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Original Article

Prevalence and Characterization of Salmonella Species and Evaluation of its Antibiotic Susceptibility Pattern Isolated from Blood Cultures among Patients attending Tertiary Care Hospital, Hyderabad

M Shailaja Rani[1], Vipparti Haritha[2], P Mallika[3], Maria Sarvath Ali Khan[4]

[1]1Associate Professor, Department of Microbiology, Government Medical College Maheswaram, Telangana, India
[2]Specialist Iii, Microbiology, Central Research Institute Kasauli, Himachal Pradesh, India
[3]Assistant Professor, Department of Microbiology, Government Medical College Nagarkurnool, Telangana, India
[4]Senior Resident, Department of Microbiology, Government Medical College Maheswaram, Telangana, India

Corresponding Author:

M Shailaja Rani
Associate Professor, Department of Microbiology, Government Medical College Maheswaram, Telangana, India

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ABSTRACT

Background: Enteric fever remains an important cause of bloodstream infection in India, and its management is increasingly affected by changing antibiotic resistance patterns. This study aimed to determine the prevalence, characterization and antibiotic susceptibility profile of Salmonella species isolated from blood cultures of patients attending a tertiary care hospital in Hyderabad.

Materials and Methods: This prospective laboratory-based study was carried out on blood culture samples received from patients clinically suspected of enteric fever. During the study period, 1164 blood cultures were processed in the microbiology laboratory. Of these, 134 samples were positive for Salmonella species, giving a prevalence rate of 11.5%. Patient details, sample type, organism isolated and antibiotic susceptibility results were recorded. The isolates were identified as The isolates were identified and characterized as Salmonella Typhi, Salmonella Paratyphi and other Salmonella species using standard microbiological methods. Antibiotic susceptibility testing was performed for commonly used antimicrobial agents and interpreted as sensitive or resistant according to routine laboratory protocol.

Results: A total of 134 Salmonella isolates were recovered from blood cultures. Salmonella Typhi was the predominant isolate, while Salmonella Paratyphi and other Salmonella enterica serotypes were less frequent. Cases were seen in both paediatric and adult age groups, with involvement of both males and females. The isolates showed better susceptibility to third-generation cephalosporins and azithromycin. Reduced susceptibility or resistance was more commonly observed against ampicillin, chloramphenicol, cotrimoxazole, ciprofloxacin and nalidixic acid.

Conclusion: Salmonella Typhi was the leading blood culture isolate. Regular blood culture and antibiotic susceptibility testing are essential for appropriate treatment and resistance surveillance.

Keywords*: Salmonella Typhi; Salmonella Paratyphi; blood culture; enteric fever; antibiotic susceptibility; antimicrobial resistance.*

INTRODUCTION

Enteric fever is a systemic bacterial infection caused mainly by *Salmonella enterica* serovar Typhi and, less commonly, by *Salmonella enterica* serovars Paratyphi A, B and C [1,2]. The disease spreads through ingestion of contaminated food or water and is strongly associated with poor sanitation, unsafe drinking water, overcrowding and inadequate hygiene practices [3,4]. Although enteric fever is preventable and treatable, it continues to remain an important public health problem in many low- and middle-income countries, particularly in South Asia and sub-Saharan Africa [5,6]. Recent

global estimates also show that typhoid and paratyphoid fever still contribute substantially to febrile illness, hospital admission and avoidable mortality in endemic regions [7].

The clinical diagnosis of enteric fever is often difficult because the early symptoms are nonspecific. Patients may present with prolonged fever, headache, abdominal pain, vomiting, diarrhoea, constipation, malaise and sometimes hepatosplenomegaly [8]. These manifestations overlap with several other causes of acute febrile illness, including malaria, dengue, scrub typhus, leptospirosis and urinary tract infection. Therefore, laboratory confirmation is necessary for accurate diagnosis and proper management. Blood culture is considered the most useful diagnostic method during the first week of illness because it confirms bloodstream infection and also provides the organism for species identification and antimicrobial susceptibility testing [9]. The diagnostic yield of blood culture depends on factors such as timing of sample collection, blood volume, prior antibiotic exposure and laboratory processing methods [10].

Characterization of *Salmonella* isolates is important because the relative distribution of *S. Typhi* and *S. Paratyphi* may vary across regions, age groups and time periods [11]. Traditionally, *S. Typhi* has been the dominant cause of enteric fever in India, but *S. Paratyphi A* has also been increasingly reported in some settings [12]. Identification of the infecting serovar helps in understanding the local epidemiology, planning public health measures and monitoring possible changes in transmission. It also has vaccine-related relevance because currently available typhoid vaccines mainly target *S. Typhi* and do not provide comparable protection against paratyphoid fever [13,14]. Hence, hospital-based microbiological data remain useful for both clinical management and surveillance.

Antibiotic treatment has greatly reduced complications and deaths due to enteric fever. However, the management of *Salmonella* bloodstream infection has become more challenging because of changing resistance patterns [15]. Chloramphenicol, ampicillin and cotrimoxazole were used extensively as first-line drugs in the past, but their usefulness declined after the emergence of multidrug-resistant *S. Typhi* [16]. Fluoroquinolones later became the preferred treatment in many areas, but reduced ciprofloxacin susceptibility and nalidixic acid resistance have become common in South Asia [17]. This has led to greater dependence on third-generation cephalosporins and azithromycin for empirical therapy. At the same time, reports of cephalosporin-resistant and extensively drug-resistant *S. Typhi* have raised concern regarding future treatment options [18].

The antimicrobial profile of typhoidal *Salmonella* is not fixed. It changes with local prescribing practices, over-the-counter antibiotic use, incomplete treatment courses and the spread of resistant clones [19]. The global dissemination of the H58 lineage of *S. Typhi* has shown how resistant strains can spread across countries and become established in endemic populations [20]. Recent Indian studies also highlight the need for continuous surveillance, as multidrug resistance may decline in some areas while resistance or reduced susceptibility to fluoroquinolones, cephalosporins or azithromycin may emerge in others [21]. Therefore, each hospital should periodically analyse its own blood culture isolates and prepare a local antibiogram to support rational empirical therapy.

In tertiary care hospitals, prospective blood culture-based monitoring of *Salmonella* isolates provides meaningful information on the burden of enteric fever and the prevailing antibiotic susceptibility pattern. This is particularly important in urban referral centres, where patients with prolonged fever may report after prior antibiotic exposure. In the present prospective laboratory-based study, blood culture samples were received from patients clinically suspected of enteric fever at a tertiary care hospital in Hyderabad. During the study period, a total of 1164 blood cultures were processed in the microbiology laboratory, of which 134 samples were positive for *Salmonella* species. The study showed predominance of *Salmonella Typhi*, while *Salmonella Paratyphi*, and other *Salmonella* species were reported less frequently. The isolates were also tested against commonly used antibiotics, including ampicillin, chloramphenicol, cotrimoxazole, ciprofloxacin, nalidixic acid, ceftriaxone, cefixime and azithromycin, to understand the local susceptibility pattern.

Considering the continuing burden of enteric fever and the evolving pattern of antimicrobial resistance, this study was undertaken to assess the prevalence and characterization of *Salmonella* species isolated from blood cultures among patients attending a tertiary care hospital in Hyderabad. The study also aimed to evaluate the antibiotic susceptibility pattern of these isolates. The findings may help clinicians select appropriate empirical treatment, support antimicrobial stewardship and contribute to local surveillance of enteric fever.

MATERIALS AND METHODS

Study Design

Prospective laboratory-based study was carried out on blood culture samples received from patients clinically suspected of enteric fever. During the study period, 1164 blood cultures were processed in the microbiology laboratory. Of these, 134 samples were positive for *Salmonella species*. The study focused only on culture-confirmed cases, as blood culture provides both organism identification and antibiotic susceptibility information.

Place of Study
The study was carried out in the Department of Microbiology, Fever Hospital, Osmania General Hospital, Hyderabad. The hospital caters to a large number of patients presenting with acute febrile illness and suspected bloodstream infections. Blood culture samples received in the microbiology laboratory from clinically suspected cases of enteric fever were processed as part of routine diagnostic work.

Duration of Study
The study was conducted over a period of two years, from January 2021 to December 2023. During this period, all blood culture samples received from patients clinically suspected of enteric fever were processed in the microbiology laboratory. The culture-positive samples were screened for the presence of *Salmonella* species and included in the final analysis.

Study Population
The study population included patients attending the tertiary care hospital with clinical suspicion of enteric fever or bloodstream infection, whose blood culture samples were submitted to the Department of Microbiology. Patients of all age groups and both sexes were considered. Only blood culture-positive cases showing growth of *Salmonella* species were included in the final analysis.

Sample Size
A total of 134 blood culture-positive ***Salmonella*** isolates were included in the study from a total of 1164 blood cultures. These isolates were obtained from the available lab data and formed the basis for species characterization and antibiotic susceptibility analysis. The data showed patient-wise entries, including age, sex, organism isolated and antibiotic susceptibility pattern.

Inclusion Criteria
All patients whose blood culture samples showed growth of *Salmonella* species during the study period were included. The laboratory data were considered eligible when the organism identification and antibiotic susceptibility results were available in the microbiology laboratory register. Both *Salmonella Typhi* and non-typhoidal or paratyphoidal *Salmonella* entries were included wherever documented.

Exclusion Criteria
Blood cultures that did not yield *Salmonella* species were excluded from the study. Incomplete records where organism identification was not clearly documented were not considered for final analysis. Duplicate isolates from the same patient, if present, were excluded to avoid repeated counting of the same infection episode.

Collection of Blood Samples
Blood samples were collected under aseptic precautions from patients clinically suspected to have enteric fever or septicaemia. The venepuncture site was cleaned properly before sample collection to reduce contamination. An appropriate volume of blood was collected depending on the age of the patient and inoculated into blood culture bottles. The samples were then transported to the microbiology laboratory without delay for further processing.

Blood Culture Processing
The inoculated blood culture bottles were incubated and monitored for bacterial growth as per standard microbiological procedures followed in the laboratory. Bottles showing signs of growth were sub cultured on to suitable solid media. The culture plates were examined for colony morphology, and suspected colonies were subjected to further identification.

Identification and Characterization of *Salmonella* Isolates
The isolates were identified using colony characteristics, Gram staining and standard biochemical reactions. Suspected *Salmonella* colonies were characterized further to differentiate *Salmonella Typhi*, *Salmonella Paratyphi* and other reported *Salmonella* species. The characterization was based on routine microbiological methods documented in the laboratory records. In the present dataset, most isolates were recorded as *Salmonella Typhi*, while a smaller number were documented as *Salmonella Paratyphi*, or other *Salmonella* species.

Antibiotic Susceptibility Testing
Antibiotic susceptibility testing was performed for the confirmed *Salmonella* isolates according to routine laboratory protocol. The susceptibility pattern was recorded as sensitive or resistant against commonly used antimicrobial agents. The antibiotics documented in the register included ampicillin, chloramphenicol, cotrimoxazole, ciprofloxacin, nalidixic acid, ceftriaxone, cefixime, azithromycin and other relevant drugs. The results were used to assess the overall antibiotic sensitivity and resistance pattern among the isolates.

Data Collection
Data were collected prospectively from the microbiology laboratory records during the study period. Blood culture samples received from patients clinically suspected of enteric fever were processed as part of routine laboratory work. The recorded variables included age, sex, specimen type, *Salmonella* species isolated and antibiotic susceptibility pattern. Since this was a prospective laboratory-based study, the relevant details were entered at the time of sample processing and reporting. Only complete and clearly documented records were included in the final analysis, while incomplete or unclear entries were excluded.

Data Analysis
The collected data were entered into a master chart and analysed descriptively. The total number of *Salmonella* isolates was expressed as frequency. Species distribution was summarized as the proportion of *Salmonella Typhi*, *Salmonella Paratyphi* and other reported *Salmonella* isolates. Antibiotic susceptibility results were presented as sensitive and resistant patterns for each antimicrobial agent. Age-wise and sex-wise distributions were also assessed wherever complete details were available.

Ethical Consideration
Ethical approval was obtained from the Institutional Ethics Committee before conducting the study. As this was a prospective laboratory-based study, blood culture samples were processed as part of routine diagnostic care for patients clinically suspected of enteric fever. No additional sample was collected exclusively for research purposes. Patient confidentiality was maintained throughout the study, and personal identifiers were not included during data analysis or manuscript preparation. The collected information was used only for academic and research purposes, following institutional ethical standards.

RESULTS

Overall culture-confirmed *Salmonella* isolates
During the study period, a total of 1164 blood culture samples were received and processed. Among these, 134 samples showed growth of ***Salmonella*** species and were included in the final analysis. All isolates were recovered from blood samples of patients who attended the Department of Microbiology, Fever Hospital, Osmania General Hospital, Hyderabad. Patient-wise details, including age, sex, blood culture isolate and antibiotic susceptibility profile, were recorded for each confirmed case. Most isolates were reported as *Salmonella Typhi*, while a smaller number were documented as *Salmonella Paratyphi*, and nonspecified *Salmonella* species.

Distribution according to year
Among the 134 isolates, the highest number was observed in 2023, with 51 isolates, 38.1%**,** followed by 2022 with 45 isolates, 33.6%**,** and 2021 with 38 isolates, 28.3%**.** Although a gradual rise was seen across the study period, the difference was not statistically significant ($\chi^2 = 1.90$, $p = 0.388$) (Table 1 and Figure 1).

Table 1: Year-wise distribution of blood culture-positive *Salmonella* isolates

Year	Number of isolates	Percentage
2021	38	28.3
2022	45	33.6
2023	51	38.1
Total	**134**	**100.0**

Chi-square value: 1.90; **p value:** 0.388

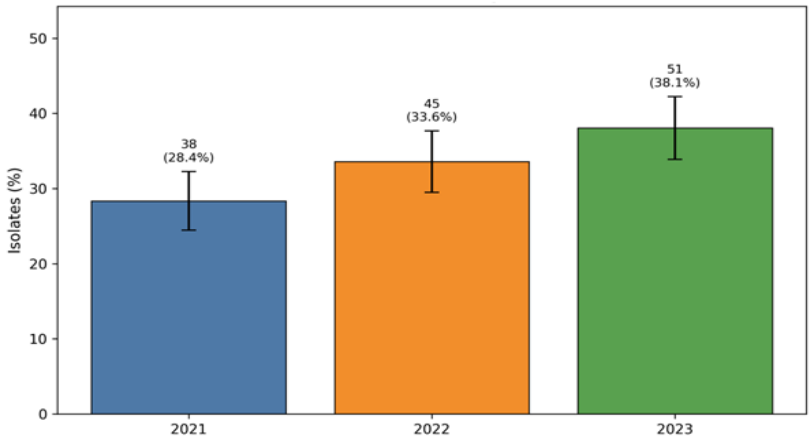

Figure 1: Year-wise distribution of *Salmonella* isolates

Age-wise distribution

The age of affected patients ranged from paediatric to adult age groups. The highest number of isolates was seen in the 11-20 years age group, 44 cases, 32.8%**,** followed by 21-30 years, 39 cases, 29.1%**.** Children aged 0-10 years contributed 22 cases, 16.4%**.** Patients above 40 years formed the smallest group, with 11 cases, 8.2%**.** The age-wise difference was statistically significant (χ^2 = 29.66, p < 0.00**1**), showing that enteric fever was more frequent among adolescents and young adults in this dataset (Table 2 and Figure 2).

Table 2: Age-wise distribution of patients with *Salmonella* bloodstream infection

Age group	Number of cases	Percentage
0-10 years	22	16.4
11-20 years	44	32.8
21-30 years	39	29.1
31-40 years	18	13.4
>40 years	11	8.2
Total	**134**	**100.0**

Chi-square value: 29.66; **p value:** <0.001

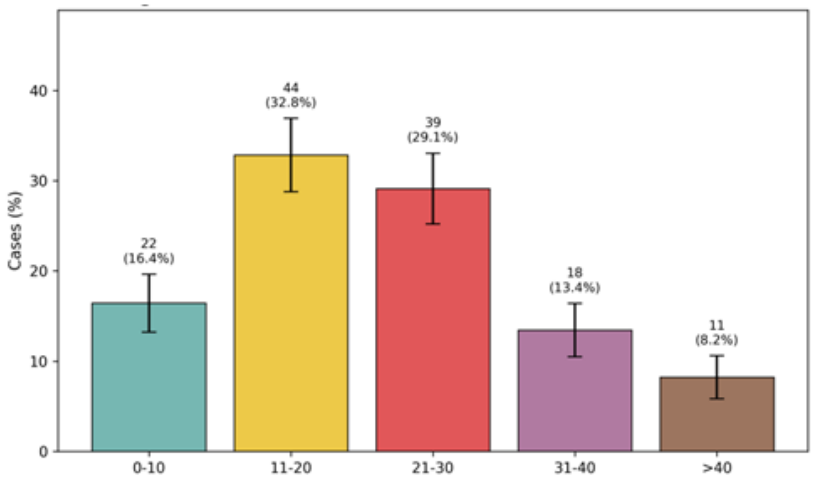

Figure 2: Age-wise distribution of cases

Sex-wise distribution

Out of 134 patients, 78 were males, 58.2%**,** and 56 were females, 41.8%. A male preponderance was observed; however, the difference did not reach statistical significance (**χ^2 = 3.61, p = 0.057**) (Table 3 and Figure 3).

Table 3: Sex-wise distribution of patients

Sex	Number of cases	Percentage
Male	78	58.2
Female	56	41.8
Total	**134**	**100.0**

Chi-square value: 3.61; **p value:** 0.057

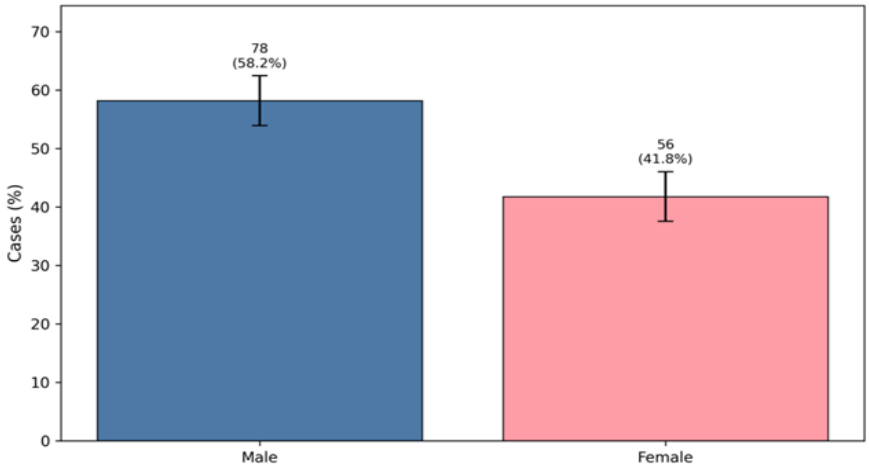

Figure 3: Sex distribution of patients

Characterization of *Salmonella* isolates

Among the 134 isolates, *Salmonella Typhi* was the dominant organism, accounting for 123 isolates, 91.8%**.** *Salmonella Paratyphi* was seen in 7 isolates, 5.2%. Other nonspecified *Salmonella* species accounted for 4 isolates, 3.0%**.** The organism-wise distribution was statistically significant ($\chi^2 = 277.64$, $p < 0.001$), confirming the clear predominance of *S. Typhi* among culture-positive cases (Table 4 and Figure 4).

Table 4: Characterization of *Salmonella* isolates

Organism isolated	Number of isolates	Percentage
Salmonella Typhi	123	91.8
Salmonella Paratyphi	7	5.2
Other *Salmonella* species	4	3.0
Total	**134**	**100.0**

Chi-square value: 277.64; **p value:** <0.001

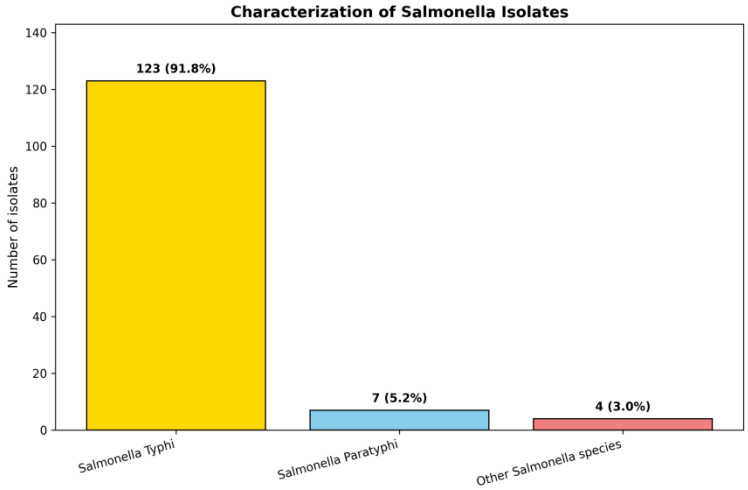

Figure 4: Species-wise distribution of *Salmonella* isolates

Seasonal distribution of isolates

When the cases were grouped according to quarters, the highest number was observed during July-September, 39 isolates, 29.1%, followed by April-June, 35 isolates, 26.1%**,** October-December, 33 isolates, 24.6%**,** and January-March, 27 isolates, 20.1%**.** Although the monsoon and post-monsoon months showed a mild increase, the seasonal difference was not statistically significant ($\chi^2 = 2.24$, $p = 0.524$) (Table 5 and Figure 5).

Table 5: Seasonal distribution of *Salmonella* isolates

Period	Number of isolates	Percentage
January-March	27	20.1
April-June	35	26.1
July-September	39	29.1
October-December	33	24.6
Total	**134**	**100.0**

Chi-square value: 2.24; **p value:** 0.524

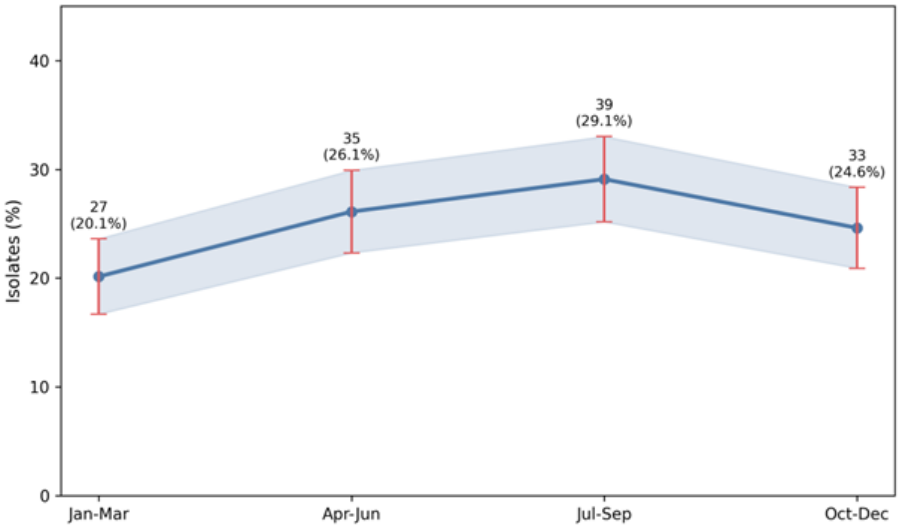

Figure 5: Seasonal trend of *Salmonella* isolates

Antibiotic susceptibility pattern

The antibiotic susceptibility pattern showed better activity for third-generation cephalosporins and azithromycin. Ceftriaxone showed sensitivity in 124 isolates, 92.5%, while cefixime showed sensitivity in 119 isolates, 88.8%**.** Azithromycin sensitivity was observed in 101 isolates, 75.4%**.** In contrast, lower susceptibility was seen with ciprofloxacin, cotrimoxazole, ampicillin and chloramphenicol. Nalidixic acid showed the highest resistance, with only 18 isolates, 13.4%**,** being sensitive and 116 isolates, 86.6%**,** being resistant. The difference between sensitive and resistant isolates was statistically significant for ceftriaxone, cefixime, azithromycin, cotrimoxazole, ciprofloxacin and nalidixic acid (Table 6 and Figure 6).

Table 6: Antibiotic susceptibility pattern of *Salmonella* isolates

Antibiotic	Sensitive n (%)	Resistant n (%)	Chi-square value	p value
Ceftriaxone	124 (92.5)	10 (7.5)	96.99	<0.001
Cefixime	119 (88.8)	15 (11.2)	80.72	<0.001
Azithromycin	101 (75.4)	33 (24.6)	34.51	<0.001
Chloramphenicol	64 (47.8)	70 (52.2)	0.27	0.604
Ampicillin	58 (43.3)	76 (56.7)	2.42	0.120
Cotrimoxazole	55 (41.0)	79 (59.0)	4.30	0.038
Ciprofloxacin	48 (35.8)	86 (64.2)	10.78	0.001
Nalidixic acid	18 (13.4)	116 (86.6)	71.67	<0.001

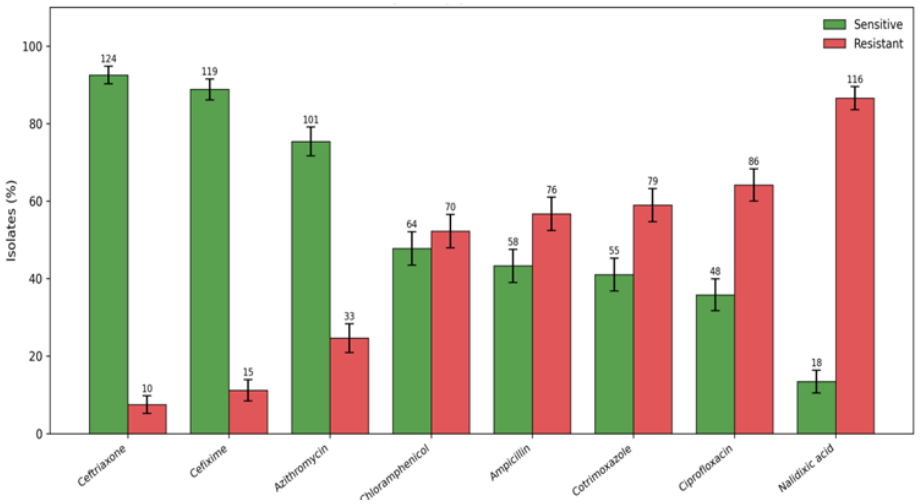

Figure 6: Antibiotic susceptibility pattern of *Salmonella* isolates

Multidrug resistance pattern

Resistance to older first-line drugs such as ampicillin, chloramphenicol and cotrimoxazole was observed in a considerable proportion of isolates. Based on combined resistance to these conventional first-line agents, 42 isolates, 31.3%**,** were categorized as multidrug-resistant, while 92 isolates, 68.7%**,** were non-MDR. The difference between MDR and non-MDR isolates was statistically significant ($\chi^2 = 18.66$, $p < 0.001$) (Table 7 and Figure 7 & 8).

Table 7: Multidrug resistance pattern among *Salmonella* isolates

MDR status	Number of isolates	Percentage
MDR isolates	42	31.3
Non-MDR isolates	92	68.7
Total	**134**	**100.0**

Chi-square value: 18.66; **p value:** <0.001

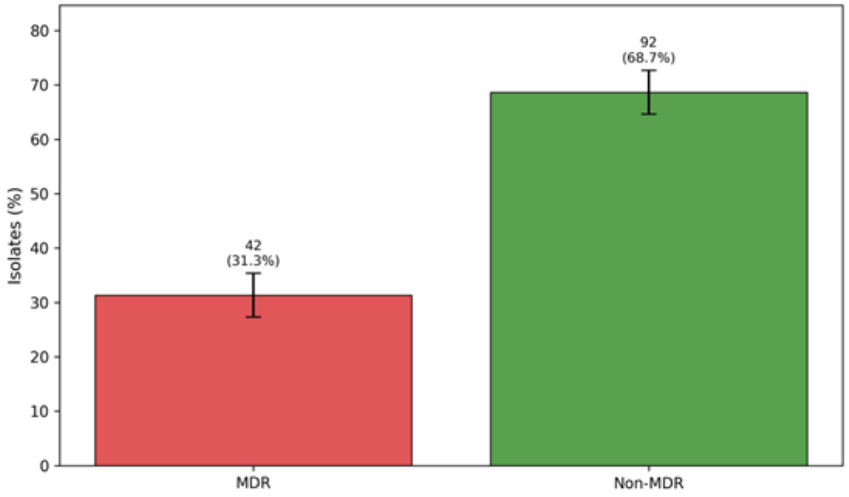

Figure 7: MDR and non-MDR distribution among *Salmonella* isolates

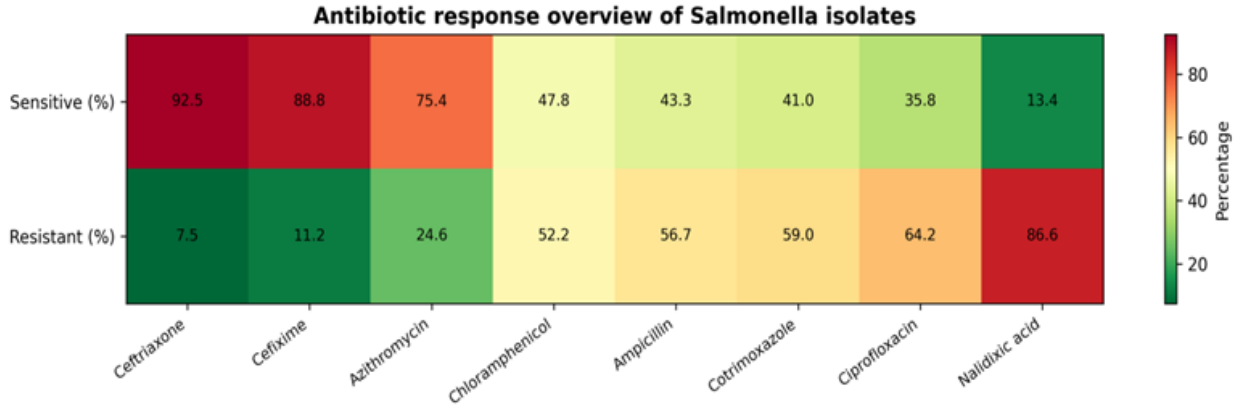

Figure 8: Antibiotic Response Heatmap

DISCUSSION

A total of 1164 blood culture samples were processed during the study period. Out of these, 134 cultures were positive for Salmonella species, and these positive isolates were taken forward for detailed analysis. The findings showed that *Salmonella Typhi* was the dominant isolate, accounting for the major proportion of culture-confirmed bloodstream infections, while *Salmonella Paratyphi* and other *Salmonella* species were reported less frequently. The highest number of cases was observed among adolescents and young adults, particularly in the 11-20 years and 21-30 years age groups. A mild male predominance was also noted. The antibiotic susceptibility pattern showed relatively better sensitivity to ceftriaxone, cefixime and azithromycin, whereas reduced susceptibility was more evident with ciprofloxacin, nalidixic acid, ampicillin, chloramphenicol and cotrimoxazole. These observations indicate that enteric fever remains an important bloodstream infection in this tertiary care setting and that antibiotic resistance continues to influence treatment decisions. The study data showed that most entries were blood culture-positive *Salmonella* isolates, with documented organism identification and antibiotic susceptibility profiles..

Burden of blood culture-positive *Salmonella* infection

Enteric fever remains a major cause of systemic febrile illness in India and other endemic regions. It is mainly caused by *Salmonella Typhi* and, less commonly, by *Paratyphi* [1,2]. In the present study, all included isolates were recovered from blood cultures, which confirms bloodstream infection rather than probable or serology-based disease. This is important because the clinical features of enteric fever are often nonspecific and may resemble dengue, malaria, scrub typhus, leptospirosis or other febrile illnesses [3]. Therefore, blood culture remains valuable not only for diagnosis but also for antimicrobial susceptibility testing [4]. The recovery of 134 *Salmonella* isolates over the study period reflects the continuing clinical relevance of culture-confirmed enteric fever in this hospital population.

Species distribution of *Salmonella* isolates

The predominance of *S. Typhi* in the present study is consistent with the known epidemiology of enteric fever in India, where typhoid fever continues to form the major share of culture-confirmed enteric fever cases [5,6]. *S. Paratyphi* contributed a smaller proportion in this dataset. Similar observations have been reported in Indian and Asian studies, although some centres have shown an increasing contribution of *S. Paratyphi* over time [7,8]. This variation may be related to differences in sanitation, population movement, prior antibiotic use, vaccination coverage and local transmission dynamics. Species-level identification is clinically relevant because current typhoid conjugate vaccines mainly target *S. Typhi* and do not provide comparable protection against paratyphoid fever [9,10]. Hence, routine documentation of both *S. Typhi* and *S. Paratyphi* remains important for hospital surveillance and public health planning.

Age and sex distribution

In this study, the highest burden was seen in the 11-20 years age group, followed by the 21-30 years age group. This suggests that adolescents and young adults formed the most affected population in the present dataset. This finding is in agreement with previous reports showing that enteric fever commonly affects school-going children, adolescents and young adults in endemic areas [11, 12]. Increased exposure to outside food, school or college environments, travel, shared water sources and community-level sanitation gaps may contribute to higher infection rates in these age groups. Children also remain vulnerable because of frequent exposure and developing immunity. The male predominance observed in this study may be related to greater outdoor exposure, occupational mobility and food consumption outside the home, although the sex-wise difference was not statistically significant. Similar male preponderance has been described in some hospital-based studies, but this pattern is not universal and may differ according to health-seeking behaviour and local population characteristics [12].

Seasonal pattern of infection

A relatively higher number of isolates was observed during the July-September period, followed by April-June and October-December. Although the seasonal difference was not statistically significant, the mild increase during monsoon and post-monsoon months is epidemiologically meaningful. Rainfall, contamination of drinking water sources, poor drainage and mixing of sewage with water supplies may increase transmission of enteric pathogens during these months. Previous studies from endemic countries have also reported seasonal clustering of enteric fever cases, often linked to rainfall, temperature and water quality [13]. However, seasonal trends may not be uniform across all regions because they are influenced by local sanitation, water supply systems, food hygiene and population density.

Antibiotic susceptibility pattern

The susceptibility pattern observed in this study showed good activity of ceftriaxone and cefixim**e,** suggesting that third-generation cephalosporins remain useful therapeutic options for many culture-confirmed cases**.** Azithromycin also showed good sensitivity in a substantial proportion of isolates. This pattern supports the current clinical shift towards cephalosporins and azithromycin for empirical treatment of enteric fever, particularly in regions where fluoroquinolone susceptibility has declined [14]. However, continued reliance on these drugs should be cautious because resistance to cephalosporins and azithromycin has been reported in several regions [15,16]. Periodic monitoring is therefore essential to detect early changes in susceptibility.

The present study showed reduced susceptibility to ciprofloxacin and high resistance to nalidixic acid. This is an important finding because nalidixic acid resistance has historically been used as an indicator of reduced fluoroquinolone susceptibility in *Salmonella* isolates. Reduced ciprofloxacin susceptibility can result in delayed fever clearance, prolonged illness and treatment failure even when the isolate may appear susceptible by older interpretive criteria [17]. Similar trends have been reported in India and other South Asian countries, where fluoroquinolone non-susceptibility has become common among *S. Typhi* and *S. Paratyphi* isolates [18,19]. This finding supports the need to avoid blind fluoroquinolone use unless susceptibility is clearly documented.

Resistance to older first-line antibiotics

Resistance to older first-line drugs such as ampicillin, chloramphenicol and cotrimoxazole was observed in a considerable number of isolates. These drugs were widely used for enteric fever treatment before the emergence of

multidrug-resistant *S. Typhi* [20]. The present findings suggest that resistance to these agents persists in a meaningful proportion of isolates. However, some isolates still showed sensitivity to chloramphenicol, ampicillin or cotrimoxazole, which reflects the fluctuating nature of antimicrobial resistance. In some regions, partial re-emergence of susceptibility to older drugs has been reported after reduced clinical use, but their routine empirical use remains risky without culture confirmation [21]. Therefore, these agents may have limited value unless guided by isolate-specific susceptibility testing.

Multidrug resistance pattern

In the present analysis, approximately one-third of isolates were categorized as multidrug-resistant based on resistance to conventional first-line agents. MDR *Salmonella* is clinically important because it narrows treatment options and may lead to prolonged fever, increased complications and longer hospital stay. The spread of resistant *S. Typhi* lineages, particularly the H58 lineage, has contributed to regional and global dissemination of drug resistance [22]. More concerning is the emergence of extensively drug-resistant *S. Typhi*, which shows resistance not only to older first-line drugs and fluoroquinolones but also to third-generation cephalosporins [23]. Although the present dataset did not show widespread cephalosporin resistance, the finding of MDR isolates reinforces the importance of continuous local surveillance.

Comparison with Indian and global trends

The findings of this study are broadly comparable with recent Indian surveillance data, where *S. Typhi* continues to predominate and fluoroquinolone non-susceptibility remains a major concern [18,19]. Indian studies have shown that multidrug resistance has varied over time, while reduced susceptibility to ciprofloxacin has become a persistent therapeutic challenge [18]. Global systematic reviews have also documented widespread antimicrobial resistance among *S. Typhi*, especially in South Asia and parts of Africa [14,19]. The present study adds hospital-level evidence from Hyderabad and highlights the need for local antibiogram-based empirical therapy rather than depending only on national or global resistance patterns.

Clinical implications

The results have direct clinical relevance. First, blood culture should be encouraged in suspected enteric fever, especially before starting antibiotics. Second, empirical fluoroquinolone use should be restricted in settings where nalidixic acid resistance and ciprofloxacin non-susceptibility are common. Third, ceftriaxone, cefixime and azithromycin may remain useful options, but their use should be guided by local susceptibility data. Fourth, periodic review of microbiology laboratory records can help identify changing resistance patterns early. This approach supports antimicrobial stewardship and reduces the risk of treatment failure, inappropriate antibiotic use and further resistance development.

Public health relevance

Enteric fever is closely linked to water safety, sanitation, food hygiene and population-level preventive measures. Hospital-based susceptibility data are useful for treatment guidance, but prevention requires broader public health interventions. Safe drinking water, improved sewage disposal, food safety practices and vaccination are important components of enteric fever control [9,10]. Since the present study was conducted in a tertiary care hospital receiving febrile illness cases from the community, the findings may reflect ongoing transmission in the population served by the hospital. Continued surveillance, early diagnosis and rational antibiotic use are essential to reduce the burden of typhoid and paratyphoid fever.

Strengths and limitations

The main strength of this prospective laboratory-based stud**y** is that it included only blood culture-confirmed *Salmonella* isolates, which makes the diagnosis more reliable than studies based only on serological tests. The study also documented organism-level identification along with antibiotic susceptibility patterns from a tertiary care hospital setting, providing useful local information for clinical decision-making.

However, a few limitations should be noted. Although the data were collected prospectively in the microbiology laboratory, detailed clinical information such as duration of fever, prior antibiotic intake, complications, treatment given and patient outcome was not available for all cases. The study was also limited to laboratory-confirmed isolates and therefore may not represent all clinically suspected enteric fever cases. Despite these limitations, the findings provide meaningful evidence on *Salmonella* bloodstream infection and its antibiotic susceptibility pattern in this hospital population.

Overall interpretation

Overall, this prospective study showed that *S. Typhi* was the main cause of culture-confirmed Salmonella bloodstream infection in this tertiary care hospital. The cases were more frequent among adolescents and young adults. The antibiotic susceptibility pattern showed that third-generation cephalosporins and azithromycin still had good activity against many

isolates. In contrast, reduced susceptibility was noted with fluoroquinolone-related drugs, and the response to older first-line antibiotics was variable. These findings highlight the need for routine blood culture testing, regular preparation of a hospital antibiogram and judicious antibiotic selection in suspected enteric fever. Continued surveillance is essential to identify emerging resistance early and to guide both clinical treatment and public health measures.

CONCLUSION

The present prospective study showed that *Salmonella* remains an important cause of bloodstream infection among patients attending a tertiary care hospital in Hyderabad. Out of 1164 blood culture samples processed during the study period, 134 were positive for *Salmonella* species. Among these isolates, *Salmonella Typhi* was the most common organism, whereas *Salmonella Paratyphi* and other *Salmonella* species were identified less frequently. Cases were seen across different age groups, with relatively higher involvement of adolescents and young adults, indicating increased exposure and susceptibility in these age categories.

The antibiotic susceptibility pattern showed good sensitivity to third-generation cephalosporins and azithromycin, suggesting that these drugs continue to be useful in many culture-confirmed cases of enteric fever. However, reduced susceptibility to ciprofloxacin and nalidixic acid, along with variable resistance to older first-line drugs such as ampicillin, chloramphenicol and cotrimoxazole, reflects the changing resistance profile of *Salmonella* isolates. These findings underline the need to avoid unnecessary empirical antibiotic use without culture and sensitivity support.

Overall, the study highlights the value of routine blood culture, proper species identification and regular antibiotic susceptibility testing in suspected enteric fever. Periodic preparation of a local antibiogram can help clinicians select appropriate empirical therapy, reduce treatment failure and support antimicrobial stewardship. Continuous surveillance is also important to identify emerging resistance trends and to guide effective prevention and treatment strategies for enteric fever.

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Ethical Consideration

Ethical approval was obtained from the Institutional Ethics Committee before starting the study. As this was a prospective laboratory-based study, blood culture samples were collected and processed as part of routine diagnostic evaluation in patients clinically suspected of enteric fever. No extra blood sample was taken only for research purposes. Patient confidentiality was maintained during data collection, analysis and reporting. Personal details were not disclosed in the manuscript, and the data were used only for academic and research purposes.

Authors' Contribution

All authors contributed to the concept, study design, data collection, data analysis, interpretation of findings and manuscript preparation. All authors reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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