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Susceptibility Profile of *Salmonella typhi* and *Salmonella paratyphi* A in A Tertiary Care Hospital

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A B S T R A C T

Enteric fever is a life-threatening systemic illness caused by Salmonella Typhi and Salmonella paratyphi. It is transmitted by the fecal-oral route via contaminated food and water and is therefore common where sanitary conditions are inadequate and access to clean water is limited. Historically, the first-line agents (ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole) were the drug of choice for the management of enteric fever. Since the emergence of drug-resistant strains of Salmonella, first-line antibiotics fell out of favor and were not frequently used for this illness lately. Interestingly, there have been recent reports of first-line antibiotic susceptible Salmonella strains. This reemergence of first-line antibiotic sensitive Salmonella strains is promising and highlights the importance of continuous antibiogram surveillance and helps in typhoid management. To study the change in antibiogram pattern of Salmonella Typhi and Salmonella paratyphi a over two years. Samples such as blood, stool, urine, body fluids received in microbiology department of ASTER MIMS HOSPITAL are examined for salmonella using standard bacteriological methods. Antimicrobial susceptibility is tested using Kirby -Bauer disc diffusion method results interpreted according to CLSI guidelines. The VITEK® 2 Compact automatic system is employed for identification. Among the 133 isolates studied 66 identified as Salmonella Typhi and Salmonella Paratyphi A, people aged 21–30 were more in number. majority of isolates were from blood followed by bone marrow and stool, case numbers was peaking between April and July the overall antimicrobial susceptibility profile of Salmonella Typhi and S. Paratyphi A remained highly favorable for the firstline drugs that is ampicillin, amoxiclav, ceftriaxone and cefixime which continued to show 100 % sensitivity Although ciprofloxacinsusceptibility rate for S. Typhi was unchanged, resistance incresed by 6 %, and the proportion of intermediate isolates decreased by 7 %, In S. Paratyphi A, effectiveness of ciprofloxacin has declined by 17%, . Azithromycin Susceptibility has decreased in both isolates (1% for S. Typhi, 6 % for S. Paratyphi A). An increase in sensitivity to chloramphenicol was recorded (4% for S. Typhi, 14 % for S. Paratyphi A). Ampicillin, amoxiclav, ceftriaxone and cefxime continue to be the Most reliable empirical options, the gradual changes in ciprofoxacin and azithromycin susceptibility pattern highlights the importance of continual monitoring of change in antibiotic susceptibility to ensure effective treatment and address emerging resistance.

Introduction

Enteric fever is a disease caused by Typhoidal strains of Salmonella, including *S. Typhi* and S. Paratyphi. It is transmitted through contaminated food and water. Typically, in regions lacking adequate sanitation and access to clean drinking water. (1) Once it enters the body, *S. typhi* primarily targets the small intestine (specifically the ileum), along with the liver, spleen, and bone marrow. Gallbladder, and bloodstream, potentially leading to conditions like bacteremia and septicemia.

The disease usually presents with symptoms such as a high-grade fever, exhaustion, abdominal discomfort, and diarrhea. Complications can include Leukopenia and platelet counts, along with elevated levels of C-reactive protein and alanine aminotransferase (ALT). Poor sanitation and low socioeconomic status play an important part in the continued transmission of the disease. (2) Historically, antibiotics including antibiotics like ampicillin, chloramphenicol, and cotrimoxazole were considered the primary treatment options. (2) Although the introduction of antibiotics significantly decreased the rates of illness and death, the growing issue of antibiotic-resistant strains now poses a significant issue in public health concern. Currently S. enterica serovar Typhi shows considerable resistance to commonly prescribed antibiotics. Multidrug-resistant (MDR) strains of both S. Typhi and S. Paratyphi have become more prevalent, especially in developing nations. Reports have documented resistance to antibiotics like chloramphenicol, amoxicillin, cotrimoxazole, and ciprofloxacin, further complicating treatment. (2) Due to the rise of these resistant strains, earlier first-line treatments fell out of common use. However, new findings have shown that some strains have regained sensitivity to these older antibiotics, suggesting a possible shift in treatment strategies. This reap of antibiotic- sensitive strains underlines the importance of ongoing antibiotic susceptibility testing (antibiogram surveillance) in effectively managing typhoid fever. (3) This study helps in identifying the change in susceptibility profile of S. Typhi and S. Paratyphi A

Materials and Methods

Salmonella species isolated from clinical samples in laboratory were collected. during a period of one year prospective and one year retrospective. Demographic Information comprising the patient's name, age, and sex, together with the identified organism and its antibiotic sensitivity pattern for ampicillin, azithromycin, amoxiclav, cefixime, co-trimoxazole, ciprofloxacin, ceftriaxone, and chloramphenicol are done. Samples were processed, identified and confirmed by biochemical reactions and automated methods i.e. BACT ALERT and VITEK systems, done as per the standard laboratory procedures. The antibiotic susceptibility test by the Kirby Bauer's disc diffusion method diffusion technique and interpreted using Clinical and Laboratory Standards Institute (CLSI) recommendations and VITEK 2 system.

Results and Discussion

The study was conducted in the Department of Microbiology, Aster MIMS hospital Calicut during a period of one year prospective and one year retrospective from January 2024 to December 2024.

A total of 133 Salmonella isolates obtained during the study period, with 66 identified as *Salmonella Typhi* and *Salmonella Paratyphi A*. Out of these, 32 isolates were from the year 2023, and 34 were from the year 2024.

Year wise data of salmonella isolated

Sample Wise Incidence

In 2023 out of 32 isolates majority of isolates were from blood followed by bone marrow, Whereas In 2024 out of 34 isolates majority of organism were from blood followed by stool

Gender Wise

Males accounted for the majority of the cases (n=46, 70%) compared to females (n=20, 30%).

Month Wise

Antibiotic susceptibility pattern of the salmonella typhi 2023 -2024

Year-wise trend in antibiotic sensitivity rates of salmonella typhi from 2023 to 2024

All *S. Typhi* isolates were 100% sensitive to ampicillin, ceftriaxone, cotrimoxazole, amoxiclav and an increased sensitivity rates were seen in chloramphenicol (4%) and decreased sensitivity was seen in azithromycin (1%) in

2024 than in 2023. cefixime and ciprofloxacin remained sensitivity rates same in both years. ciprofloxacin, resistance was increased by 6% from 2023 to 2024

Year-wise trend in antibiotic intermediate results of salmonella typhi from 2023 to 2024

Intermediate susceptibility was observed only for ciprofloxacin in *S. Typhi* intermediate susceptibility rate of ciprofloxacin was decreased (7%) from 2023 to 2024

Year -wise trend in antibiotic sensitivity rates of salmonella paratyphi a from 2023 to 2024

Sensitivity rates of salmonella paratyphi a from 2023 to 2024

All S. Paratyphi A isolates were 100% sensitive to ampicillin, ceftriaxone, cotrimoxazole, amoxiclav and cefixime. Increased sensitivity was seen in chloramphenicol (14%) decreased sensitivity rates was seen in azithromycin (6%) and ciprofloxacin (17%) from 2023 to 2024

In this study out of total 133 salmonella isolates obtained during the study period, 49 isolates were found to be S. *Typhi* and 17 were found to be *S. Paratyphi.* according to the study conducted by Buckle *et al.,* [4] *S. Typhi* is more prevalent than *S. Paratyphi A* globally in the present study Males accounted for the majority of the cases (70%) compared to females 30%. This shows similarities between the study conducted by Masab Umair *et al.,* [3], in which Males accounted for the majority of the cases 66. 3% and 33. 7%were females here highest incidence was observed among young adults aged 21-30 years accounting for 42% of cases which is similar to study by Sudeepa Kumar *et al.,* [5]*Salmonella Typhi* and *Paratyphi A* were highest in the age group 21 – 30 years. In this study, The highest number of cases were reported in months of April, May, June, July, indicating a seasonal trend which is similar to a study conducted by Yasir Mayeli Flores Monter *et al.,* [6] where more cases are in April and May reaching a peak in July, with a decrease in September. All *S. Typhi* isolates were 100% sensitive to ampicillin, ceftriaxone, cotrimoxazole, amoxiclav which is similar to study of Satish Kumar Reddy *et al.,* [7] which showed 100% isolates were susceptible to ceftriaxone, 99% isolates were susceptible to Ampicillin, 95% isolates were susceptible to cotrimoxazole. a study by Mohammed Nafiudin Rashed *et al.,* [8] found that All isolates were 100% sensitive to amoxicillin-clavulanic acid. In this study increased sensitivity rates were seen in chloramphenicol (4%) which is similar to study by Krishnan, Padimate *et al.,* [9] In which *Salmonella enterica* serovar typhi showed significant increase in sensitivity to chloramphenicol. here decreased sensitivity was seen in azithromycin (1%) which is similar to study by Usman Baig *et al.,*[10] in which The lowest resistance was noted for azithromycin, and. ciprofloxacin, resistance was increased by 6% in 2024 than in 2023. which is similar to study by Jaffar A. Al- Tawfiq *et al.,* [11] The study showed that the resistance rate to ciprofloxacin increased over time, with values ranging from 1. 6% to 6%, respectively. Intermediate susceptibility was observed only for in *S. Typhi*. All *S. Paratyphi A* isolates were 100% sensitive to ampicillin, ceftriaxone, cotrimoxazole, amoxiclav, cefixime. Increased sensitivity was seen in chloramphenicol (14%) which is similar to study by Lakshmi V, Ashok *et al.,* [12] in which the *S. Paratyphi A* isolates showed a significant increase in the sensitivity pattern to chloramphenicol . in this study decreased sensitivity rates was seen for ciprofloxacin (17%) from 2023 to 2024 which is similar to study by Mohammad S I Sajib *et al.,* [13] in which 16. 8 % isolates had decreased ciprofloxacin susceptibility. in this study decreased sensitivity rates was seen for azithromycin (6%) which is similar to a study by Maria Sjölund-Karlsson *et al.,* [14] in which azithromycin susceptibility for *S. Paratyphi A,* Susceptible proportion dropped from 99 % (2021) to 92–94 % (2024) – i. e. 6–8 % now non-susceptible

Table.1 Year wise incidence of Salmonella Typhi and Salmonella Paratyphi A

2023		2024	
S. Typhi	**S. *Paratyphi***	***S. Typhi***	**S. Paratyphi**
25	**7**	**24**	**10**

Table.2 Sample wise incidence of Salmonella Typhi and Salmonella Paratyphi A

Sample	2023		2024	
	S. Typhi		S. Paratyphi	
Blood	24	7	23	**10**
Bone marrow	1	0	0	**0**
Stool	**0**	**0**	**1**	**0**

Table.3 Gender wise distribution of Salmonella *Typhi and Salmonella Paratyphi A*

Gender	Number of *Salmonella Typhi and Salmonella Paratyphi A*	
	Number	Percentage
Male	46	**70**
Female	**20**	**30**

Table.4 Age wise distribution of Salmonella *Typhi and Salmonella Paratyphi A*

AGE	NUMBER
1 to 10	**4**
11 to 20	**14**
21 to 30	**24**
31 to 40	**13**
41 to 50	**3**
>60	**8**

Table.5 Month wise incidence of Salmonella Typhi and Salmonella Paratyphi A (2023-2024)

Month	No. of Salmonella isolated
January	**4**
February	**2**
March	**6**
April	**7**
May	**10**
June	**9**
July	**8**
August	**4**
September	**4**
October	**6**
November	**2**
December	**4**

Table.6 Year-wise trend in antibiotic sensitivity rates of *Salmonella Typhi* from 2023 to 2024

ANTIBIOTIC	2023		2024	
	No	%	No	%
AMPICILIN	25	100	24	**100**
AZITHROMYCIN	23	92	23	**96**
CEFTRIAXONE	25	100	24	**100**
CIPROFLOXACIN	2	8	2	**8**
COTRIMOXAZOE	25	100	24	**100**
AMOXYCLAV	25	100	24	**100**
CEFIXIME	24	96	23	**96**
CHLORAMPHENICOL	**22**	**88**	**22**	**92**

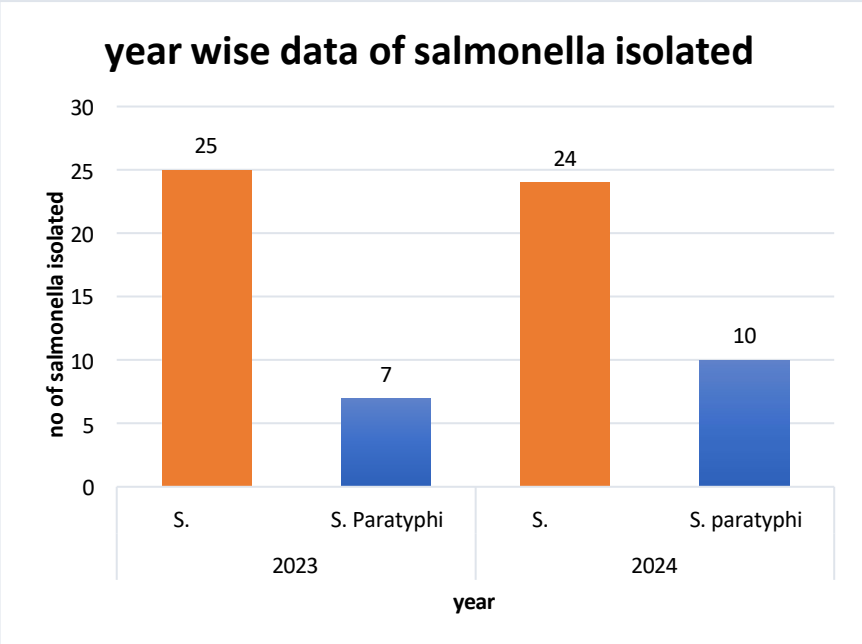
Table.7 Year -wise trend in antibiotic intermediate results of *Salmonella Typhi* from 2023 to 2024

Antibiotic	2023		2024	
	No	%	No	%
Ampicilin	0	0	0	**0**
Azithromycin	0	0	0	**0**
Ceftriaxone	0	0	0	**0**
Ciprofloxacin	9	36	7	**29**
Cotrimoxazole	0	0	0	**0**
Amoxyclav	0	0	0	**0**
Cefixime	0	0	0	**0**
Chloramphenicol	**0**	**0**	**0**	**0**

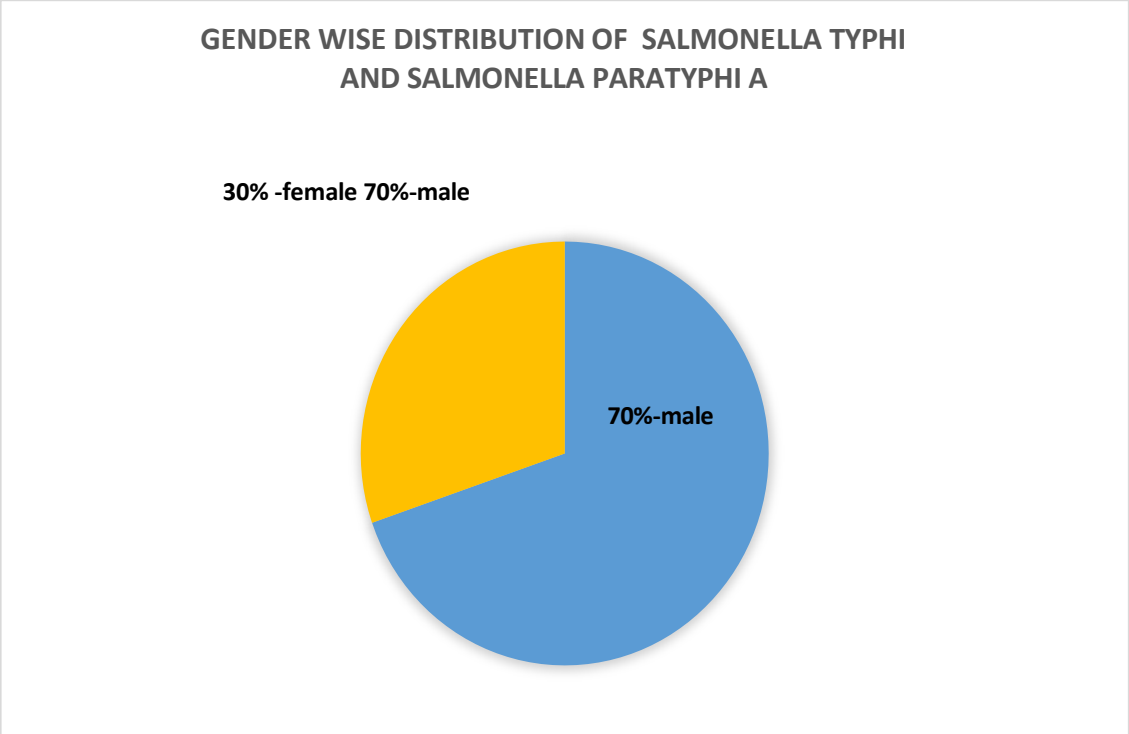
Table.8 Year -wise trend in antibiotic sensitivity

Antibiotic	2023		2024	
	No	%	No	%
Ampicilin	7	100	10	**100**
Azithromycin	6	86	8	**80**
Ceftriaxone	7	100	10	**100**
Ciprofloxacin	4	57	4	**40**
Cotrimoxazole	7	100	10	**100**
Amoxyclav	7	100	10	**100**
Cefixime	7	100	10	**100**
Chloramphenicol	**6**	**86**	**10**	**100**

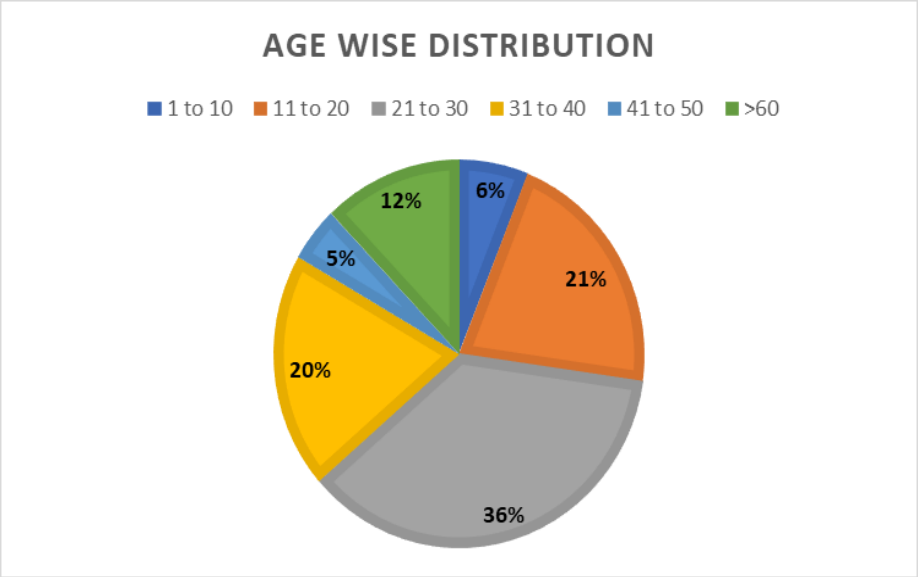
Graph.1 Year wise data of *Salmonella* isolated



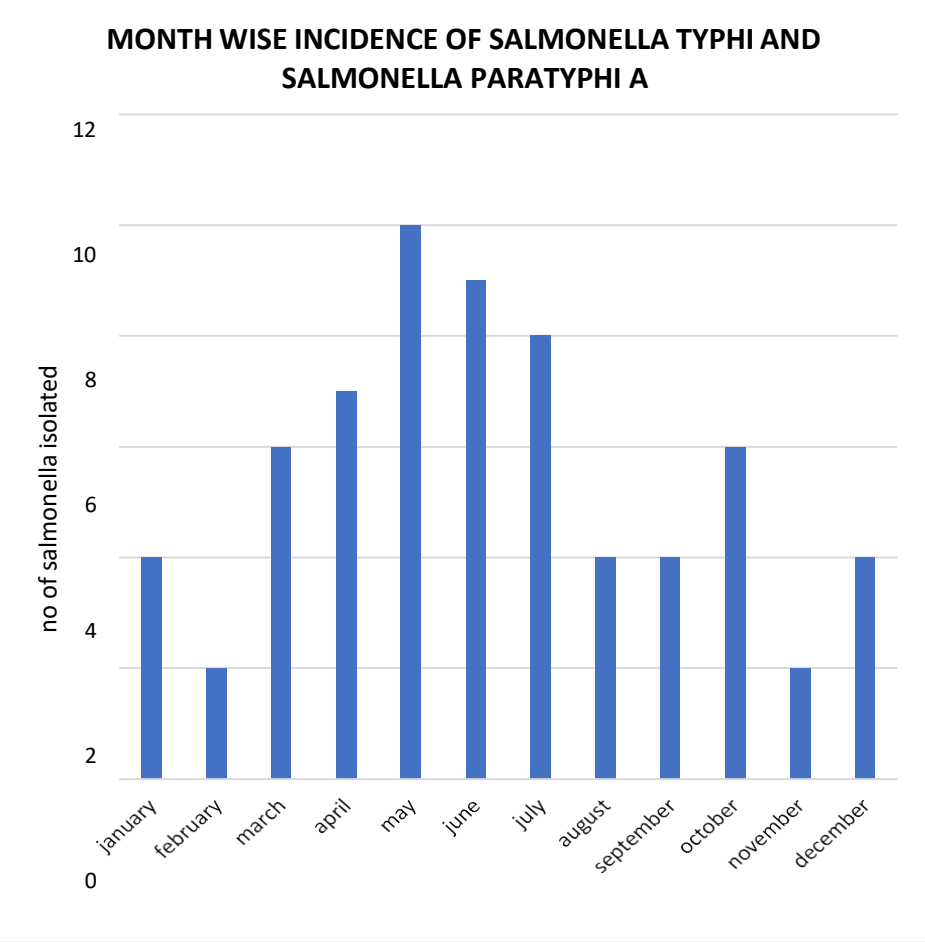
Graph.2 Gender wise distribution of Salmonella *Typhi and Salmonella Paratyphi A*



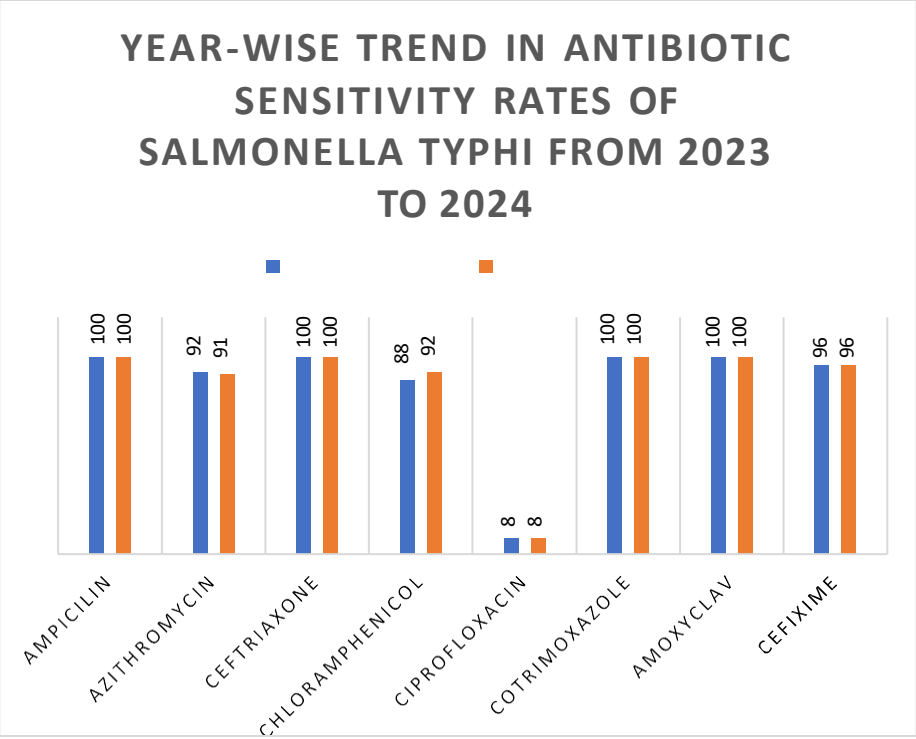
Graph.3 Age wise distribution of Salmonella *Typhi and Salmonella Paratyphi A*



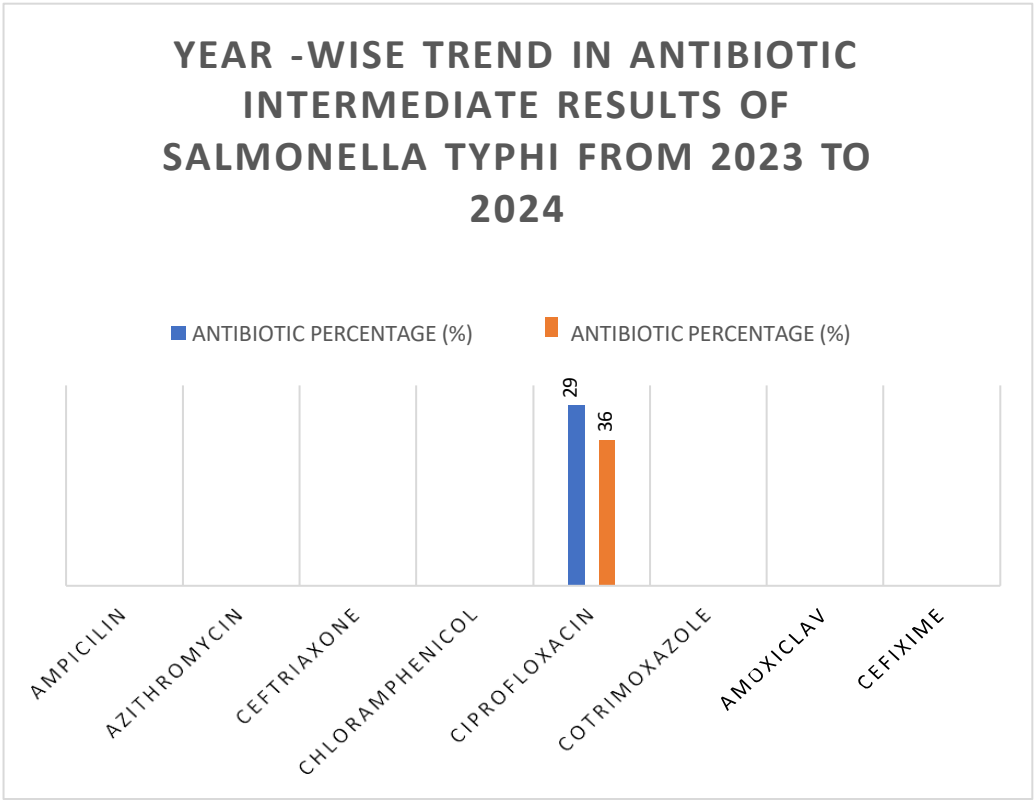
Graph.4 Month wise incidence of Salmonella Typhi and Salmonella Paratyphi A



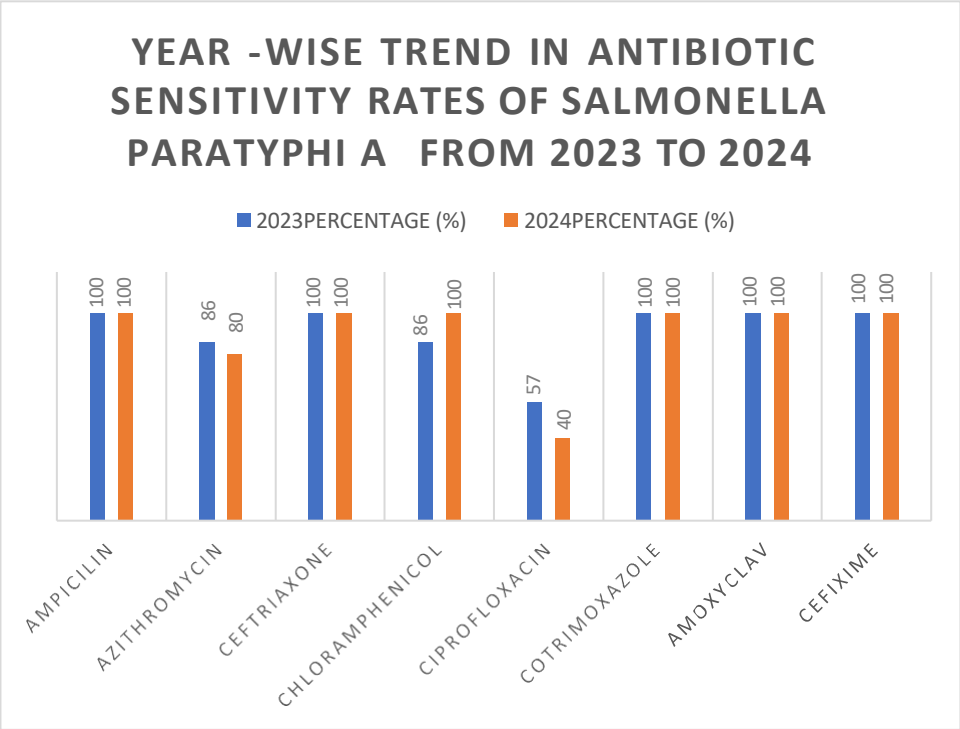
Graph.5 Year-wise trend in antibiotic sensitivity rates of *Salmonella Typhi* from 2023 to 2024



Graph.6 Year -wise trend in antibiotic intermediate results of *Salmonella Typhi* from 2023 to 2024



Graph.7 Year -wise trend in antibiotic sensitivity rates of *Salmonella Paratyphi A* from 2023 to 2024



In the current study the change in antibiotic pattern of *S. Typhi* and *S. Paratyphi A,* between 2023 and 2024 was studied. Among the 133 isolates studied 66 identified as *Salmonella Typhi* and *Salmonella Paratyphi A*, people aged 21–30 were more in number. Majority of isolates were from blood followed by bone marrow and stool with case numbers peaking between April and July. The overall antimicrobial susceptibility profile of *Salmonella Typhi* and *S. Paratyphi A* remained highly favourable for the Firstline drugs that is ampicillin, amoxiclav, ceftriaxone and cefixime which continued to show 100 % sensitivity.

Although ciprofloxacin susceptibility rate for *S. Typhi* was unchanged, resistance increased by 6 %, and the proportion of intermediate isolates decreased by 7 %, indicating a drift of previously intermediate strains toward full resistance.

In *S. Paratyphi A*, effectiveness of ciprofloxacin has declined by 17%, making it an unreliable choice for initial treatment without prior testing. Azithromycin Susceptibility has decreased in both isolates (1 % for *S. Typhi*, 6 % for *S. Paratyphi A*), suggesting reduced effectiveness. An increase in sensitivity to chloramphenicol was recorded (4 % for *S. Typhi*, 14 % for *S. Paratyphi A*), indicates increased effect observed after limited use. Clinical use still demands caution because resistance can reemerge rapidly.

The study highlights the importance of monitoring antibiotic susceptibility pattern in *S. Typhi* and *S. Paratyphi A* while first line drugs, ampicillin, amoxiclav, ceftriaxone and cefixime continue to Be effective, and reliable empirical options.

The gradual changes in ciprofloxacin and azithromycin Susceptibility emphasize the need for ongoing surveillance to ensure effective treatment

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Author Contributions

M. M. Athulya: Investigation, formal analysis, writing—original draft. M. Savitha: Validation, methodology, writing—reviewing. Reshmi Gopalakrishnan:—Formal analysis, writing—review and editing. Swathy Viswanath: Investigation, writing—reviewing. M. P. Anjali: Resources, investigation writing—reviewing. Irfana: Validation, formal analysis, writing—reviewing. Gayathri Meyana: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript. P. P. Vismaya: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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