World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Seroprevalence of *Salmonella* infections among HIV-Infected Patients in South-South, Nigeria

Gbolagade Morufu ADEWUYI [1, 2], Kenneth Oshiokhayamhe IYEVHOBU [3, 4, *], Bolanle Toyin ADEWUYI [5, 6], Abdul-Razak McSionel MOMOH [1], Olowo Samuel SUNDAY [1] and Kennedy Oberhiri OBOHWEMU [7]

[1] *Department of Medical Microbiology and Parasitology, Ambrose Alli University, Ekpoma, Edo State, Nigeria.*
[2] *Department of Medical Microbiology and Parasitology, Irrua Specialist Teaching Hospital, Irrua, Edo State, Nigeria.*
[3] *Department of Medical Microbiology, Faculty of Medical Laboratory Science, Ambrose Alli University, Ekpoma, Edo State, Nigeria.*
[4] *Research and Publication Department, St Kenny Consult, Ekpoma, Edo State, Nigeria.*
[5] *Department of Family Medicine, Ambrose Alli University, Ekpoma, Edo State, Nigeria.*
[6] *Department of Family Medicine, Irrua Specialist Teaching Hospital, Irrua, Edo State, Nigeria.*
[7] *Department of Health, Wellbeing & Social Care, Global Banking School, London, United Kingdom.*

World Journal of Advanced Research and Reviews, 2024, 24(01), 1980–1987

Publication history: Received on 11 September 2024; revised on 20 October 2024; accepted on 22 October 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.24.1.3204

Abstract

Clinical syndromes caused by *Salmonella* infection in humans are divided into typhoid fever, caused by *Salmonella typhi* and *Salmonella* para*typhi* and a range of clinical syndromes, including diarrhea disease caused by a large number of non-typhoidal salmonella serovars (NTS). One hundred (100) blood samples of compromised HIV patients were used for this study. It was found that female compromised HIV patients were more prevalent to typhoid fever than male compromised HIV patients. Patients around the age range of 26 - 35 years were more prevalent to typhoid fever while patients of the age range of 51 - 65 years are at low risk of typhoid fever. Agglutinins to *S. typhi* were the most prevalent among the sera tested at various dilutions in both males and females. Seventeen [17(17%)] had higher titre for *S. typhi* 'O' and 17 (17%) for S. *typhi* 'H' in the females and in males with 2(2%) for the S. *typhi* 'O' and 3 (3%) for the S. *typhi* 'H' and all others. The results also showed that more females had Salmonella agglutinin titres for *S. typhi* H [17 (17%)], *S. typhi* O [17(17%)], *S. paratyphi* B-H [17 (17%)] and *S. paratyphi* C-H [17 (17%)] more followed by *S. paratyphi* A-H [16 (16%)] then, *S. paratyphi* B-O [15(15%)] and *S. paratyphi* C-O [12(12%)], Bloodstream infections with *Salmonella typhi* is uncommon in human immunodeficiency virus (HIV)-infected persons. The symptoms in such patients are often non-specific and have a rather insidious onset and progression. We report a patient with sepsis and lower limb gangrene due to *Salmonella typhi* infection in an HIV-infected patient. In conclusion, *Salmonella typhi* is prevalence in compromised female patients than male patients, and it was also observed that *Salmonella typhi* is present, more amongst the age range of 26 – 35 years and low among 51-65 of age. Compromised female patients and mid age people (26 - 35 years) should take preventive measure to ensure that they are not infected with *Salmonella typhi*

Keywords: Infection; *Salmonella typhi;* Immunocompromised; HIV; Typhoid

1. Introduction

Typhoid fever (enteric fever) caused by *Salmonella typhi* is an endemic disease in the tropic and sub-tropic and has become a major public health problem in developing countries of the world with an estimated annual incidence of 540 per 100,000. The annual incidence of typhoid is estimated to be about 17 million cases worldwide (WHO, 2008; Iyevhobu *et al.,* 2021). It is often encountered in tropical countries including Nigeria where they constitute serious

* Corresponding author: Iyevhobu KO

sources of morbidities and mortalities (Tula *et al*., 2018). Typhoid and paratyphoid fevers are infections caused by bacteria, which are transmitted from faeces to ingestion. Clean water, hygiene and good sanitation prevent the spread of typhoid and paratyphoid. Contaminated water is one of the pathways of transmission of the disease (WHO, 2008). Typhoid and paratyphoid fevers are caused by the bacteria *Salmonella typhi* and *Salmonella paratyphi, respectively. Salmonella typhi* is Gram-negative bacteria, which are motile, though non-flagellate variants occur. Capsules are not formed. They are intestinal pathogens, which comprises of a species *Salmonella typhi,* which causes an enteric fever known as typhoid fever (Adesegun *et al*., 2020). It is pathogenic to both man and mammals with associable inflammatory reaction in the intestinal tract (Iyevhobu *et al.,* 2021).

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 (Waldram *et al*., 2018). Typhoid and paratyphoid germs are passed in the faeces and urine of infected people. People become infected after eating food or drinking beverages that have been handled by a person who is infected or by drinking water that has been contaminated by sewage containing the bacteria. Once the bacteria enter the person's body they multiply and spread from the intestines, into the bloodstream (WHO, 2008). Even after recovery from typhoid or paratyphoid, a small number of individuals (called carriers) continue to carry the bacteria. These people can be a source of infection for others. The transmission of typhoid and paratyphoid in less-industrialized countries may be due to contaminated food or water. In some countries, shellfish taken from sewage-contaminated beds is an important route of infection. Where water quality is high, and chlorinated water piped into the house is widely available, transmission is more likely to occur via food contaminated by carriers handling food (WHO, 2008). Infection through contaminated surgical equipment and person-to-person contact in hospital has also been reported (Waldram *et al*., 2018).

It is a major public health problem in the developing countries of the world with an estimated annual incidence of 540 per 100,000 (Tula *et al*., 2018). Salmonella are divided into distinct serologic groups (A through E) on the basis of their somatic O antigens. While all group D organisms, such as S. *typhi* possess O antigen 9, about 60 of the 78 groups D serotypes including S. *typhi* also have O antigen 12 (Iyevhobu *et al.,* 2021). Thus, infection by any of the group D serotypes can produce antibodies that can react with the O antigen used in the Widal reaction (Osue *et al*., 2022). Also, since all groups A and B organisms possess O antigen 12, cross-reactions with 0 antibody of group D serotype can occur with any of the group A and B serotype 0 antigens. Depending on the relative quality and quantity of antigenicity of the O antigens 9 and 12 contained in other common non-typhoidal *Salmonella serotypes,* cross-reaction may occur frequently enough to lessen considerably the diagnostic specificity of the Widal agglutination reaction (Iyevhobu *et al.,* 2020; Osue *et al*., 2022). In endemic areas, most individuals are careers. Thus, 35.9% of such apparently healthy persons have been detected with normal antibody titres of up to 1:40 and 1:80 for 0 and H *Salmonella* antigens (Iyevhobu *et al.,* 2021) and the levels reflected severity of infection with *Salmonella.* Even though the associable mortality rate is very low, the high prevalence of salmonellosis has caused major economic and health impacts. As such, vaccines have been developed against strains of *Salmonella* (Diard *et al*., 2021). Based on the immunology of *Salmonella* infection, serological diagnostic tests relying on *Salmonella antigens* as tentative evidence of salmonellosis have been developed, notably, the Widal agglutination test (Ma *et al*., 2018).

The Widal agglutination test, developed by Widal in 1896 to aid in the diagnosis of typhoid fever, utilizes a suspension of killed *Salmonella typhi* as antigen, to detect typhoid fever in serum from suspected S typhi-infected patients who present with febrile illness (Iyevhobu *et al.,* 2021). The value and clinical application of the Widal test in developed countries has diminished considerably in recent years (McPherson & Pincus, 2021) and a large number of antigenically related determinants of both typhoid and non-typhoid Salmonella organisms are now recognized (Osue *et al*., 2022). The Widal test is a presumptive serological test for Enteric fever or Undulant fever. In case of *Salmonella* infections, it is a demonstration of agglutinating antibodies against antigens O-somatic and H-flagellar in the blood. Two types of agglutination techniques are available: the slide test and the tube test. The slide test is rapid and is used as a screening procedure. Using commercially available antigens of S. typhi, a drop of the suspended antigen is added to an equal amount of previously prepared serum. An initial positive screening test requires the determination of the strength of the antibody. This is done by adding together equal amounts of antigen suspension and serially diluted serum from the suspected patient. Agglutinations are visualized as clumps. Weakly reactive agglutinations may require an adequate light source for proper visualization, while strongly reactive agglutinations are easily seen. The result of the tests is scored from 0 to 4+ i.e., 0 (no agglutination), 1+ (25% agglutination), 2+(50% agglutination), 3+(75% agglutination) or 4+(100% agglutination). The smallest quantity of serum that exhibits 2+ or 50% agglutination is considered the end-point of serum activity or titre (Osue *et al*., 2022). The tube agglutination test requires much more technical work than the rapid slide test, and is a macroscopic test (Jaiswal *et al*., 2019). It also serves as a means of confirming the results of the slide test. A mixture of suspended antigen and antibody is incubated for up to 20 h at 37°C in a water bath. Agglutinations are visualized in the form of pellets clumped together at the bottom of the test tube. Results are scored

from 0-4+positive agglutination as described above for the slide test. The tube test is useful to clarify erratic or equivocal agglutination reactions obtained by the more rapid slide test (Osue *et al*., 2022).

Several investigations have been done in several places in Nigeria and other parts of the world even in this area of study. Since it has been established in other parts of Nigeria and other countries that there is prevalence of infection of *Salmonella typhi* on immune compromised patients (HIV patients), it is necessary that similar study be carried out in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State, Nigeria. Since immune compromised patients are particularly susceptible to the adverse effect of *Salmonella typhi* infection due to their greater immunological vulnerability (Montresor *et al.,* 2002), as in the course of this research, it will help to determine the effect of *Salmonella typhi* infection on the health of immune compromised patients in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State, so that the government and other relevant authorities responsible for education and healthcare policy making will take necessary measures in treating and preventing *Salmonella typhi* disease in the Local Government Area. To assess the occurrence and intensity of *Salmonella typhi* in immune compromised patients in the study Area.

2. Methodology

2.1. Study Area

This study was carried out in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria. The area lies 7.0667° N, 6.2667°E. Majority of the population are civil servants, traders, businessmen/women, transporters, farmers, teachers/lecturers and students and Etsako West were the control samples were taken. The samples were examined in the Research Diagnostic Laboratory of the Department of Medical Microbiology, Faculty of Medical Laboratory Science, College of Medical Sciences, Ambrose Alli University, Ekpoma.

2.2. Study Population

A total of 100 samples from both females and males were used in this study from the study area. One hundred samples comprising of seventy-one (71) samples from females and twenty-nine (29) from males were collected from the study area.

2.3. Sample Collection

Specimen containers (EDTA anticoagulant bottles) (Cheesbrough, 2006), and properly labelled with patients' names, sex, age, and serial number were used for sample collection. The patients were properly educated on how and why the samples need to be collected. The samples were collected and properly labelled with each patient's name, age, sex and serial number entered into the record book. The samples were then transported immediately to the laboratory for examination. Samples that could not be examined early enough were preserved in the refrigerator.

2.4. Sample Analysis

Blood samples collected were preserved with Ethylene diamine tetra-acetic acid (EDTA) before being transported to the Research Diagnostic Laboratory of the Department of Medical Microbiology, Faculty of Medical Laboratory Science, College of Medical Sciences, Ambrose Alli University, Ekpoma for analysis.

Widal test as described by Cheesbrough (1998) was carried out and labelled accordingly as recommended by W.H.O., (2002).

Two milliliters (2mls) of the blood samples were centrifuged at a high speed for 5 m in in order to separate the serum from the blood cells.

2.5. Widal Agglutination Test

ANTEC febrile antigen kit (United Kingdom) was used for the Widal test. The rapid slide screening test was first carried out followed by the tube agglutination test according to the manufacturer's specifications. The ANTEC febrile antigens are suitable for both the rapid slide and tube agglutination tests against human sera for the detection of these agglutinins. The stained antigen suspensions are killed bacteria, stained to enhance the reading of agglutination tests. The blue stained antigens are specific to the somatic 'O' antigens whilst the red stained antigens are specific to the flagellar 'H' antigens. Using a pipette, 0.08, 0.04, 0.02, 0.01and 0.005 ml of undiluted serum was dispensed onto a row of 3cm diameter circles. The reagent bottle was rigorously shaken and a drop of the undiluted antigen suspension was added to each serum aliquot. This was thoroughly mixed with the aid of a stirring stick and the slide was gently rotated.

The reactions were observed after a minute. The agglutination observed in any circle was indicative of the following results in a test tube. 0.08ml=1:20,0.04ml=1:40,0.02ml=1:80,0.01ml=1:160and 0.005ml=1:320.

2.6. Analysis of Results

The percentage prevalence was calculated in each case. Comparative analysis of the results was done using Chi-square. A p-value less than 0.05 ($p<0.05$) was considered statistically significant

3. Results

One hundred (100) patients between the ages of 20 - 65 years old from Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria comprising of 29(29%) males and 71(71%) females were investigated for infections with *Salmonella* typhi. Out of the samples 17(17%) from females and 3(3%) from males were infected with *Salmonella typhi* given an overall infection rate of 20(20%). Table 1 shows the incidence of Widal positive sera (Salmonella agglutinin titres) in relation to sexes of the subjects in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria. It showed that 20 (20%) of the samples analyzed for *Salmonella* agglutinin titres were Widal positive while 80 (80%) were Widal negative as shown in Table 2. It also showed that 3% (n =3) of the sera from males were Widal positive and 17% (n=17) of the sera from females were also Widal positive.

Table 1 Incidence of Widal positive sera (Salmonella agglutinin titres) in relation to sex of Patients Examined in Study Area

No. of sera tested (%)	No. of sera positive (%)	No. of sera negative (%)
Male	3 (3%)	26 (26%)
Female	17 (17%)	54 (54%)
Overall	20 (20%)	80 (80%)

Table 2 shows the distribution of *Salmonella* agglutinin titres in 29 male subjects in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria. The result showed that males had *Salmonella* agglutinin titres for S. *typhi* 02 (2%) and *S. typhi* HI 3 (3%). More so, 3 (3%) males had Salmonella agglutinin titres for *S. paratyphi* A-0, 1 (1%) for *S. paratyphi* B-0, 3 (3%) for *S. paratyphi* C-0, 3 (3%) for *S. paratyphi* A-H, 3(3%) for *S. paratyphi* B-H, and 3(3%) for *S. paratyphi* C-H as shown in Table 2.

Table 2 Distribution of Salmonelia Agglutinin Titres In Males Patients Studied

Salmonellae Tested	No. of sera positive (%)	No. of widal negative (%)	No. of widal
S. paratyphi A-O	29	3 (3)	36 (26)
S. paratyphi B-O	29	1 (1)	28 (28)
S. paratyphi C-O	29	3 (3)	26(26)
S. typhi O	29	2 (2)	27(27)
S. paratyphi A-H	3(3)	26 (26)	
S. paratyphi B-H	3(3)	26 (26)	
S. paratyphi C-H	3(3)	26 (26)	
S. typhi H	3(3)	26 (26)	

Table 3 shows the frequency and percentage of sera with end-titres in 29 male subjects in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria. It was observed that with exception of *S. paratyphi* B-O and *S. paratyphi* A-H, *S. paratyphi* B-H, and *S. paratyphi* C-H, all other agglutinins tested were present in the sera of males up to the titre of 320 and at frequencies/percentages was just 1 (1%). However, the frequency of *Salmonella agglutinins* titre of <1:80

was 0 (0%); 1:80 was 1(1%); 1:160 ranges from 1 (1%) to 3 (3%) and 1(1%) for 1:320. The results showed titres of 1:80 and 1:160 occurred in a significant proportion of the samples as shown in Table 3 below.

Table 3 Number and percentage of sera with end titres in male subjects in the Study Area

Salmonellae positive (%)	No. of widal	<80	80	160	320
S. paratyphi A-0	3(3)	0(0)	0(0)	3(3)	0(0)
S. paratyphi B-O	1(1)	0(0)	0(0)	1(1)	0(0)
S. paratyphi C-0	3(3)	0(0)	0(0)	3(3)	0(0)
S. typhi 0	2(2)	0(0)	0(0)	1(1)	1(1)
S. paratyphi A-H	3(3)	0(0)	1(1)	2(2)	0(0)
S. paratyphi B-H	3(3)	0(0)	0(0)	2(2)	1(1)
S. paratyphi C-H	3(3)	0(0)	1(1)	2(2)	0(0)
S. typhi H	3(3)	0(0)	0(0)	3(3)	0(0)

Table 4 shows the distribution of *Salmonella agglutinin* titres in 71 female subjects in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria. The result also showed that more females had Salmonella agglutinin titres for *S. typhi* H [17 (17%)], *S. typhi* O [17(17)], *S. paratyphi* B-H [17(17%)] and *S. paratyphi* C-H [17(17%)] more followed by *S. paratyphi* A-H [16 (16%)] then, *S. paratyphi* B-0 [15(15%)] and *S. paratyphi* C-0 [12(12%)], as shown in Table 4 below.

Table 4 Distribution of Salmonella Agglutinin Titres in Female Patients in the Study

Salmonellae Tested	No. of sera positive (%)	No. of widal negative (%)	No. of widal
S. paratyphi A-O	71	17 (17%)	54 (54%)
S. paratyphi B-0	71	15 (15%)	56 (56%)
S. paratyphi C-O	71	12 (12%)	59 (59%)
S. typhi O	71	17 (17%)	54 (54%)
S. paratyphi A-H	71	16 (16%)	55 (55%)
S. paratyphi B-H	71	17 (17%)	54 (54%)
S. paratyphi C-H	71	17 (17%)	54 (54%)
S. typhi H	71	17 (17%)	54 (54%)

Table 5 shows the frequency and percentage of sera with end-titres in 71 female subjects in Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State Nigeria. It was observed that with exception of *S. paratyphi* A-H, *S. paratyphi* B-H and *S. paratyphi* C-H, all other agglutinins tested were present in the sera of females up to the titre of 320 and at frequencies/percentages ranging from 1(1%)-17(17%). However, the frequency of *Salmonella agglutinins* of <1:80 titre was 0(0%); 1:80 was 1(1%); 1:160 from 10(10%) to 17(17%) and 1(1%) to 3(3%) for 1:320. The results showed that titres of1:320 and 1:160 occurred in a significant proportion of the samples as shown in Table 5 below.

Table 5 Number and percentage of sera with end titres in female subjects Patients in the Study

Salmonellae Positive (%)	No. of widal	<80	80	160	320
S. paratyphi A-O	17(17]	0(0)	1(1)	16(16)	0(0)
S. paratyphi B-O	15(15)	0(0)	2(2)	10(10)	3(3)
S. paratyphi C-O	12(12)	0(0)	0(0)	12(12)	0(0)
S. typhi O	17(17)	0(0)	0(0)	17(17)	0(0)
S. paratyphi A-H	16(16)	0(0)	1(1)	14(14)	1(1)
S. paratyphi B-H	17(17)	0(0)	0(0)	17(17)	0(0)
S. paratyphi C-H	17(17)	0(0)	1(1)	16(16	)0(0)
S. typhi H	17(17)	0(0)	0(0)	17(17)	0(0)

4. Discussion

In this study, 20 (20%) of the 100 (100%) blood samples gave positive Widal reaction. This indicates a high prevalence of typhoid fever in the sampled population. However, some of the subjects may not be having the active disease. This is in agreement with the observations of Ma *et al*., (2018) and Ahmad et al., (2019) in a similar study on Widal reaction as being more relevant in diagnosing post-infection complications when *S. typhi* may not be isolated. The Widal test reaction involves the use of bacterial suspensions of *S. typhi* and *S. paratyphi* 'A' and 'B', treated to retain only the 'O' and 'H' antigens. These antigens are employed to detect corresponding antibodies in the serum of a patient suspected of having typhoid fever (Iyevhobu *et al.,* 2021). The IgM somatic O antibody appears first and represents the initial serologic response in acute typhoid fever, the IgG flagella H antibody usually develops more slowly but persists for longer period (Iyevhobu *et al.,* 2021; McPherson & Pincus, 2021; Osue *et al*., 2022). While bacteriological culture remains the gold standard for definitive diagnosis of typhoid fever, lack of its immediate availability during the acute febrile illness may limit its use. In an acute febrile illness in an endemic typhoid region where the clinical picture is ambiguous, a rapid, accurate, specific and sensitive test should be used to differentiate typhoidal from non-typhoidal febrile illnesses. Clinicians usually elect to treat, rather than wait for blood or stool culture results, which may take 3-5 days (Iyevhobu *et al.,* 2020). While there might be some merit in this approach, particularly in areas where culture facilities are either poor or not available, and where Widal testing is the norm, the use of rapid antigen screening directly from the stool of the suspected patient would be more useful (Iyevhobu *et al.,* 2021; Osue *et al*., 2022).

Also in this study, more sera from females were more Widal positive than sera from males. This is probably a reflection of different eating habits and level of personal hygiene. This differs from the findings of Ahmad et al., (2019). In 380 males, the titre of Salmonella 'O' were higher than those of the 'H' whereas in 460 females, Salmonella 'H' titres were higher than those of 'O'. This is also agreement with what was reported in a similar study by Tula *et al*., (2018) where 82 apparently normal males had higher titre of Salmonella 'H' and 118 apparently normal females had higher Salmonella 'O' titres (Tula *et al*., 2018). Agglutinins to S. *typhi* were the most prevalent among the sera tested at various dilutions in both males and females. Seventeen [17(17%)] had higher titre for S. *typhi* 'O' and 17 (17%) for S. *typhi* 'H' in the females and in males with 2(2%) for the *S. typhi* 'O' and 3 (3%) for the *S. typhi* 'H' and all others. Agglutinin level for the typhoid and paratyphoid group tested in this study were evidently very frequently found in the sera of the subjects. The levels of agglutinin of *Salmonella paratyphi* B-O [1(1%)] and *Salmonella typhi* C-O [2(2%]] in the males were however, low. Agglutinin titres of 80 were observed in only 1 and 2% for *Salmonella typhi* B-O and *Salmonella paratyphi* C-H respectively. In the females, the low significant agglutinin titres for *Salmonella typhi* O and *Salmonella paratyphi* A-O were observed in 1 and 2% of the sera respectively.

The value of Widal test depends upon the standardization and maintenance of the antigens to produce consistent results, and it has become evident from work done in recent years on standardization of the Widal test and interpretation of the results that both the O and H antigens are necessary for proper serologic analysis of the suspected serum. However, according to Welch in 1936 (reviewed in Osue *et al*., 2022), no Widal test, regardless of the composition and standardization of the antigens used, is infallible, and thus it is unlikely that any will be developed that will lower the validity of the isolation of the aetiologic agent. Wam et al., (2019) published a case report where the Widal reaction to typhoid O antigen on admission for an unexposed patient was 1:320, with an increase in titre to 1:20 480 by the fourth day. In an individual with no prior exposure to *S. typhi* infection (either lack of active infection or absence of passive immunization), a higher than 1:50 or 1:100 titre on an initial single test, usually correlates fairly well with

exposure to typhoid fever (Iyevhobu *et al.,* 2021; Osue *et al*., 2022). However, even these single high-value titres in an endemic area where repeated exposures to *S. typhi* may have occurred, do not have any clinical relevance in the absence of a positive isolate of the causative organism or its antigen. A second sample collection have proof useful. But, in a situation where second sample collection is not feasible, knowledge of the agglutinin levels in the sera of normal subjects from the patients' community can form the baseline on which a diagnosis can be made (Tula *et al*., 2018).

Therefore, serological findings have to be interpreted with a lot of caution particularly in country like Nigeria where there are yet to be laid down standard baseline titres (Tula *et al*., 2018). In endemic typhoid regions, a single testing of a serum specimen for Widal agglutinin cannot provide a reliable diagnosis due to: repeated exposure to small inocula of *S. typhi* or to other Salmonella spp. that contain type 9 or 12 antigens, previous typhoid fever immunization and other infectious agents such as malaria (Iyevhobu *et al.,* 2021; Osue *et al*., 2022). Although a number of reports from some developing countries have suggested that a single Widal test is sufficient to make the diagnosis of typhoid fever (Odugu *et al*., 2019; Iyevhobu *et al.,* 2021), others have disputed the usefulness of such a single test result (Aquino *et al.,* 1991; Malik *et al*., 2021). In some developing countries where the use of a single Widal test appears to be the norm, there has been an increase in the rate of false positive results (Osue *et al*., 2022).

The review of Osue *et al*., (2022) and Ahmad et al., (2019) suggesting Widal agglutination test as being bedeviled with controversies in term of quality of *Salmonella* antigens and interpretation of results is also pertinent. It should be stressed that a single Widal agglutination test has no diagnostic significance.

According to Malik *et al*., (2021), the results of a single Widal test, tube dilution, micro-agglutination or slide agglutination are virtually un-interpretable unless the sensitivity and specificity of the test for the specific laboratory and patient population are known, as well as predictive values. Even in the extreme case of a high titre in a single Widal agglutination test, the causative organism may often be due to other species of *Salmonella,* rather than S. *typhi* (Iyevhobu *et al.,* 2021; Osue *et al*., 2022). Thus, for a more definite diagnosis of typhoid fever, serologic test and blood culture as well as stool culture from every patient are quite relevant. Therefore, efforts must be made however, to confirm the diagnosis by paired sera investigation more than in presently the case.

5. Conclusion

In conclusion, *Salmonella typhi* is prevalent in compromised female patients than male patients, and it was also observed that *Salmonella typhi* is present, more amongst the age range of 26 - 35 years and low among 51 - 65 years of age. Compromised female patients and mid age people (26 - 35 years) should take preventive measures to ensure that they are not infected by *Salmonella typhi.* Infected ones should be treated for a healthy living. Cleanliness should be encouraged to avoid been affected.

Compliance with ethical standards

Acknowledgments

The authors would like to acknowledge the management of Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State, Nigeria for creating the enabling environment for this study. Thanks to all the Laboratory and technical staff of St Kenny Research Consult, Ekpoma, Edo State, Nigeria for their excellent assistance and for providing medical writing support/editorial support in accordance with Good Publication Practice (GPP3) guidelines.

Availability of Data and Materials

The authors declare consent for all available data present in this study.

Disclosure of conflict of interest

The authors declare no conflicts of interest. The authors alone are responsible for the content and the writing of the paper.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

The entire study procedure was conducted with the involvement of all writers.

Statement of ethical approval

This was obtained from Edo State University Teaching Hospital (EDSUTH), Auchi, Edo State. The aim and objectives, economics importance and health benefits of the study were explained to the subjects.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Adesegun, O. A., Adeyemi, O. O., Ehioghae, O., Rabor, D. F., Binuyo, T. O., Alafin, B. A., ... & Osonuga, A. (2020). Current trends in the epidemiology and management of enteric fever in Africa: a literature review. Asian Pacific Journal of Tropical Medicine, 13(5), 204-213.

[2] Ahmad, M. M., Umar, U. Z., Abdullahi, I. I., Mukhtar, I. H., & Isa, S. (2019). Detection of Salmonella Species among Patients with Suspected Cases of Typhoid Fever in Wudil General Hospital. Fudma Journal of Sciences, 3(3), 535-539.

[3] Diard, M., Bakkeren, E., Lentsch, V., Rocker, A., Bekele, N. A., Hoces, D., ... & Slack, E. (2021). A rationally designed oral vaccine induces immunoglobulin A in the murine gut that directs the evolution of attenuated Salmonella variants. Nature Microbiology, 6(7), 830-841.

[4] Iyevhobu KO (2020). Assessment of the Co-existence of Typhoidal Antibodies and Malaria Parasitaemia among Pregnant Women. Gulf Journal of Clinical Medicine and Medical Research. 1(1): 06-11.

[5] Iyevhobu KO, Obodo BN, Irobonosen OI and Ken-Iyevhobu BA (2021). Assessment of the Prevalence of Malaria and Typhoid Fever among Apparently Healthy Undergraduates. International Journal of Healthcare and Medical Sciences, 7(2), 13-17.

[6] Jaiswal, N. K., Chandrasekaran, S., & Rukadikar, A. (2019). Usefulness of dark field microscopy (DFM), IGM ELISA and microscopic agglutination test (MAT) for the early diagnosis of acute leptospirosis. Indian J. Microbiol. Res, 6, 166-169.

[7] Ma, Z., Yang, X., Fang, Y., Tong, Z., Lin, H., & Fan, H. (2018). Detection of Salmonella infection in chickens by an indirect enzyme-linked immunosorbent assay based on presence of PagC antibodies in sera. Foodborne Pathogens and Disease, 15(2), 109-113.

[8] Malik, I. A., Kanani, A. A., Elgadi, A. S., & Hassan, W. A. (2021). The dilemma of diagnosing typhoid fever in Sudan. Khartoum Medical Journal, 14(1).

[9] McPherson, R. A., & Pincus, M. R. (2021). Henry's clinical diagnosis and management by laboratory methods E-book. Elsevier Health Sciences.

[10] Odugu, J. A., Musa, B. O. P., & Oyati, A. I. (2019). Baseline Antibody Titre to. Salmonella typhi. Scand J. Immunol., 11(suppl): 153-156.

[11] Osue, H. O., Buhari, B., Abdullahi, S. U., & Ahmed, I. G. (2022). Assessing Reliability of Widal. Postgraduate Med. J., 76(892): 80-84.

[12] Tula, M., Iyoha, O., Okojie, R., Filgona, J., & Onyeje, G. (2018). Seroprevalence of Salmonella Agglutinins among Apparently Healthy Students of a Tertiary Institution in North-Eastern Nigeria. International Blood Research & Reviews, 8(3), 1-7.

[13] Waldram, A., Dolan, G., Ashton, P. M., Jenkins, C., & Dallman, T. J. (2018). Epidemiological analysis of Salmonella clusters identified by whole genome sequencing, England and Wales 2014. Food Microbiology, 71, 39-45.

[14] Wam, E. C., Arrey, C. N., Sama, L. F., Agyingi, L. A., & Wam, A. N. (2019). Comparative study on the use of Widal test to stool culture in the laboratory diagnosis of typhoid fever in Holy Family Hospital Akum, North West Region of Cameroon. The Open Microbiology Journal, 13(1).

[15] World Health Organization (W.H.O) (2008). Prepared for World Water Day 2001.Reviewed by staff and experts from the cluster on Communicable Diseases (CDS) and the Water, Sanitation and Health unit (WSH), World Health Organization (W.H.O), 2008.