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Antibiotic Susceptibility Pattern of *Salmonella typhi* Isolated from Hostel Tap Water of a Tertiary Institution in Makurdi

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Abstract

Typhoid fever is caused by *Salmonella enterica* serovar Typhi. This study was undertaken and the study aims to ascertain the antibiotic susceptibility pattern of *Salmonella typhi*. Isolation of *Salmonella typhi* strains from a total of 20 tap water samples from four different hostels in the Federal University of Agriculture, Makurdi was done by standard microbiological and biochemical techniques. The strains isolated were examined for their susceptibility to ten antibiotics using the disc diffusion method. The highest susceptibility was to Tarivid and Streptomycin (65%), followed by Amoxicillin (50%), Gentamycin (40%), Septrin (30%), the drug with the highest resistance was Pefloxacin (100%), Sparfloxacin (65%), intermediate resistance in Ciprofloxacin and Chloramphenicol (40%). Block A isolates recorded the highest susceptibility to antibiotics in the hostels while Block C had the least, but there was no significant difference in their mean ($P > 0.05$). This study indicates that the hostel water supply is contaminated with *Salmonella typhi* strains and these strains were resistant to Ciprofloxacin and other quinolones. Therefore, improvements in public sanitation facilities, vaccinations, availability of potable water for safe drinking, and rational use of antibiotics are some recommended ways of preventing antibiotic resistance in *Salmonella typhi*.

Keywords: Antibiotics, diseases, sanitation, strains, susceptibility, water

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Introduction

Water is life; it is also known as the universal solvent. Water serves as the habitat of virtually all living organisms. More importantly, many living organisms use it in one area or the other for metabolic activities. Therefore, access to potable drinking water and improved sanitation is essential for a healthy life and avert the likelihood of outbreaks of diseases such as cholera, typhoid, diarrhoea and other waterborne diseases [1]. It obvious that an estimation of about 1.7 million people's deaths are associated with the drinking of unsafe water every year of which infants are most at risk as a result of their low immunity to wage war against infection from contaminated water and lack of hygienic sanitation. Worse still, about 783 million people across the globe do not have access to potable drinking water, nearly 2.5 billion people lack access to adequate sanitation, resulting in 6 to 8 million deaths annually due to waterborne diseases [2].

The ubiquity of microorganisms gives them ample opportunity to survive in poorly treated tap water or when not treated at all. Bacteria such as *Escherichia coli*, *Salmonella* spp., *Shigella dysenteriae*, *Campylobacter jejuni*, and *Pseudomonas aeruginosa* are some of the water-borne pathogens. Water borne diseases can be life threatening or at worst lead to the death of infected individuals. In many parts of the world, the changing modes of presentation and the development of multidrug resistance have made typhoid fever increasingly difficult to treat [3-5]. Multidrug resistant (MDR) *Salmonella typhi* strains are resistant to the three first line drugs and other antibiotics recommended for treatment of typhoid fever. Some of these antibiotics include Chloramphenicol, Ampicillin, Ceftriaxone, trimethoprim-sulfamethoxazole [6].

In addition, *Salmonella* spp. showed resistance to antimicrobials, with chloramphenicol resistance dating back to 1972. This led to superbug infections across various drugs used against multidrug-resistant strains [7]. Thus, the antimicrobial resistance in *Salmonella* has led to the failure of treatment of typhoid. Globally, there is report on increase in the prevalence of multidrug resistance among *Salmonella* species. The resistance antibiotic such as fluoroquinolones which is one of the important clinical antibiotics were used in treatment of infection caused by *Salmonella* species [8]. Meanwhile, typhoid fever is a familiar disease in the public health; it is a potentially life-threatening gastrointestinal infection cause by non-spore-bearing bacilli known as *Salmonella enterica* serovar *typhi*. The bacterium is often gain access to the body by means of faecal oral contamination with the organism into the body through the intestinal mucosa in the region of the Peyer's patches [9].

However, public health strategies through advancement in technology and maintenance of personal hygiene have reduced typhoid fever to endemic level in the many developing countries across the globe since 1800s [10, 11]. But, this way forward also resulted into the emergence of multidrug resistant (MDR) *Salmonella typhi* strains against first line antimicrobials such as Ampicillin, Chloramphenicol, and Cotrimoxazole [10].

The bacteria can survive for weeks in water or dried sewage. Therefore, an estimated of 3 - 5% of people become carriers of the bacteria after the acute illness; whereas, others suffer a very mild illness that goes unrecognized. These people may in the long run become long-term carriers of the bacteria. So it will become difficult to break the route of the infection in such as an environment. With regards to stool contamination, an approximate of 10% patients recovering from the infection of *Salmonella typhi* contracted it for three months, and in the past 2-3% became permanent carriers [2, 12].

Further, symptoms of typhoid fever do begin after an incubation period of 10 to 14 days [13]. Qamar *et al*. [14] showed that *Salmonella typhi* is a particular *Salmonella* serovar that causes typhoid fever is a major public health concern in developing countries. *Salmonella typhi* is a motile, non- spore-forming, rod-shaped bacterial isolates, it is facultative anaerobe and it belongs to the family of enterobacteriaceae [14]. This bacterium exhibits different metabolic features, levels of virulence, and multi-drug resistance genes [15, 16].

Despite newer antibiotics, *Salmonella typhi* still develop resistance to antibiotics like ampicillin, ceftriaxone, ciprofloxacin and co-trimoxazole. Thus, enteric fevers can be fatal without appropriate antibiotics treatment [17].

Antimicrobial therapy, including penicillins (e.g., amoxicillin, ampicillin), cephalosporins (e.g., ceftriaxone, cefuroxime), aminoglycosides (e.g., streptomycin, gentamicin), macrolides (e.g., erythromycin), fluoroquinolones (e.g., ciprofloxacin, ofloxacin, perfloxacin), and tetracyclines, is essential for treating enteric fever and its complications caused by *Salmonella typhi* [18].

According to Arora and Arora [19], typhoid fever responds slowly to ampicillin, amoxicillin, cotrimoxazole or trimethoprim alone. Among fluoroquinolones, ciprofloxacin, ofloxacin and perfloxacin are commonly used antibiotics as a result of their ability to inhibit bacterial enzymes like DNA gyrase which is vital for bacterial DNA replication. Out of the third generation cephalosporins; ceftriaxone, cefotaxime and cefoperazone are effective therapeutic agent that can be used as an alternative in combating of multidrug resistant *Salmonellatyphi* [19, 20]. Raveendran *et al*. [21] revealed that fluoroquinolones including ciprofloxacin and ofloxacin, third generation cephalosporins which include ceftriaxone and cefixime, and azithromycin are very useful as the second line of treatment for multidrug resistant strains. Mechanism of antibiotics resistance in *Salmonella typhi* is mediated by two factors which include acquisition of foreign genes via plasmids and mutation on chromosome [22]. So, *Salmonella typhi* resists the action of antimicrobials by inactivation of the antimicrobial agent, efflux or transport of the antimicrobial, modification of the antimicrobial target site, reduced permeability of the antimicrobial agent. Thus, most drug resistance is due to a genetic change in the organism, either a chromosomal mutation or the acquisition of a plasmid or transposon [8].

Moreover, Wain [23] reported antibiotic resistance in *Salmonella typhi* which is usually plasmid mediated. Plasmids of incompatibility group (Inc) HI1 are important vectors of antibiotic resistance in *Salmonella typhi*. Plasmid associated genes have been implicated in resistance to aminoglycosides, chloramphenicol, penicillins, cephalosporins, erythromycin, tetracycline, sulphonamides and others [24, 25]. More so, chloramphenicol contains two hydroxyl groups that can be acetylated in a reaction catalyzed by the enzyme chloramphenicol acetyltransferase with acetyl CoA as the donor. Aminoglycosides can be modified and inactivated in several ways. Acetyltransferase catalyzes the acetylation of amino groups. Some aminoglycoside modifying enzymes catalyze the addition of hydroxyl groups of either phosphates (phosphotransferases) or adenyl groups (adenyltransferases) [20, 24]. Therefore, to reduce membrane permeability, pathogens often become resistant simply by preventing the entrance of the drug. In *Salmonella typhi*, resistance to tetracycline, quinolones, and some aminoglycosides has occurred by this mechanism. A decrease in permeability can also lead to sulfonamide resistance [20, 24].

Denyer *et al*. [8] further investigated that chromosomal resistance has been attributed to a mutation in the gene that codes for either the target of the drug or the transport system in the membrane that controls the uptake of the drug. The frequency of spontaneous mutations usually ranges from 10^{-7} to 10^{-9} which is much lower than the frequency of acquisition of resistance plasmids. Therefore, chromosomal resistance is less of clinical problem than is plasmid-mediated resistance.

In general, the enteric fever prevention focuses on improving hygiene and sanitation for safety of food and water supplies, as well as identification and treatment of chronic carriers of *Salmonella typhi* and the use of typhoid vaccines to reduce the susceptibility of hosts to infection [11]. Two vaccines available for the prevention of typhoid fever include The Ty21a vaccine is a live, attenuated, oral vaccine containing the *Salmonella typhi* strain Ty21a, and the parenteral Vi vaccine is based on the *Salmonella typhi* Vi antigen and Ty21a is available as enteric capsules and is licensed in the United States for use in children 6 years of age and elsewhere including Nigeria, for children as young as 2 years of age. The Vi-based vaccine is licensed in the United States for children aged 2 years. The effectiveness of the parenteral Vi vaccine has recently been confirmed in young children, and the protection of unvaccinated neighbours of Vi vaccines has been demonstrated [11, 26].

The identification and treatment of *Salmonella typhi* carriers, particularly those involved with food production, has proven to be an important strategy for the control of typhoid fever in low-incidence settings. Although carriers can be identified by serial culture of stool specimens, this approach is labour-intensive. Anti-Vi antibody assays have proven to be a useful

alternative to stool culture for identifying carriers in outbreak settings. However, when used at the community level in an area where typhoid is endemic, the high background levels of anti-Vi antibodies appear to render the method impractical [27].

In the University of Agriculture Makurdi, a good percentage of the students reside in the school hostels. These hostels' main source of water is the tap water. And the students depend on tap water supplied for drinking and cooking on daily basis. The need for this study is to ascertain the antibiotics resistance of *Salmonella typhi*, the causative organism for typhoid fever present in this water the students consume daily. The results of this study will hopefully be useful for public health agencies and the management of the water board responsible for providing water to the school hostels.

Materials and Methods

Study area

The study area is the hostels of Federal University of Agriculture, Makurdi Benue State. The University has four hostels in South Core area of it. The four hostels are Block A, Block B, Block C and Block C annex. The Blocks A and B are the female hostels while Block C and its annex are male hostels. Each of the hostels has 79 rooms except the annex that has 20, also the main hostels are all a one-Storey building but the annex is a bungalow. Blocks A, But and C accommodates up to 500 or 550 students each, the annex is 130 students. These hostels are all in the South Core axis just after the multipurpose building and adjacent the Cafeteria block.

Sample collection

A total of 20 samples of tap water were collected from 5 taps in each of these 4 hostels. This is done in a way that 3 water samples are collected from the left wing, the other 2 from the right wing of the hostels. The water samples were collected aseptically using a sterile universal container. The tap was turned on and water was allowed to run for about 20 sec before being collected. The sample were covered, labelled and immediately taken to the laboratory for bacteriological analysis.

Preparation of culture media

The various media viz: *Salmonella shigella* agar, selenite broth and nutrient agar, *Mueller hinton* agar used for the work were prepared according to the manufacturer's instructions. Required quantities of the powdered media were weighed using a digital weighing machine and dissolved in appropriate volumes of distilled water. These were swirled gently to allow proper mixing and autoclaved or heated in water baths as need be. They are then dispensed into sterile petri dishes or test tubes for various inoculations as described by Cheesbrough [28]. The various media and their preparations used for this research are:

Biochemical test

Catalase: 2 ml of Hydrogen peroxide (H_2O_2) was poured into Petri dishes and using a sterile applicator stick or broom stick, several colonies were immersed in the Hydrogen peroxide solution and carefully observed for immediate bubbling. The presence of bubbles indicates a positive result.

Citrate: Simmons citrate agar was used to prepare slants in test tubes according to the number of samples to be tested, using a sterile wire loop; the slant was streaked with the inoculum and then stabbed. It was allowed for 24 h. A colour change from green to blue indicates a positive result.

Sulphide Indole Motility (SIM)

This is a three-in-one tests that tests for

Sulphide: This changes the colour of medium to black for the positive result and no colour change in the negative

Indole: Kovac's reagent was added in drops to the top of the already inoculated SIM media after 48 h. A colour change to Pink of the kovac's reagent which forms a ring on top indicates a positive result. No colour change indicates a negative result.

Motility: The inoculum is stabbed into the medium and if the inoculum disperses or moves away from the initial point of stab and spread to other parts of the medium, it is a positive result. It is negative if there is no sign of dispersion or the stab remains the same as it were when the organisms were inoculated.

Urease

Urea was used to prepare broth which was mixed thoroughly and dispensed aseptically in sterile tubes and cooled in slanted positions and a wireloop is used to inoculate the isolates on the slant and then stab. It is left for 48 h, a pink color change indicates a positive result, no colour change indicates a negative result.

Gram Staining

A wireloop was sterilized in Bunsen burner and allowed to cool. A drop of normal saline was added on a clean microscope slide, and the wireloop was used to pick the isolates and smeared it on the drop of normal saline on the slide after which it was heat fixed by passing over a flame. The smear was flooded with Crystal violet as a primary stain for the 1 min, followed by Lugols Iodine for 30 – 60 sec and then washed off. It was decolourized by Acetone for 30 sec and washed off with distilled water. The slides were counterstained with Safranin for 1 min and then washed off. The slides were kept in a rack to air dry after wiping the back with cotton wool. The stained slides were then viewed with a microscope under oil immersion at x100 objective lens. Gram positive bacteria stains purple while Gram negative stains red as described by Cheesbrough [28].

Antibiotic Susceptibility test

The *Salmonella typhi* was isolated and identified from each water sample collected. The standard Kirby-Bauer test disc diffusion method was used to determine the

antibiotic susceptibility profile of the isolates. *Salmonella typhi* inoculum was prepared by suspending the sub-cultured *Salmonella typhi* isolates in 3 ml of normal saline for 24 h in bijou bottles and the turbidity was compared with a Barium Chloride standard (0.5 McFarland). The antibiotics sensitivity was performed by pour plating 1 ml of the normal saline containing the inoculum on Müeller Hinton agar the antibiotics impregnated on this discs are:
Tarivid (10 ug), Streptomycin (30 ug), Septrin (30 ug), Chloramphenicol (30 ug), Sparfloxacin (10 ug), Ciprofloxacin (10 ug), Amoxicillin (30 ug), Augmentin (30 ug), Gentamycin (10 ug), Pefloxacin (30 ug). The antibiotics discs were dispensed unto the surface of the solidified inoculated agar plate using sterile forceps. The plate was incubated at 37°C for 24 h. The zone of inhibition were measured in millimeters using a calibrated metre rule and interpreted with Clinical Laboratory Standard Institute guidelines [29].

Statistical analysis

Data were entered and analyzed using Statistical Package for Social Science Version 20 Software. Results were presented through graphs and tables. Statistical significance of means was measured by using the ANOVA. A ($P<0.05$) was considered as statistically significant. All results are expressed as the mean ± standard error of the mean.

Results and Discussion

Table 1, shows the colony and morphological characteristics of the isolates as grown on Salmonella Shigella Agar. The black colony colour, smooth edge, flat elevation are all indicative of the presence of *Salmonella typhi.* The isolates count varied from 16 colony forming unit (CFU) as the minimum to 180CFU as the maximum. However, majority of the organisms evolved in the study had CFU greater than 50 CFU.

Table 1: Colony and morphological characteristic of salmonella

Isolates	Colony colour	Colony count	Shape	Grams	Edge	Elevation
A1	Black	53	Rod	-	Smooth	Flat
A2	Black	64	Rod	-	Smooth	Flat
A3	Black	72	Rod	-	Smooth	Flat
A4	Black	102	Rod	-	Smooth	Flat
A5	Black	75	Rod	-	Smooth	Flat
B1	Black	68	Rod	-	Smooth	Flat
B2	Black	70	Rod	-	Smooth	Flat
B3	Black	55	Rod	-	Smooth	Flat
B4	Black	59	Rod	-	Smooth	Flat
B5	Black	88	Rod	-	Smooth	Flat
C1	Black	68	Rod	-	Smooth	Flat
C2	Black	16	Rod	-	Smooth	Flat
C3	Black	40	Rod	-	Smooth	Flat
C4	Black	160	Rod	-	Smooth	Flat
C5	Black	120	Rod	-	Smooth	Flat
CE1	Black	29	Rod	-	Smooth	Flat
CE2	Black	44	Rod	-	Smooth	Flat
CE3	Black	180	Rod	-	Smooth	Flat
CE4	Black	60	Rod	-	Smooth	Flat
CE5	Black	48	Rod	-	Smooth	Flat

+ = positive; - = negative

Table 2, shows the result of the biochemical test of the isolates. The isolates were identified or characterized as *Salmonella spp* and *Salmonella typhi*. All the twenty isolates were catalase positive. With regards to catalase, citrate, sulphide and motility tests, only two isolates (A1 and B2) were positive, while the remaining eighteen isolates were negative.

Table 2: Biochemical test result

Isolates	Catalase	Citrate	Indole	Sulphide	Motility	Urease	Grams	Probable organism
A1	+	+	-	+	+	-	-	*Salmonella spp*
A2	+	-	-	+	+	-	-	*Salmonella typhi*
A3	+	-	-	+	+	-	-	*Salmonella typhi*
A4	+	-	+	+	+	-	-	*Salmonella typhi*
A5	+	-	-	+	+	-	-	*Salmonella typhi*
B1	+	-	-	+	+	-	-	*Salmonella typhi*
B2	+	+	+	+	+	-	-	*Salmonella spp*
B3	+	-	-	-	+	-	-	*Salmonella typhi*
B4	+	+	+	+	+	-	-	*Salmonella typhi*
B5	+	-	-	-	+	-	-	*Salmonella typhi*
C1	+	-	-	+	+	-	-	*Salmonella typhi*
C2	+	-	+	-	+	-	-	*Salmonella typhi*
C3	+	-	-	-	+	-	-	*Salmonella typhi*
C4	+	+	-	+	+	-	-	*Salmonella typhi*
C5	+	+	+	+	+	-	-	*Salmonella typhi*
CE1	+	-	-	+	+	-	-	*Salmonella typhi*
CE2	+	-	-	+	+	-	-	*Salmonella typhi*
CE3	+	+	+	+	+	-	-	*Salmonella typhi*
CE4	+	-	+	-	+	-	-	*Salmonella typhi*
CE5	+	-	-	+	+	-	-	*Salmonella typhi*

+ = positive; - = negative

Table 3: Antibiotic disk diffusion susceptibility test results for *Salmonella* spp. on various water samples from the hostel

Hostel	Isolates	OFX (10 ug)	S (30 ug)	SXT (30 ug)	CH (30 ug)	SP (10 ug)	CPX (10 ug)	AM (30 ug)	AU (30 ug)	CN (10 ug)	PEF (30 ug)
Block A	A1	18S	15 S	14 I	18S	18I	17I	12I	12R	7R	11R
	A2	17S	15 S	18 S	15I	15 R	20I	18S	18S	15S	16R
	A3	20S	20 S	18S	18S	18I	19I	17S	15I	16S	17R
	A4	11R	14I	6R	7 R	14 R	12R	15S	15I	12R	14R
	A5	20S	15S	14I	7 R	10R	18I	15S	17I	17S	16R
Block B	B1	12R	16S	15I	18S	11R	13R	8 R	12R	15S	17R
	B2	17S	12I	18S	15I	10 R	18I	8 R	14I	15S	12R
	B3	19S	15S	11I	14I	16I	13R	-R	13R	15S	14R
	B4	9 R	14I	16S	14I	18I	16I	12I	10R	- R	7 R
	B5	18S	14I	15I	- R	12R	13R	14S	17I	16S	17R
Block C	C1	13I	6 R	- R	12 R	- R	15R	6 R	- R	- R	5 R
	C2	15I	16S	17S	10 R	15R	16I	15S	15I	13I	12R
	C3	15I	17S	15I	16I	9 R	18I	16S	12R	5 R	- R
	C4	17S	15S	16S	13I	14R	17I	15S	14I	12R	9 R
	C5	16S	17S	11I	11R	17I	15R	- R	- R	12R	16R
Block CE	CE1	17S	9 R	14I	20 S	17I	12R	7 R	3 R	- R	10R
	CE2	9 R	- R	- R	14I	10R	14R	6 R	7 R	- R	- R
	CE3	17S	14I	13I	- R	- R	17I	18S	18S	18S	17R
	CE4	19S	12I	14I	17I	15R	17I	16S	17I	11R	13R
	CE5	16 S	17S	- R	- R	16I	16I	9 I	-R	- R	16R

OFX: tarivid, S: streptomycin, SXT: septrin, CH: chloramphenicol, SP: sparfloxacin, CPX: ciprofloxacin, AM: amoxicillin, AU: augmentin, CN: gentamycin, PEF: pefloxacin, S: susceptible, I: intermediate-resistant, R: resistant, - : nil.

Table 3, shows the susceptibility test of the isolates to different antibiotics. The isolates were resistant to Pefloxacin (100%), Sparfloxacin (65%), Augmentin (50%) but susceptible to Tarivid and Streptomycin (65%), Amoxicillin (50%), Gentamycin (40%), Septrin (30%). Intermediate resistance was observed in Ciprofloxacin and Chloramphenicol.

Table 4, shows the percentage susceptibility and resistance in hostel Blocks. Block C extension has the isolates with the highest resistance with a mean of 50 ± 8.03, followed by block C. and the least is Block A with a mean of 32± 9.52. However, there's no significant difference in their mean (P>0.05).

Table 4: Percentage susceptibility and resistance in Hotel Blocks

Block A		Block B		Block C		Block CE	
S(%)	R(%)	S(%)	R(%)	S(%)	R(%)	S(%)	R(%)
80	20	60	40	40	0	80	20
80	0	60	20	40	0	80	20
40	20	40	0	40	20	0	40
40	40	20	60	0	60	20	40
0	60	0	60	0	80	0	60
0	20	0	60	0	40	0	40
0	0	20	60	60	40	40	40
20	20	0	60	0	60	20	60
60	40	80	20	0	80	20	80
0	100	0	100	0	100	0	100
Ẋ	**Ẋ**	**Ẋ**	**Ẋ**	**Ẋ**	**Ẋ**	**Ẋ**	**Ẋ**
40 ± 10.75[a]	32 ± 9.52[a]	28 ± 9.52[a]	44 ± 9.33[a]	18 ± 7.57[a]	48 ± 10.83[a]	26 ± 9.91[a]	50 ± 8.03[a]

*Means in rows with similar superscript are not significantly different from each other

The antibiotics resistant bacteria have become a global challenge and even a threat to public health as result of the multiple resistant pathogens also known as superbug infections. In this study, a total of 20 tap water samples were collected from 4 different hostels in Federal University of Agriculture, Makurdi. It revealed that all the 20 isolates were resistant to Pefloxacin (100%), other higher resistance was observed in Sparfloxacin (65%), Gentamycin (55%), Augmentin (50%), and Intermediate resistance in Ciprofloxacin (65%), Septrin (50%), and Chloramphenicol (40%). The susceptibility of the isolates was majorly to Tarivid and Streptomycin (65%), Amoxicillin (50%), Gentamycin (55%). This show consistency to the report of Zaki and Karande [25] that *Salmonella typhi* gained resistance to antibiotics like ampicillin, ceftriaxone, and co-trimoxazole, as well developing resistance to other highly effective drugs such as ciprofloxacin. Umair and Siddiqui [30] are of similar opinion with regards to the high resistance of the isolates in this study. Umair and Siddiqui [30] recorded that similar isolates were resistant to amoxicillin, co-trimoxazole 61.4%, chloramphenicol and ciprofloxacin. Further results in the study shows that it was observed that Block C extension has the highest resistance with a mean of 50 ± 8.03, followed by Block C with a mean of 48 ± 10.83 with the least found in Block A with a mean of 32 ± 9.52. However, there is no significant difference in their mean (p>0.05). This implies that the students living in Block C and its annex have greater chances of contracting antibiotics resistant typhoid fever. This also indicates that there is a contamination of water supplied to these hostels; this could be as a result of inadequate treatment of the water or from dirty and contaminated storage tanks used as reservoirs for these hostels. It was reasoned that these *Salmonella typhi* strains are already the resistant ones as they survived some measures of chemical treatment.

This is in agreement with the previous studies that improvement in the quality of drinking water may be relatively more important for the prevention of enteric infection of which *Salmonella typhi* is not exempted [31].

In addition, the resistant factor (R-factor) in *Salmonella typhi* could be transferred from one strain to another during conjugation. This agrees with the report of Harriet and Nandita [1] who recorded that the chromosomal-mediated drug resistance phenomenon against fluoroquinolones has been reported recently and attributed to a single point mutation in the quinolone resistance determining region (QRDR) of the topoisomerase gene gyrA, which encodes DNA gyrase. Further investigations on the bacteria make it clear that it that the initial development of resistance by *Salmonella typhi* and most other bacterial pathogens are as a result of miss use of antibiotics. This also corroborates the studies of other researchers who recorded that difference in resistance rate which have been attributed to differences in sample strains examined [1, 25, 32].

The emergence of multidrug resistance to the commonly used antibiotics has further complicated the treatment and management of enteric fever and this is recognized as one of the greatest challenges in the management of this disease [17].

Conclusion

This study revealed that some water source for the school hostels contains *Salmonella typhi* indicating contamination. Certain antibiotics such as tarivid, streptomycin, amoxicillin, and gentamycin prove effective against the bacteria. Moreover, there is a growing trend of resistance to ciprofloxacin and other quinolones in the region, possibly due to their excessive or inappropriate use. Thus, it is recommended to conduct bacterial identification and antibiotic susceptibility testing before administering treatment, emphasizing the importance of proper antibiotic use and public health measures to tackle resistance.

Based on the findings of this study, there should be a thorough examination through the laboratory diagnostic test before the choice of antibiotics for the treatment of typhoid fever by physicians. The use of typhoid vaccine as means of immunization should be supplied by government to the students of tertiary institution and as well as to infants, primary and secondary schools children in the study area because they are at high risk of the disease. In addition, the leaf extract as alternative medicine should be used to cure typhoid fever where the bacteria develop multiple resistant to most of the commonly used antibiotics. Lastly, further research should be conducted on antibiotics to combat *Salmonella typhi* resistant strains.

Conflict of interest: The authors of this article declare no conflict of interest.

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