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| RESEARCH ARTICLE

Phenotypic Characterization and Antibiotic Susceptibility Pattern of Salmonella Species to Selected Antibiotics in Bauchi State, Nigeria.

Yakubu Dauda Abubakar[1], Wada Muhammad Nafiu[2] ✉ Elisha Victor Zuya[3] and Ambi A Ahmad[4]
[1234]Department of Science Laboratory Technology Federal Polytechnic Bauchi, Nigeria
Corresponding Author: Wada Muhammad Nafiu, **E-mail**: wnmuhammad.slt@fptb.edu.ng

| ABSTRACT

The study investigated phenotypic characterization and antibiotic susceptibility patterns of salmonella species to selected antibiotics in Bauchi State, Nigeria. This study was carried out in Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Infectious Disease Hospital Bayara (IDH), and Specialist Hospital Bauchi (SHB) in Bauchi State. A simple random sampling technique was employed in the collection of the sample. A total of 200 samples were collected, comprising of stool and blood samples from patients visiting the three facilities selected for the study. 100 samples from the Infectious Disease Hospital and 50 each from ATBUTH and Specialist Hospital Bauchi. The research reported the presence of *Salmonella* species with an overall prevalence of 5.5% in blood and stool samples from Bauchi state; the work has reported that there are *Salmonella* spp resistant to commonly used antibiotics and pose considerable health hazards unless prudent control measures are instituted. This could be due to the indiscriminate use of antibiotics in those areas, the use of substandard antibiotics or improper storage of antibiotics (as this could affect the potency of the drugs). However, the study showed that the *Salmonella* spp isolated was 95% sensitive to ciprofloxacin. Many alternative diagnostic tools for typhoid fever have been developed to utilize antibody-based methods. However, there are limitations with this method, such as the complication of having false-positive due to prior exposure to the antigen. Thus, there is a need for the development of antigen-based detection of pathogens.

| KEYWORDS

Salmonella species, Antibiotics, Pathogens

| ARTICLE INFORMATION

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1. Introduction

Salmonellosis is a disease condition caused by a large group of bacteria of the genus *Salmonella* that can affect human beings throughout the world. *Salmonella* infections remain a serious problem of public health significance worldwide and cause substantial economic loss resulting from mortality, morbidity, and poor growth with the hazard of transmitting food poisoning with gastroenteritis to humans and represents a serious problem for the food industry (Nesa et al., 2012). *Salmonella* infections in humans can range from self-limited gastroenteritis, usually associated with non-typhoidal *Salmonella* (NTS), to typhoidal fever with complications such as fatal intestinal perforation, severe infections, including bacteraemia and meningitis, have also been reported (Wattiau et al., 2011,(Faleke et al., 2017). *Salmonella* infections commonly present with watery diarrhoea, abdominal cramps, fever, headache, nausea, and vomiting. In approximately 1 to 4% of immunocompetent patients, bacteraemia occurs, and in 5 to 10% of those individuals, other extra-intestinal complications, including central nervous system infections, endocarditis, reactive arthritis, and urinary tract infections, may occur. It is estimated that in the United States, 1.2

million non-typhoidal *Salmonella* infections occur annually, resulting in 19,336 hospitalizations and 378 deaths(Kumar et al., 2012).

Salmonellosis is significantly underreported; therefore, it is very difficult to precisely determine the actual public health burden of *Salmonella* worldwide(Kumar et al., 2012). Typhoid fever, which is caused mainly by *Salmonella typhi*, continues to be a major problem in developing countries. Recently, it has been estimated that globally, there are more than 22 million cases of typhoid fever each year with more than 200,000 deaths; however, the true magnitude is difficult to quantify because the clinical picture is confused with many other febrile illnesses, and most typhoid endemic areas lack facilities to confirm the diagnosis (Faleke et al., 2017). A mild form of the disease, paratyphoid fever, is caused by serovars paratyphi A, B and C of *Salmonella enterica* subspecies *enterica*. The bacterium is generally carried in the bloodstream, intestinal tract, and faecalmatter of a human host and, therefore, highly contagious. It can be acquired by ingestion of food and water contaminated by faeces of infected humans or person-to-person contact. Developing countries with a low level of public hygiene are frequently reported with endemic typhoid infection(Adeshina et al., 2009). Whereas developed countries have an uncommon occurrence of typhoid fever where most cases are either acquired abroad or imported by emigrants, with an estimated annual incidence of 540 per 100,000 or about 17 million cases worldwide(Abioye et al., 2017).

Salmonella enterica subspecies *enterica* serovar Typhimurium (*S.* Typhimurium) is one of the most commonly detected serovars from food animals, retail meats and human clinical isolates in the U.S. According to the Center for Disease Control and Preventions' FoodNet, *S.* Typhimuriumwas the second most commonly isolated Salmonella serovar in 2009, after *S.* Enteritidis, and is the most common serovar responsible for Salmonella-related hospitalization in children under the age of 4 years in the U.S(Louden et al., 2012).

Several animals, including food animals such as pigs, are reservoirs of this pathogen. Healthy carriers of Salmonella can transfer the bacteria in their faeces by which pork can be contaminated during slaughter and processing. Such contaminated pork and related products can act as vehicles for the transmission of Salmonella to humans. Transmission can also occur through contact with animals(Fashae & Hendriksen, 2014).

The progressive increase in antimicrobial resistance to enteric pathogens is of greatest concern in the developing world. Since the 1960s, several *Salmonella* spp. have shown resistance to various common antibiotics such as ampicillin, chloramphenicol, and sulfamethoxazole-trimethoprim with increasing frequency throughout the world. Extended-spectrum cephalosporin and fluoroquinolones have become the drugs of choice for the treatment of infections caused by multidrug-resistant *Salmonella* serotypes due to the increased resistance to conventional antibiotics. However, since 1991, several studies from different countries have been reporting cases of infections by extended-spectrum cephalosporin-resistant salmonellae(Ochiai et al., 2008,(Shaikhani et al., 2013). Antimicrobial agents such as ampicillin, chloramphenicol and trimethoprim-sulfamethoxazole are used as the traditional first-line treatments for *Salmonella* infections. *Salmonella* species resistant to these agents are referred to as multi-drug resistant (MDR). For many years, the phenotypic trait of MDR was widely distributed among *Salmonella typhi* and, at a lower rate, among *Salmonella*paratyphi(Eng et al., 2015). Mechanisms of bacterial antimicrobial resistance include (i) changes in bacterial cell wall permeability, (ii) removal of antimicrobials via efflux pumps mechanisms, (iii) modification of the site of drug action, and (iv) destruction or inactivation of antimicrobials(Ochiai et al., 2008).

2. Materials and Methods

2.1 Ethical Clearance

Ethical approval to carry out this study was obtained from the Hospital Management Board Bauchi State, Nigeria. HMB/ADM/OFF/23/V.I

2.2 Study Area

This study was carried out in Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Infectious Disease Hospital Bayara (IDH), and Specialist Hospital Bauchi (SHB) in Bauchi State, Nigeria. The justification of the selected study area was based on the rate of the growing population of people visiting the respective facilities compared to

other medical institutions in Bauchi. The state has a varying climate with a cool, dry season (harmattan) from October to February, a hot, dry season from March to May and a warm, wet season from June to September. Water supply in Bauchi State is sourced through the damming of rivers and the digging of wells and boreholes. (*www.bauchistate.gov.ng*). The choice of one of the study areas goes with the fact that most inhabitants of Bayara (IDH) are from the rural setting; as such, utmost hygienic practice is not observed, which could lead to a high rate of salmonella infection, IDH particularly has a high number of reported cases for WIDAL test which sums up to about 1500 – 1700 cases per month.

2.3 Sampling Technique

A simple random sampling technique was employed in the collection of the sample. A total of 200 samples were collected comprising of stool and blood samples from patients visiting the three facilities selected for the study. 100 samples from the Infectious disease hospital and 50 each from ATBUTH and Specialist Hospital Bauchi.

2.4 Preparation and Storage of Culture Media

All media used were prepared according to the manufacturer's instructions.

2.4.1 Sample Collection

Blood was drawn aseptically using a 5 ml syringe and needle. About 2 ml of blood were collected from patients. The blood was aseptically transferred to an 8ml tetrathionate broth tube and incubated. Tubes that show no turbidity were kept for 48 and 72 hours, respectively. Each tube was carefully labelled with the patient's number already indicated in the research consent form. For the collection of stool specimens, the subjects were provided with clean wide-mouthed containers and about 2 g of the stool was transferred unto tubes containing 8ml of Selenite F Broth and was incubated at 37^{o}C for 24 hours. (Rabiu et al., 2018).

2.4.2 Microbiological Analysis

Processing of blood and stool samples. *Tubes that showed turbidity were sub-cultured each from each of the containers unto freshly prepared and dried Salmonella-Shigella agar (SSA) and incubated at 37°C for 24 hours; the plates were further differentiated on MacConkey agar and incubated at 37 °C. The stool samples were first inoculated into the enrichment medium (selenite–F broth), and after incubation for 24 hours at 37 ºC, each was sub-cultured unto Salmonella-Shigella agar and MacConkey agar (MCA) (Rabiu et al., 2018). The SSA and MCA plates were incubated overnight at 37 ºC and examined* for colonies typical of Salmonella. Suspected colonies were streaked on nutrient agar plates to obtain pure cultures, which were subjected to biochemical confirmation (OGU & AKINNIBOSUN, 2019).

2.4.3 Biochemical Test for the Detection Of Salmonella Species

The following biochemical tests were carried out as recommended for the biochemical screening of *Salmonella* species: TSI, Urease, Citrate, Motility / Indole / Ornithine, Methyl red and Voges Proskauer Test (Organization, 2003).

2.5 Serological Typing

All biochemically confirmed Salmonella isolates were serologically identified, a drop of antisera O Polyvalent group A and D was used, followed by O monovalent anti sera0:1,2, O:9, and VI was placed on a slide and isolate was picked from nutrient agar slant following Kauffman–White scheme.

2.5.1 Procedure

An agglutination test was performed on a clean glass slide. The slide was divided into sections with a wax pencil, and one small drop of physiological saline was placed in each test section on the slide. By using a sterile inoculating loop, a portion of growth from the surface of the nutrient agar slant was removed and emulsified in each drop of physiological Saline on the slide. It was then mixed thoroughly to create a moderately milky suspension. A bent inoculating loop was used to pick a small drop of the polyvalent antiserum groups A and D and transfer it to one of the suspensions; the second suspension served as the control (usually an approximately equal volume of antiserum and growth suspension was mixed). The suspension and antiserum were mixed very well, and then the slide was rocked to observe for agglutination (agglutination is more visible if the slides are observed under a bright light and

over a black background). If the reaction is positive, clumping will appear within 10 to 15 seconds. The saline suspension (control) was examined carefully to ensure that it was even and did not show clumping resulting from auto agglutination. If auto agglutination occurs, the culture is termed"rough" and cannot be serotyped. Also, cultures that reacted to the respective polyvalent antiserum were further serologically typed using the individual mono valent anti sera and subsequently checked the Kauffman white catalogue to identify the species.

2.6 Antibiotic Susceptibility Test

Antibiotics susceptibility test was performed using the Kirby-Bauer disc diffusion method. Bacterial suspensions were prepared from a fresh culture grown overnight using sterile normal saline, and the turbidity of the suspension was adjusted to 0.5 McFarland Standard, corresponding to approximately $1x10^8$ CFU/ml of suspension. Two plates of Mueller Hinton Agar were prepared for each isolate. A sterile cotton swab was dipped into the inoculum and then streaked on the Mueller-Hinton agar plate properly. Then antibiotic discs impregnated with Meropenem (30µg), Ceftriaxone (30 µg), Ofloxacin (5µg), Nalidixicacid (30µg), Pefloxacin(15µg), Gentamycin (10µg), Amoxicillin (30µg), Ciprofloxacin (5µg), co-trimoxazole (25µg) and Streptomycin (10µg) were dispensed onto the dried agar surface using sterile forceps. The plates were incubated overnight at 37°C. After the incubation period, the resulting zone of inhibition was compared with that of the CLSI guideline (CLSI, 2012) for the interpretation of the data and categorization of the test strains as sensitive, intermediate or resistant. Escherichia coli ATCC 25922 collected from NVRI Vom Plateau state was used as the control strain.

2.7 Statistical Analysis

Data collected in the study and the result of the laboratory investigations were entered into Microsoft Excel and analyzed by (SPSS) Statistics software program Version 23.0. Percentage to measure the prevalence of Salmonella was used, and p value<0.05 was considered significant.

3. Results

Although the prevalence of *Salmonella* (5.5%) with respect to facilities was not statistically significant in Table 1, IDH, however, demonstrated the highest occurrence of *Salmonella* in this study; this could be attributed to the fact that patients attending IDH Bayara are mostly from rural communities who could probably be sourcing their drinking water from wells and rivers.

The difference in the prevalence in Table 2 of *S.Typhi* (72.7%) and *S. paratyphi* (27.3%) from the findings of this study was not statistically significant. However, *S. Typhi* demonstrates a higher prevalence than *S. paratyphi*. It is also very relevant to screen for *Salmonella typhi,* given the high morbidity and mortality rates that characterize the disease, especially in developing countries like Nigeria. The current magnitude of the disease in the country is not known as there has been no surveillance study carried out nationally or at the State or Local Government level.

Table 3 demonstrates the prevalence rate of Salmonella from different locations and specimens; a total of (7.1%) prevalence was recorded from stool, while (4.3%) was recorded from blood samples. IDH and specialist hospitals recorded a higher prevalence of (6.0%) each, while ATBUTH recorded a (4.0%) prevalence of Salmonella.

From Table 4, diarrhoea, Stomach cramps, and Nausea demonstrated association with Salmonella infection. On the other hand, Fever, Headache and vomiting were not statistically associated with salmonella infection; however, all the Salmonella isolates recovered demonstrated an association with Fever and Headache, whereas only six patients were associated with vomiting.

From the findings in Table 5, Salmonella infection was not statistically associated with the source of drinking water. However, more Salmonella isolates were recovered from patients who drank well/rainwater. Salmonella infection has also shown association with Restaurant food and mode of sanitation (Hand hygiene after toilet). However, eating homemade food and food from public gatherings is not statistically significant for Salmonella infection, though a majority of patients from the study answered yes to eating homemade food and from public gatherings.

From the findings of this study, isolates of *S. Typhi* and *S. paratyphi A* were most sensitive to ciprofloxacin. The strains of Salmonella demonstrated no sensitivity to Nalidixic acid, Amoxicillin and streptomycin. Furthermore, all *S. paratyphi A* isolates were not sensitive to ceftriaxone, pefloxacin and co-trimoxazole from Table 6.

Table 1. Prevalence of *Salmonella* based on facilities (sampling locations)

Facility	No. of sample	No. positive (%)	No. negative (%)	χ^2	p-value
IDHB	100	6 (6.0)	94 (94.0)	0.289	0.866
ATBUTH	50	2 (4.0)	48 (96.0)		
Specialist	50	3 (6.0)	47 (94.0)		
Total	200	11 (5.5)	189 (94.5)		

Key: IDHB: Infectious disease hospital Bayara, ATBUTH: Abubakar Tafawa Balewa university teaching hospital.

Table 2. Prevalence of *Salmonella* (*S. Typhi and S. paratyphi*) based on facilities (sampling locations)

Facility	No. of *Salmonella*	*Salmonella*		χ^2	p-value
		No. of *S.* Typhi (%)	No.of *S.*Paratyphi(%)		
IDHB	6	4 (66.7)	2 (33.3)	0.917	0.632
ATBUTH	2	2 (100.0)	0 (0.0)		
Specialist	3	2 (66.7)	1 (33.3)		
Total	11	8 (72.7)	3 (27.3)		

Key: *S. Typhi: Salmonella typhi, S. paratyhi; Salmonella paratyphi A*

Table 3 Prevalence of *Salmonella* based on specimen type

Location	Specimen	No. of sample	No. Positive (%)	χ^2	p-value
IDHB	Stool	45	4 (8.9)		0.404†
	Blood	55	2 (3.6)		
	Total	100	6 (6.0)		
ATBUTH	Stool	21	1 (4.8)		1.000†
	Blood	29	1 (3.4)		
	Total	50	2 (4.0)		
Specialist	Stool	18	1 (5.6)		1.000†
	Blood	32	2 (6.3)		
	Total	50	3 (6.0)		
Overall	Stool	84	6 (7.1)	0.752	0.386
	Blood	116	5 (4.3)		
	Total	200	11 (5.5)		

† = Fischer's exact test

Table 4: Association of *Salmonella* prevalence with symptoms

Symptoms	Response	No. Tested	No. positive	p-value
Diarrhoea	Yes	145	11 (7.6)	0.037*
	No	55	0 (0.0)	
	Total	200	11 (5.5)	
Stomach Cramp	Yes	187	10 (5.3)	0.001*
	No	12	0 (0.0)	
	NS	1	1 (100.0)	
	Total	200	11 (5.5)	
Nausea	Yes	72	4 (5.6)	0.001
	No	128	7 (5.5)	
	Total	200	11 (5.5)	

Fever	Yes	177	11 (6.2)	0.619†
	No	23	0 (0.0)	
	Total	200	11 (5.5)	
Headache	Yes	173	11(6.4)	0.366†
	No	27	0 (0.0)	
	Total	200	11 (5.5)	
Vomiting	Yes	100	6 (6.0)	0.756†
	No	100	5 (5.0)	
	Total	200	11 (5.5)	

Table 5: Association of Salmonella Prevalence with Risk factors (Source of Drinking water)

Risk Factor	Response	No. Tested	No. Positive	p-value
Drink Borehole Water	Yes	186	7 (4.9)	0.513†
	No	14	4 (7.0)	
	Total	200	11 (5.5)	
DrinkRiver/ Stream Water	Yes	48	5 (10.4)	0.087†
	No	152	6 (3.9)	
	Total	200	11 (5.5)	
Drink Well/Rain water	Yes	143	10 (5.4)	0.559†
	No	57	1 (7.1)	
	Total	200	11 (5.5)	
Swim in Stream	Yes	46	5 (5.9)	0.069†
	No	154	6 (3.9)	
	Total	200	11 (5.5)	
Restaurant Food	Yes	181	7 (3.9)	0.013*
	No	19	4 (21.1)	
	Total	200	11 (5.5)	
Home-made food only	Yes	199	10 (5.0)	0.055†
	No	1	1 (100.0)	
	Total	200	11 (5.5)	
Food from public gathering	Yes	141	10 (7.1)	0.180†
	No	59	1 (1.7)	
	Total	200	11 (5.5)	
Hand Hygiene after toilet	Yes	178	7 (3.9)	0.021*
	No	17	3 (17.6)	
	NS	5	1 (20.0)	
	Total	200	11 (5.5)	

Table 6: Antibiotic resistance profile of *Salmonella* isolates

Antibiotics	*S.* Typhi			*S.* Paratyphi		
	S (%)	I (%)	R (%)	S (%)	I (%)	R (%)
Meropenem	2 (25.0)	2 (25.0)	4 (50.0)	1 (33.3)	0 (0.0)	2 (66.7)
Ceftriaxone	1 (12.5)	2 (25.0)	5 (62.6)	0 (0.0)	0 (0.0)	3 (100.0)
Ofloxacin	2 (25.0)	1 (12.5)	5 (62.5)	1 (33.3)	0 (0.0)	2 (66.7)
Nalidixic acid	0 (0.0)	0 (0.0)	8 (100.0)	0 (0.0)	0 (0.0)	3 (100.0)
Pefloxacin	1 (12.5)	0 (0.0)	7(87.5)	0 (0.0)	1 (33.3)	2 (66.7)
Gentamycin	1 (12.5)	1 (12.5)	6 (75.0)	1 (33.3)	0 (0.0)	2 (66.7)
Amoxicillin	0 (0.0)	0 (0.0)	8 (100.0)	0 (0.0)	0 (0.0)	3 (100.0)
Ciprofloxacin	5 (62.5)	2 (25.0)	1 (12.5)	3 (100.0)	0 (0.0)	0 (0.0)
Co-trimoxazole	2 (25.0)	0 (0.0)	6 (75.0)	0 (0.0)	1 (33.3)	2 (66.7)
Streptomycin	0 (0.0)	2 (25.0)	6 (75.0)	0 (0.0)	1 (33.3)	2 (66.7)

Key: S: Susceptible, I: Intermediate, R: Resistant

Quality control: *E. coli* ATCC 25922

4. Discussion

Enteric fever has continued to pose a serious threat to public health, especially in economically poor countries where the level of hygiene is below standards and sanitary conditions are poor. In Nigeria specifically, enteric fever constitutes a great socio-medical problem, being responsible for many cases of pyrexia of unknown origin (Ajayi et al., 2015). Out of the total number of 200 samples collected, eleven 11 (5.5%) Salmonella species were isolated from both the blood and stool culture, with a total of six 6 (7.1%) Salmonella isolates from stool culture and a total of five 5 (4.3%) Salmonella isolates from blood culture. Typhoid fever is among the water-borne infections characteristics of environments with poor sanitation and hygiene (Okonkwo et al., 2010). As reported in this study, the highest number of Salmonella isolates were collected from an Infectious disease hospital which is situated in a rural environment, and the high prevalence generally observed here could be due to a lack of portable drinking water, proper sanitation and hygiene and also food prepared by infected individuals(Abioye et al., 2017).

Human infection with *Salmonella* is mainly by the oral route through ingestion of faecal contaminated food and water, unclean hands, flies and meat from infected animals.(Okonkwo et al., 2010).

Various studies have been conducted by many researchers in different parts of the world, establishing the significance of Salmonella typhi and Salmonella paratyphi in the causation of salmonellosis (Abdullahi, 2010). The above two species of Salmonella were encountered in the present study. Among the Salmonella species, Salmonella typhi 8(72.7%) was predominant, followed by Salmonella paratyphi A 3(27.3%)**.** This indicates a significant prevalence of typhoid fever in the sampled population. Good knowledge of food safety and hygiene could contribute to positive attitudes towards the prevention of *Salmonella* infection, as well as taking appropriate actions and seeking medical care in the event of a food handler having the infective diarrheal disease (Olalekan et al., 2018).

The overall prevalence of 5.5% obtained in this work is considered to be moderately low, although it calls for control measures in the study area. The prevalence obtained agrees with the work of Rabiu(Rabiu et al., 2018), who reported a 4.8% prevalence from three facilities in Bauchi State of Nigeria. My prevalence is, however, lower than the 50.0% prevalence reported by Ajibade (Richard et al., 2019) in Ekiti State, South-Western Nigeria. It is also lower than the prevalence obtained in Nassarawa by Abioye(Abioye et al., 2017), (62.70%); it is also lower than the prevalence of 26.6% and 42.4% reported among University of Ilorin students (Umegbolu, 2017)Likewise, it is lower than the 42.0% prevalence obtained in Biu, Borno State (Isa et al., 2013), however, in another study conducted in Malaysia where a lower prevalence of 2.8% (Woh et al., 2017) was recorded. The burden of typhoid fever shows substantial variation within as well as between countries. Commonly identified risk factors include a lack of clean drinking water, poor sanitation, inadequate hygiene practices and low socio-economic status. *Salmonella typhi* continues to be a burden in most developing countries (Abioye et al., 2017 and Rabiu et al., 2018).

From this study, certain risk factors have been identified which showed significant association with salmonella infection, especially with restaurant food and toilet hygiene; despite improvements in hygiene and sanitation, the incidence of Salmonella infections continues to increase, creating a burden in both industrialized and underdeveloped countries (Majowicz et al., 2010). Contaminated water or food is the major transmission route of enteric fever. Historically, the USA and Western Europe were endemic for enteric fever; however, the incidence of *Salmonella* infection decreased significantly with proper food and water sanitation, pasteurization of milk and other dairy products, and elimination of the use of human faeces in food production. A decrease in the incidence of *Salmonella* infections was observed in Latin America in parallel with the introduction of sanitation measures (Crump et al., 2004). At present, preventive measures for enteric fever concentrate on access to safe water and food, proper sanitation and the use of typhoid vaccines. Salmonellosis is one of the leading causes of diarrhoea diseases globally and is directly associated with poor water hygiene and food contamination(Nwabor et al., 2015); this agrees with this study where diarrhoea has shown significant association alongside other symptoms of salmonella infection. In Nigeria, Typhoid fever is a major cause of death, second only to malaria. Given the high incidence of diseases caused by Salmonella, it is necessary to understand wholly this highly virulent and pathogenic organism, its epidemiology and its pattern of spread to promote better and early detection, which certainly would spare mankind the stress and burden of these diseases (Nwabor et al., 2015).

The antibiotic susceptibility of *Salmonella* isolates showed that *Salmonella* isolates from Infectious disease hospital, ATBUTH and Specialist Hospital Bauchi were resistant to commonly used antibiotics. There was also resistance to multiple antimicrobials, including Nalidixic acid, Gentamycin and streptomycin, but all the isolates were sensitive to ciprofloxacin except for 1(12.5%) isolate of *S. Typhi*which was resistant to ciprofloxacin. This finding is similar to that described by (Chen et al., 2004), who carried out antibiotic sensitivity on *Salmonella* isolates in China and reported that all isolates were sensitive to ciprofloxacin. The probable reason for multidrug resistance with 100% resistance on Nalidixic acid, Amoxicillin and streptomycin may be due to the inappropriate use of antibiotics by patients in preventing or treating certain diseases. This could lead to mutations from susceptible bacteria to new resistant bacteria through gene transfer (that is, the emergence of antimicrobial resistance). It could also lead to prolonged treatment and additional costs of diagnostic testing on patients and calls for concern.

This study reveals 10 antibiotic patterns from the antimicrobial agents used for the antibiotic susceptibility testing on the *Salmonella* species; the Salmonella isolates demonstrated no sensitivity to Nalidixic acid 11 (100%), Amoxicillin 11(100%) and streptomycin. Furthermore, all *S. paratyphi A* isolates show multiple drug resistance to ceftriaxone 3(100%), pefloxacin 3(100%), co-trimoxazole 2(66.7%) and 1(33.3) intermediate. This further suggests that *S. paratyphiA* are more resistant than *S. Typhi*in this study. The antibacterial resistance observed here in the isolated Salmonellae might be due to the routine indiscriminate use of those antibacterial agents. A study done by Ki Bok Yoon in Korea reported a similar resistance rate to Nalidixic acid, Amoxicillin and streptomycin.

This study further provides a guideline for physicians to select appropriate antibiotics to reduce economic loss through selecting sensitive antibiotics.

5. Conclusion

The prevalence of diseases caused by salmonella has indeed assumed a public health. Dimension, salmonellosis is one of the leading causes of diarrhoea diseases globally and is directly associated with poor water hygiene and contamination of food. In Nigeria, Typhoid fever caused by *Salmonella spp* is a major cause of death, second only to malaria. Current clinical diagnosis of typhoid fever using the Widal test relying on the antigen-antibody agglutination is often not reliable and hence leads to false test results. Given the high incidence of diseases caused by Salmonella, it is necessary to understand wholly this highly virulent and pathogenic organism, its epidemiology and pattern of spread to promote better and early detection, which certainly would spare mankind the stress and burden of these diseases. Molecular techniques which will guarantee quick and reliable diagnosis should also be introduced and adopted by hospitals, diagnostic laboratories and other health professionals as a means for better health service delivery. It is also recommended that *Salmonella* research institutes and

organizations be established as a means of broadening the general understanding of this organism and the various diseases it causes.

In conclusion, this research has reported the presence of *Salmonella* species with an overall prevalence of 5.5% in blood and stool samples from Bauchi state; the work has reported that there are *Salmonella* spp resistant to commonly used antibiotics and pose considerable health hazards unless prudent control measures are instituted. This could be due to the indiscriminate use of antibiotics in those areas, the use of substandard antibiotics or improper storage of antibiotics (as this could affect the potency of the drugs). However, the study showed that the *Salmonella* spp isolated was 95% sensitive to ciprofloxacin.

5.1 Recommendations

Based on the findings from the study, the following recommendations are provided:

1. Public health awareness should be developed to reduce the incidence of Salmonellosis among people in order to avoid foodborne illness. Proper treatment should be done with Strict Sanitary measures.
2. There should be active surveillance of salmonellosis in patients to reduce the disease.
3. Food should be properly cooked before consumption.
4. Government agencies like the National Agency for Food and Drug Administration and Control (NAFDAC)is to assess the indiscriminate use of antibiotics among individuals.
5. Antibiotic susceptibility evaluation should be carried out on the resistant isolates to determine the appropriate drug of choice.

Contribution to Knowledge: This research has established the presence of Salmonella species with an overall prevalence of 5.5%; this indicates poor hygienic practices in the respective study areas and, therefore, calls for corrective measures through public health enlightenment. Furthermore, the research pointed out the risk factors associated with salmonella infection in Bauchi state and further provided useful information for selecting effective antibiotics against Salmonella infection in Bauchi state.

Suggestions for Further Studies: Many alternative diagnostic tools for typhoid fever are developed to utilize antibody-based methods. However, there are limitations with this method, such as the complication of having false-positive due to prior exposure to the antigen. Thus, there is a need for the development of antigen-based detection of pathogens.

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