

Original Article



The Study of *Salmonella enterica* Agglutinin Among Residents of Barama, Mubi-North LGA, Adamawa State, Nigeria

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Article history:

Received: September 15, 2025

Revised: December 30, 2025

Accepted: July 19, 2026

ePublished: September 29, 2026

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Abstract

Introduction: *Salmonella enterica* infections remain a major global public health challenge with significant economic implications arising from surveillance, prevention, and treatment costs. Thus, this cross-sectional study investigated the prevalence of *Salmonella* agglutinins and associated risk factors among 100 apparently healthy residents of Barama, Mubi-North Local Government Area, Adamawa State, Nigeria, between August and September 2023.

Methods: Blood samples were analyzed using the Widal agglutination method, and structured questionnaires captured sociodemographic and environmental data.

Results: Of the participants, 76% tested positive for *Salmonella* agglutinins, with a slightly higher occurrence among females (52.6%) than males (47.4%). Single participants demonstrated a higher prevalence (53.9%) compared with married individuals (46.1%), while the 28–32-year age group had the highest positivity rate (23.7%). No significant association was observed between positivity and gender ($P=0.351$) or age group ($P=0.289$). However, marital status ($P=0.005$) and lack of access to pipe-borne water ($P=0.001$) were significantly associated with *Salmonella* agglutinin occurrence. Finally, other risk factors showed no significant associations ($P>0.05$).

Conclusion: The high prevalence observed in this study indicates a potential burden of typhoid fever in this community, highlighting the influence of sociodemographic and environmental conditions. Overall, improved water infrastructure, enhanced hygiene practices, and targeted public health interventions are recommended to reduce transmission risks.

Keywords: *Salmonella Enterica*, Widal test, Prevalence, Risk factors, Typhoid fever, Adamawa state

Please cite this article as follows: Tula MY, Onyeje GA, Okpalauwaekwe EO, Filgona J. The study of *Salmonella enterica* agglutinin among residents of Barama, Mubi-North LGA, Adamawa state, Nigeria. Avicenna J Clin Microbiol Infect 2026;13(3):146-151. doi:10.34172/ajcmi.3798

Introduction

Typhoid fever, caused by *Salmonella enterica* serovars Typhi/Paratyphi, remains a significant public health challenge in many low-income and middle-income countries, including Nigeria. Globally, it substantially contributes to morbidity and mortality, with an estimated 14.3 million new cases and over 135,000 deaths recorded annually (1). In Sub-Saharan Africa, the incidence is estimated at 144.6 cases per 100,000 person-years, with the highest burden occurring among children under 15 years of age (2). In Nigeria, depending on the geographic region and diagnostic methods employed, prevalence rates vary widely, ranging from 2% to 50% (3, 4). Moreover, transmission is primarily through the fecal–oral route, facilitated by the ingestion of contaminated food and water, and further aggravated by inadequate sanitation, overcrowding, and poor hygiene practices (5).

In Nigeria, typhoid fever is highly endemic and continues to challenge the health system. A recent nationwide review has highlighted that outbreaks frequently occur during the rainy season due to flooding and contamination of water sources, while antimicrobial resistance among *Salmonella* Typhi strains further complicates management (4). Some studies from southern and northern Nigeria consistently reveal high prevalence rates of *Salmonella* exposure, with serological positivity ranging from 40% to over 80% depending on the diagnostic method and study population (6, 7).

The Widal agglutination test is an extensively used diagnostic tool for typhoid fever in resource-limited settings because of its affordability and accessibility. However, its specificity and sensitivity are limited, as cross-reactivity with other Enterobacteriaceae can result in false positives (5, 8, 9). Despite these shortcomings, the



test continues to serve as a valuable epidemiological tool for estimating exposure and identifying high-risk groups in endemic areas where culture and molecular diagnostics are not routinely available.

Nigeria continues to face recurrent typhoid fever outbreaks, compounded by the growing emergence of multidrug-resistant *Salmonella* Typhi strains that undermine treatment effectiveness (4, 7). These challenges highlight the need for reliable baseline data to guide policy, strengthen surveillance, and optimize resource allocation in endemic regions. It is noteworthy that typhoid fever continues to pose a serious public health concern in Adamawa State, northeastern Nigeria. Studies conducted in Mubi have revealed a relatively high seroprevalence of *S. enterica* agglutinins among apparently healthy individuals (6, 10). Nevertheless, there is limited information on how sociodemographic and environmental factors, such as water supply, sanitation practices, and marital status, shape the persistence of infection in semi-urban and rural communities such as Barama in Mubi North. Addressing this gap is crucial for designing context-specific preventive and control strategies. Therefore, this study aims to determine the prevalence of *S. enterica* agglutinins and the associated risk factors among apparently healthy residents of Barama, Mubi North Local Government Area, Adamawa State, Nigeria.

Materials and Methods

Study Area

The study was conducted in Barama, Mubi-North Local Government Area, Adamawa State, Nigeria, located at 10°15'33.0"N and 13°18'13.5"E.

Study Design

A cross-sectional design was employed, and 100 apparently healthy residents of Barama were randomly selected for this study.

Inclusion Criteria

Participants were eligible if they were apparently healthy, were not on medication, and had not visited a medical facility in the preceding three months.

Exclusion Criteria

Participants who declined consent or were undergoing treatment for typhoid fever during the study period were excluded from the study.

Ethical Considerations

Informed consent was obtained from all participants. In addition, ethical approval was granted by the Departmental Research and Seminar Committee. Furthermore, individual results were kept confidential and provided to participants after the study.

Sample Collection

Blood samples were collected from 100 participants and

centrifuged to separate sera, which were immediately analyzed for *S. enterica* agglutinins.

Laboratory Procedure

The Widal agglutination test was performed using the SWE-CARE Diagnostic Febrile Antigen Kit (Spain) with the rapid slide method. The kit employs stained suspensions of killed bacteria: blue and red antigens specific to somatic "O" antigens and flagellar "H" antigens, respectively. Positive and negative controls were included in all assays. Slides were shaken for one minute and then observed for visible agglutination. Additionally, agglutination within one minute was considered reactive; otherwise, the result was recorded as non-reactive (6).

Risk Factor Assessment

Structured questionnaires were administered to participants to assess risk factors associated with *Salmonella* infection.

Statistical Analysis

Data were summarized as frequencies and percentages. In addition, odds ratios were calculated, and statistical significance was set at $P < 0.05$. Analyses were performed using SPSS, version 20.0.

Results

Table 1 provides the demographic characteristics and Widal reactions of the study population. Of the 100 participants, 50% were male and 50% female; further, 64% were single and 36% married. Overall, 76% tested Widal positive, with slightly higher positivity among females (52.6%) and singles (53.9%). Furthermore, the 28–32 years age group recorded the highest positivity (23.7%). Moreover, gender ($P = 0.351$) and age ($P = 0.848$) were not significantly related to Widal positivity, whereas marital status showed a significant association ($P = 0.005$).

Table 2 presents *Salmonella* agglutinin titres among males, with *Salmonella* Typhi H (27.8%) and *Salmonella* Paratyphi CH (16.7%) as the most common, while *Salmonella* Paratyphi BH (5.6%) was the least common. The 1:160 and 1:320 titres had the same level of occurrence.

Table 3 shows the female distribution, where *Salmonella* Paratyphi BH (22.5%) and *Salmonella* Paratyphi CO (5.0%) were the most and least common, respectively. Equal numbers of females had titres of 1:160 and 1:320.

The findings (Table 4) demonstrated a significant association between the occurrences of *Salmonella* agglutinin and the lack of pipe-borne water ($P = 0.001$) and the sources of water used ($P = 0.020$). However, no significant association was found between occurrences of *Salmonella* agglutinin among the subjects with treating/boiling water ($P = 0.156$), eating out ($P = 0.156$), eating raw/fresh vegetables ($P = 0.845$), and consuming raw egg ($P = 0.587$).

Discussion

This study assessed the seroprevalence of *S. enterica*

Table 1. Demographic Characteristics and Widal Reactions of Sera of the Study Population

Demographic Characteristic	No. (%) of Sera Tested	No. (%) of Widal Positive	No. (%) of Widal Negative	OR	95% CI	P-Value
Gender						
Male	50 (50%)	36 (47.4)	14 (58.3)	0.643	0.254-1.626	0.351
Female	50 (50%)	40 (52.6)	10 (41.7)			
Total	100	76 (76.0)	24 (24.0)			
Marital status						
Single	64 (64.0)	41 (53.9)	23 (95.8)	62.39	8.013-485.765	0.005
Married	36 (36.0)	35 (46.1)	1 (4.2)			
Total	100	76 (76.0)	24 (24.0)			
Age group						
18-27	40 (40.0)	30 (39.5)	10 (41.7)	0.886	0.261-3.001	0.845
28-37	42 (42.0)	32 (42.1)	10 (41.7)			
38> above	18 (18.0)	14 (18.4)	4 (16.7)			
Total	100	76 (76.0)	24 (24.0)			

Note. OR: Odds ratio; CI: Confidence interval.

Table 2. Number (%) and Distribution of Sera With Agglutinin End Titre Among Males

Salmonella Antigen	No of Sera Tested	No (%) of Widal Positive Sera	Titre 1:320 ^a	Titre 1:160 ^a
<i>Salmonella</i> Paratyphi A-O	50	3 (8.3)	3 (16.7)	0
<i>Salmonella</i> Paratyphi B-O	50	4 (11.1)	2 (11.1)	2 (11.1)
<i>Salmonella</i> Paratyphi C-O	50	3 (8.3)	2 (11.1)	1 (5.6)
<i>Salmonella</i> Typhi O	50	5 (13.9)	3 (16.7)	2 (11.1)
<i>Salmonella</i> Paratyphi A-H	50	3 (8.3)	2 (11.1)	1 (5.6)
<i>Salmonella</i> Paratyphi B-H	50	2 (5.6)	1 (5.6)	1 (5.6)
<i>Salmonella</i> Paratyphi C-H	50	6 (16.7)	2 (11.1)	4 (22.2)
<i>Salmonella</i> Typhi H	50	10 (27.8)	3 (16.7)	7 (38.9)
Total	50	36 (72.0)	18 (50.0)	18 (50.0)

Note. Values with the same superscripts from each parameter are not significantly different ($P=0.354$).

Table 3. Number (%) and Distribution of Sera With Agglutinin End Titre Among Females

Salmonella Antigen	No of Sera Tested	No (%) of Widal Positive Sera	Titre 1:320 ^a	Titre 1:160 ^a
<i>Salmonella</i> Paratyphi A-O	50	6 (15.0)	5 (20.0)	1 (5.0)
<i>Salmonella</i> Paratyphi B-O	50	4 (10.0)	3 (15.0)	1 (5.0)
<i>Salmonella</i> Paratyphi C-O	50	2 (5.0)	1 (5.0)	1 (5.0)
<i>Salmonella</i> Typhi O	50	5 (12.5)	3 (15.0)	2 (10.0)
<i>Salmonella</i> Paratyphi A-H	50	3 (7.5)	2 (10.0)	1 (5.0)
<i>Salmonella</i> Paratyphi B-H	50	9 (22.5)	3 (15.0)	6 (30.0)
<i>Salmonella</i> Paratyphi C-H	50	3 (7.5)	2 (10.0)	1 (5.0)
<i>Salmonella</i> Typhi H	50	8 (20.0)	1 (5.0)	7 (35.0)
Total	50	40 (80.0)	20 (50.0)	20 (50.0)

Note. Values with the same superscripts from each parameter are not significantly different ($P=0.377$).

agglutinins among residents of Barama, Mubi North Local Government Area, Adamawa State, Nigeria. The findings revealed a high prevalence (76.0%) of positive Widal reactions among apparently healthy individuals, indicating widespread exposure to *S. enterica* or related organisms in the study area.

The prevalence observed in this study was higher than the 60% previously reported among students of a tertiary institution in Mubi (10), but slightly lower than the 82.7% documented in another study conducted in Mubi (6). This suggests that typhoidal infections remain endemic

in the region, with prevalence varying across different subpopulations. This variation in prevalence across the compared studies may be attributed to differences in the study years, ecological variations among the study populations and areas, and differences in cultural and hygienic practices, among other factors.

Similar high prevalence rates of positive Widal agglutination have also been found in Nigeria (11, 12, 13), Ethiopia (14), and Cameroon (15), reinforcing the endemicity of typhoid fever across sub-Saharan Africa.

The higher prevalence of *S. enterica* agglutinins

Table 4. Frequency of *Salmonella* Agglutinin Occurrences With Respect to Some Risk Factors

Risk Factors	Independent Variable	Diagnosis of <i>S. enterica</i> by the Widal Test		Total (N = 100)	OR	95% CI	P-Value
		Positive	Negative				
Presence of pipe-borne water?	Yes	28 (36.8)	18 (75.0)	46 (46.0)	0.194	0.069-0.547	0.001
	No	48 (63.2)	6 (25.0)	54 (54.0)			
Other sources of drinking water	Borehole	14 (18.4)	6 (25.0)	20 (20.0)	0.631	0.234-1.704	0.020
	Hand-dug well	8 (10.5)	7 (29.2)	15 (15.0)			
	Water sold in jerrycan	24 (31.6)	4 (16.7)	28 (28.0)			
	Sachet water	30 (39.5)	7 (29.2)	37 (37.0)			
Treating/boiling of water?	Yes	24 (31.6)	4 (16.7)	28 (28.0)	2.308	0.711-7.491	0.156
	No	52 (68.4)	20 (83.3)	72 (72.0)			
Eating out?	Yes	52 (68.4)	20 (83.3)	72 (72.0)	0.433	0.133-1.407	0.156
	No	24 (31.6)	4 (16.7)	24 (24.0)			
Eating of raw/fresh vegetables?	Yes	62 (81.6)	20 (83.3)	82 (82.0)	0.886	0.261-3.001	0.845
	No	14 (18.4)	4 (16.7)	18 (18.0)			
Consumption of raw egg?	Yes	27 (35.5)	10 (41.7)	37 (37.0)	0.771	0.302-1.970	0.587
	No	49 (64.5)	14 (58.3)	63 (63.0)			

Note. *S. enterica*: *Salmonella enterica*; OR: Odds ratio; CI: Confidence interval.

observed in this study demonstrates the endemicity of typhoid fever in the study area and highlights the low specificity of the Widal test (16). Although the clinical reliance on the Widal test is gradually declining, it remains the only readily available diagnostic tool in many resource-constrained settings, including the study area; therefore, this test is still used by clinicians to support the diagnosis of enteric fever (17). Consequently, its clinical relevance cannot be entirely disregarded. Nevertheless, bacterial culture and, where feasible, molecular methods (e.g., polymerase chain reaction), which remain the gold standards for the diagnosis of typhoid fever, are strongly recommended.

The detection of *Salmonella* agglutinins in apparently healthy individuals may not necessarily indicate active disease but could reflect persistent subclinical infections, tolerance to repeated exposure, or cross-reactivity with other Enterobacteriaceae (e.g., *Escherichia coli*, *Shigella*, *Citrobacter*, and *Proteus* species) that share common “O” and “H” antigens (8, 9, 14), potentially leading to a high rate of asymptomatic infections. This emphasizes the challenge of interpreting Widal results in endemic regions where false positives may be common.

In this study, gender distribution of *Salmonella* agglutinins showed higher prevalence among females (52.6%) compared to males (47.4%), though the difference was not statistically significant. This finding is consistent with those of the study conducted in Owerri, which reported a higher prevalence rate among females than males (16). Likewise, it conforms to the findings of studies in Cameroon (15), Pakistan (17), and South Africa (18), reporting higher seroprevalence among females. However, earlier work in Mubi (10) and Niger State (4) demonstrated higher prevalence in males than females. The lack of significant gender association in this study suggests that both genders are equally at risk, implying that control strategies should not be gender-specific.

On the contrary, a study from Ethiopia (14) documented a higher prevalence in females than males with a statistical difference, representing that females are more at risk of typhoid than their male counterparts.

Age was not significantly associated with *Salmonella* seropositivity, though the 28–32 years group had the highest prevalence, which aligns with the results of studies performed in Ethiopia (19) and Indonesia (20), documenting no consistent age-related risk. However, studies conducted in Nigeria (4) and sub-Saharan Africa (21, 22) confirmed a higher prevalence of typhoid fever among the young adult population. This phenomenon was attributed to likely increased exposure to contaminated environments and dicey behaviors, increasing their exposure to pathogens.

A significant relationship was observed between marital status and the occurrence of *Salmonella* agglutinins, with singles being more likely to test positive. This could be attributed to poor hygienic practices, frequent consumption of food from vendors, and use of unsafe water sources, which are more common among unmarried individuals. Similar observations have been made in Nigeria (3) and Ethiopia (14).

Likewise, the water source was strongly associated with *Salmonella* seropositivity. Based on the results, lack of access to pipe-borne water ($P=0.001$) and reliance on alternative sources such as wells, boreholes, and sachet water ($P=0.020$) significantly increased the likelihood of infection. This finding is in line with that of a study in Niger State, Nigeria (4). It further correlates with the findings of studies that demonstrated the association between contaminated drinking water sources with typhoid in the Republic of Congo (23), Kampala, Uganda (24), Ethiopia (14), and other parts of the world (25–27), emphasizing the role of contaminated water in typhoid transmission. As such, urgent public health action is required, including community-based health education,

improved sanitation infrastructure, reliable access to safe water, and the promotion of household water treatment practices, such as boiling before consumption.

In contrast, other lifestyle-related risk factors, such as eating raw vegetables, raw eggs, or frequent eating outside the home, were not significantly linked with infection in this study, possibly indicating that waterborne transmission remains the dominant route of typhoid spread in Mubi. The lack of significant association between the occurrence of *Salmonella* agglutinins with eating out or in the restaurant, eating fresh/raw vegetables, and eating raw egg implies that these factors do not constitute risk factors for *Salmonella* infection in the study area.

Conclusion

S. enterica exposure is widespread in Mubi and is strongly associated with unsafe water sources and high-risk lifestyle practices. The substantial prevalence among apparently healthy individuals underscores an urgent need for improved access to potable water, strengthened food hygiene practices, and the routine use of more reliable diagnostic methods beyond the Widal test, which may otherwise lead to overestimation of the disease burden in endemic settings.

Authors' Contribution

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Competing Interests

The authors declare that they have no conflict of interests.

Ethical Approval

This study was approved by the Research Committee of the Department of Biological Science Technology, Federal Polytechnic Mubi. Informed consent was also obtained from the participants prior to study enrollment.

Funding

This study received no financial support.

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