-positive cases, formal statistical comparison was not emphasized. These findings suggest that duration of fever alone may not be sufficient to predict blood culture positivity. This is in agreement with Bhutta et al [12], who reported that the sensitivity of blood culture ranges from approximately 40% to 80% and depends on several factors, including bacterial load, time of specimen collection, volume of blood collected, prior antibiotic use, and laboratory processing methods. Similarly, Adabara et al. [10] reported blood culture positivity rates of about 40–60% in the early stages of disease and noted that blood culture may still be useful even after the first week of illness if appropriate microbiological methods are used. Therefore, blood culture should not be withheld solely because the patient presents after several days of fever; rather, it should preferably be collected before initiation of antimicrobial therapy to improve diagnostic yield.

The most significant finding of the present study was the antimicrobial susceptibility profile of the three Salmonella Typhi isolates. All three isolates were sensitive to ceftriaxone, cefixime, and azithromycin, indicating that third-generation cephalosporins and azithromycin remain effective therapeutic options in the present study setting. Ampicillin, cotrimoxazole, and chloramphenicol showed sensitivity in two of the three isolates, while one isolate was resistant to each of these drugs. Although these findings suggest retained activity of conventional first-line antibiotics, the small number of isolates limits

generalization. A similar trend of re-emergence of susceptibility to conventional first-line drugs has been reported by Chand et al. [13], who observed 100% susceptibility to chloramphenicol and 98.2% susceptibility to cotrimoxazole in Nepal. Kumar et al. [14] also reported re-emergence of susceptibility, with sensitivity of 95.3% for chloramphenicol, 94.5% for ampicillin, and 94.5% for cotrimoxazole. Similarly, Gupta et al. [15] reported high susceptibility to conventional first-line drugs in India, indicating a possible reversal of multidrug resistance due to reduced use of these agents over the last two decades. However, in the present study, because only three isolates were available, these results should be considered preliminary and interpreted cautiously.

Although sensitivity to third-generation cephalosporins and azithromycin was encouraging, resistance to fluoroquinolones was prominent in the present study. All three Salmonella Typhi isolates were resistant to ciprofloxacin and nalidixic acid. This finding is clinically important, as fluoroquinolone resistance and reduced fluoroquinolone susceptibility have been increasingly reported from India and neighbouring countries. Nalidixic acid resistance has been reported to be very high, often exceeding 90%, among Salmonella Typhi isolates collected from different parts of the country [16], and reduced fluoroquinolone susceptibility has also been reported by Gupta et al. [15]. The indiscriminate and widespread use of fluoroquinolones in the community has been suggested as an important factor contributing to the emergence and persistence of resistance, mainly through chromosomal mutations in quinolone resistance-determining regions. Therefore, even though the present study included only three isolates, the finding of complete resistance to ciprofloxacin and nalidixic acid supports the recommendation that ciprofloxacin should not be preferred as empirical therapy in endemic areas unless susceptibility is confirmed by laboratory testing.

Prior empirical antibiotic use was another important observation in the current study. Among the three culture-positive cases, one patient had received prior empirical antibiotic therapy, whereas among the 150 culture-negative cases, 92 patients had received antibiotics before blood culture collection. Thus, prior antibiotic exposure was more frequent among culture-negative cases than culture-positive cases. This suggests that antibiotic administration before sample collection may have contributed to reduced blood culture yield. However, because only three Salmonella typhi isolates were recovered, inferential statistical testing was not emphasized, and the finding was interpreted descriptively. This observation is consistent with existing evidence that administration of antimicrobials before collecting blood samples can significantly decrease the likelihood of isolating bacteria from blood cultures. Bhutta et al [12] also highlighted prior antibiotic administration as one of the major causes of false-negative blood cultures in typhoid fever, especially in endemic areas where empirical antibiotic use before referral to tertiary care centers is common.

Overall, the present study highlights a low Salmonella Typhi blood culture positivity rate of 1.96% among clinically suspected enteric fever cases, which is more consistent with the expected lower range of blood culture-based prevalence reported from India. The findings also show that third-generation cephalosporins and azithromycin continue to be effective against the isolates recovered, while fluoroquinolone resistance remains a matter of concern. The apparent sensitivity to conventional first-line antibiotics should be interpreted cautiously due to the small isolate count. The study also emphasizes the importance of collecting blood cultures before initiating antibiotic therapy, using reliable identification methods, and performing antimicrobial susceptibility testing to guide treatment. Continuous local surveillance of Salmonella Typhi antimicrobial resistance patterns remains essential for evidence-based empirical treatment policies and antimicrobial stewardship.

Conclusion

The current one-year retrospective study found a low Salmonella Typhi blood culture positivity rate of 1.96% among clinically suspected enteric fever cases, placing the result within the expected lower Indian range. MALDI-TOF MS was incorporated for confirmatory identification whereas VITEK 2 for AST pattern along with conventional microbiological methods. All isolates were sensitive to ceftriaxone, cefixime and azithromycin, while resistance to ciprofloxacin and nalidixic acid remained a concern. Because only three isolates were recovered, antibiotic susceptibility percentages should be interpreted cautiously, and larger surveillance datasets are needed. The findings support routine blood culture before antibiotic initiation, reliable organism identification, periodic antimicrobial resistance monitoring and evidence-based antibiotic stewardship.

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