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Seroprevalence of Hepatitis B Virus Co-Infection with *Salmonella typhi* in Wukari North-East Nigeria

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Abstract

Hepatitis B virus (HBV) and typhoid fever remain significant public health concerns, particularly in resource-limited settings where sanitation and healthcare infrastructure are inadequate. This study investigated the prevalence of HBV, *Salmonella typhi*, and their co-infection among febrile patients attending the General Outpatient Department (GOPD) of Federal University Teaching Hospital, Wukari, Taraba State, Nigeria. A total of 50 patients aged 15–65 years were recruited, and blood samples were analyzed using serological assays for HBV and Widal tests for *Salmonella typhi* detection. The study found an overall HBV prevalence of 30%, with males (37%) having a higher prevalence than females (21.7%). The prevalence of *Salmonella typhi* was 44%, with females (52.2%) showing a higher infection rate than males (37%). The co-infection rate of HBV and typhoid was 12%, with males (18.5%) exhibiting a higher burden than females (4.3%). The highest HBV prevalence was observed in individuals aged 31–40 years (34.7%), while typhoid was most prevalent in the 20–30 years (71.4%) and 41–50 years (70%) age groups. Co-infection was most common in the 31–40 years (21.7%) group. The findings suggest that gender, age, and exposure to risk factors such as poor hygiene and unsafe practices contribute to the high prevalence of these infections. The study underscores the need for enhanced public health interventions, including vaccination, improved sanitation, health education, and regular screening programs to mitigate the spread of HBV and typhoid fever.

Keywords: Prevalence, Hepatitis B Virus, Typhoid fever, *Salmonella typhi,* Age, Sex

INTRODUCTION

The Hepatitis B Virus (HBV) is the cause of hepatitis B, a potentially fatal liver infection that is a serious global health issue. Hepatitis B Virus (HBV), an enveloped [1] and an hepadnavirus [2], has a partially double-stranded circular DNA genome [1, 2], replicates through an RNA intermediate form by reverse transcription [1]. This particular DNA virus affects individuals of all ages and causes the same incidence every year [2]. Another avoidable viral infection that damages the liver and can result in both acute and chronic liver disease is the Hepatitis B Virus (HBV) [3, 4]. A dangerous and prevalent viral illness of the liver is hepatitis B virus (HBV) mono infection. The virus enters the body of an uninfected person by the blood, semen, or other bodily fluids of an infected person [1].

Sub-Saharan Africa is among the regions of the world where it is endemic [3]. Ashafa *et al.* [1] claim that the virus has led to outbreaks in both Asia and Africa. Approximately 2 billion illnesses have been reported worldwide, and 360 million people suffer from chronic infections. According to estimates, the acute or chronic effects of hepatitis B cause over 600,000 deaths annually. The large reservoir of carriers found in the world's population, estimated at 320–350 million, emphasizes the disease's significance [4].

A 2023 World Health Report estimates that over two billion people worldwide have HBV, with over 350 million of them being chronic carriers. Hepatocellular carcinoma and liver cirrhosis, two liver diseases linked to HBV, claim the lives of over 600,000 individuals annually [2]. Unprotected intercourse, blood transfusions, tattoos, and sharing unprotected needles and blades that are contaminated by infected people are among the activities that cause it [1]. While the estimated prevalence of HBV in the general population is between 5% and 7% in Central, Eastern, and Southern Africa, it is believed to be 8% in West Africa.

Between 2000 and 2011, about 45,000 HBV infections were spread yearly through tainted or unsafe transfusions in sub-Saharan Africa, which has a high burden [2].

Two serovars of *Salmonella enterica typhi* and *paratyphi* (A, B, and C) cause enteric fever, a common systemic infection that can lead to typhoid and paratyphoid fever, respectively. *Salmonella* infections are mostly spread by consuming food or water tainted with excrement from an acutely sick, recovering, or chronically asymptomatic carrier [5]. Poor hygiene, lack of access to drinkable water, and sanitary facilities increase the risk of contracting *Salmonella* [6]. About 14 million cases of enteric fever occur worldwide each year, and in 2017, 136 000 people died from the disease, the majority of them were in low- and middle-income nations in Southeast Asia and Africa [5].

Both typhoid fever and HBV infections pose a serious hazard to public health and are co-endemic in much of tropical and sub-Saharan Africa. Because of their geographic coincidence and in regions where both diseases are endemic, typhoid fever and HBV can co-infect. Due to hepatocyte damage from HBV infection, these two infections may have similar liver developmental phases, which could hinder the liver's ability to eliminate the typhoid fever stages Consequently, an individual's co-infection with the HBV virus and *Salmonella typhi* may impact the pathogenic course of both agents, leading to significant morbidity, complications, and elevated mortality [4].

Comorbidity between typhoid fever and hepatitis B continues to pose a serious threat to public health, particularly in developing nations where there are numerous chances for transmission. Because of their shared endemic territory, both diseases constitute infectious threats of acute and prolonged pyrogen of unknown origin (PUO), and they frequently co-infect in tropical and subtropical locations [5, 7]. When returning travelers and migrants visit endemic nations, the aetiologic agents of typhoid fever and hepatitis B produce a substantial disease burden, either simultaneously or as an acute infection on top of a chronic one [7, 8].

Infectious disease constituted the most serious health issue in the world until the beginning of the 20th century, devastating a significant proportion of the population in many European cities and developed countries. Hepatitis B Virus has been found to be high among people infected with typhoid fever. Previous studies on the prevalence of HBV co-infection in patient with typhoid fever have revealed an increased incidence of co-infection. In Nigeria, HBV and enteric fever mono-infection are well documented, but data on the magnitude of their co-occurrence are lacking. To the best of our knowledge, none has been reported in the study area where most clinicians are used to linking every fever to a single pathology. As earlier noted, HBV and Typhoid fever share similar mode risk factors. For this reason it is likely that the rate of HBV infection is also in the Wukari Area owing to the high prevalence of typhoid fever.

Studies have established that the rate of typhoid fever infection is directly proportion to the rate of HBV infection due to their similar mode risk factors. Establishing the baseline HBV and enteric fever burden is important to prioritize health-resource allocation, advocate for action, and evaluate the impact of current interventions by the governments. The current study aim was to establish the seroprevalence of HBV and its associated factors typhoid and undertaken to study the prevalence of Hepatitis B and enteric fever singly and concurrently among febrile patients in Wukari Taraba State, Nigeria.

MATERIALS AND METHODS

Description of Study Area

Wukari Metropolis, located in Taraba State, serves as the headquarters of Wukari Local Government Area. The Donga and Benue rivers flow through the region [9, 10]. Located at latitude 7.53'43'N and longitude 9.47'59'E, Wukari is one of Taraba State's 16 local government areas. Its population is believed to be between 5,000 and 10,000. The site, which spans 4,308 km^2, is listed on plate 86F of the Times Comprehensive Atlas of the World [11]. In Wukari, the famous administrative hub of the ancient Kwararafa Kingdom, the Jukun people are the predominant ethnic group. The vegetation in the area is similar to that of the Savannah zone, with grasslands and sporadic tree species. The primary economic pursuits include raising cattle, farming, and fishing. Jukun, Hausa, Fulani, and Tiv are the languages that are most frequently spoken. Along with agriculture, the region's main economic include commerce and the civil service [9].

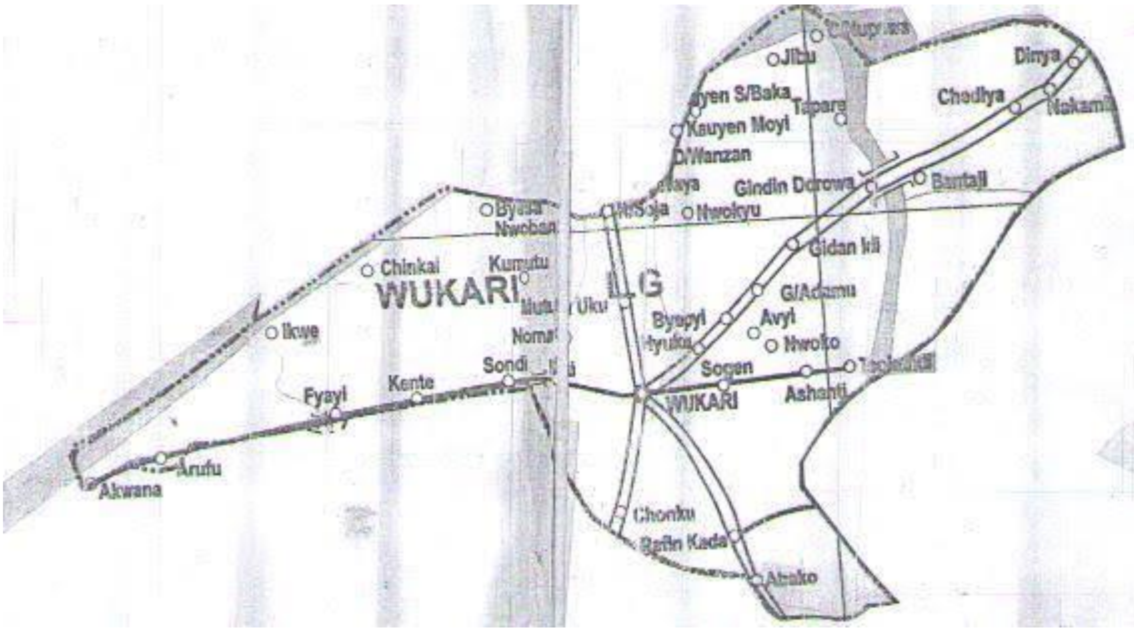

Figure 1: Map showing the study area (Wukari)

Source: Ministry of Land and Survey, Jalingo Taraba State.

Study Setting, Design and Population

Before commencement of the study, ethical clearance was obtained from the Ethical Committee of the Federal University Teaching Hospital Wukari Management Board. The study was conducted between January to March 2025, in General Outpatient Department (GOPD) of the Federal University Teaching Hospital Wukari. The study was carry out among patients presented with febrile illnesses. Fifty (50) inform and consent patients within the age group of 10-60 and above was recruited for the study. Subjects with an established clinical condition other than Typhoid fever and/or HBV infection such as obstructive jaundice, cirrhosis, renal diseases, hypertension, diabetes mellitus, sickle cell disease, cancer and patients already on course of chemotherapy or who had it in the last two weeks for treatment of an earlier diagnosed illnesses were excluded from the study.

Data Sample

The sample encompassed patient newly diagnosed with hepatitis B and typhoid fever and the known positive cases either on ART or not. All potential study participants who consented to participate in the study and met the inclusion criteria were considered.

Inclusion Criteria

- All consenting patients infested with HBV and typhoid fever evident on the ANC record booklet
- All consenting patients aged between 10 – 60 years and above.
- All consenting positive HBV whether on ART or not. This is to capture all potential study participants to achieve the objectives of the study.

Exclusion Criteria

- Non-consenting patients
- Patients with HBV and typhoid fever
- Patients whose age is not within reproductive age bracket.

Data and Blood Sample Collection

Demographic, social, and risk factor information relevant to the study was obtained from each consented patient employing a structured questionnaire [5]. At the same time, five (5) mL of blood sample was obtained through venepuncture from each individual using vercoutainer needle into a well-labeled anticoagulant tube with the assistance of the hospital personnel. [4, 12]. Three (3) mL aliquots of the blood were centrifuged at 3000rpm (2500xg) for 8–10 seconds to obtain serum for HBsAg serology. The remaining Two (2) milliliters aliquot was used for widal assays. In other way, hepatitis B serology HBsAg was detected from the serum samples using Micropoint ELISA, commercial Kits technique following the manufacturer's instructions.

Laboratory Assays

Hepatitis B Virus Assay

One step hepatitis B surface antigen test strip was used for the qualitative detection of HBsAg in serum. All test procedures and interpretation were as indicated by the kit's manufacturers. The kit has a 99.55% sensitivity and 98.5% sensitivity. Patients infected with *Salmonella* produce antibodies against the antigens of the organism. Antibodies in serum was agglutinate bacterial suspension which carries homologous antigens [5].

Salmonella species Assay

Widal Kit was used for the widal agglutination test as described by Cheesbrough [12]. Concisely, an aliquot of blood samples from patients was centrifuged at 3000 rpm for 5 minutes to separate the serum from the whole blood. Eight drops of serum was dispensed and placed in each of the eight circles on the test card to which a drop of respective polyvalent Salmonella O (somatic antigen) and H (flagellar antigen) antiserum was added. The content of each circle was mixed with a disposable stirrer and spread properly over the entire ring of the circle in the test card. The test card was rocked for 4 minutes with a mechanical rotator and the agglutination was recorded at ration (1:20, 1:40, 1:80, 1:160, and 1:320) depending on the concentration of the agglutination reaction. A test was considered significantly positive if the titer value of the agglutination reaction is 1:80. The diagnostic kit has a sensitivity and specificity of ≥70%. The assay was performed in Microbiology Laboratory, Federal University Wukari.

Statistical Analysis

Consider adding basic statistical analysis (e.g., chi-square test or confidence intervals) to validate differences in prevalence rates.

RESULTS

Infectious diseases such as Hepatitis B Virus (HBV) and *Salmonella typhi* remain significant public health concerns, particularly in regions where poor sanitation, inadequate vaccination coverage, and high-risk behaviors contribute to their spread [13]. Understanding the prevalence and distribution of these infections based on sex and age is crucial for developing targeted intervention strategies.

This study investigated the prevalence of HBV, *Salmonella typhi*, and their co-infection among individuals in the study area. The results provide insights into gender-based and age-related susceptibility patterns and offer comparisons with previous research findings.

The analysis of HBV prevalence by sex revealed a higher infection rate among males compared to females. Similarly, the prevalence of *Salmonella typhi* infection was notably higher in females. Additionally, the study examined the occurrence of HBV and *Salmonella typhi* co-infection, which was more prevalent in males than females.

Age-specific analysis of both infections showed variations in susceptibility, with middle-aged individuals (31–40 years) exhibiting the highest prevalence of HBV, while *Salmonella typhi* was most prevalent in the 20–30 and 41–50 age groups.

Table 1: Prevalence of Hepatitis B Virus According to Sex with Percentage Infected (%)

Gender	Number Examined	Number Positive HBV	Percentage Infected (%)
Male	27	10	37.0
Female	23	05	21.7
Total	**50**	**15**	**30**

Table 2: Prevalence of *Salmonella typhi* According to Sex with Percentage Infected (%)

Gender	Number Examined	Number Positive	Percentage Infected (%)
Male	27	10	37.0
Female	23	12	52.2
Total	**50**	**22**	**44**

Table 3: Prevalence of Co-infection According to Sex with Percentage Infected (%)

Gender	Number Examined	Number Positive	Percentage Infected (%)
Male	27	05	18.5
Female	23	01	4.3
Total	**50**	**06**	**12**

Table 4: Prevalence of Hepatitis B Co-Infection with *Salmonella typhi* According to Sex

Gender	Examined Number	Number of Positive HBV	Number of Positive Typhoid	Number of Positive Co-Infection
Male	27	10	10	05
Female	23	05	12	01
Total	**50**	**15**	**22**	**06**

Table 5: Prevalence of Hepatitis B Virus According to Age with Percentage Infected (%)

Age	Number Examined	Number of Positive HBV	Percentage Infected (%)
0 – 10	0	0	0
20 – 30	07	02	28.5
31 – 40	23	08	34.7
41 – 50	10	03	30.0
51 – 60	07	02	28.6
61 – above	03	0	0
Total	**50**	**15**	**30**

Table 6: Prevalence of *Salmonella typhi* According to Age with Percentage Infected (%)

Age	Number Examined	Number of Positive Typhoid	Percentage Infected (%)
0 – 10	0	0	0
20 – 30	07	05	71.4
31 – 40	23	10	43.4
41 – 50	10	07	70
51 – 60	07	03	42.8
61 – above	03	0	0
Total	**50**	**25**	**50**

Table 7: Prevalence of Co-infection According to Age with Percentage Infected (%)

Age	Number Examined	Number of Positive Co-Infection	Percentage Infected (%)
0 – 10	0	0	0
20 – 30	07	0	0
31 – 40	23	05	21.7
41 – 50	10	0	0
51 – 60	07	01	14.3
61 – above	03	0	0
Total	**50**	**06**	**12**

Table 8: Prevalence of Hepatitis B Co-Infection with *Salmonella typhi* According to Age

Age	Number Examined	Number of Positive HBV	Number of Positive Typhoid	Number of Positive Co-Infection
0 – 10	0	0	0	0
20 – 30	07	02	05	0
31 – 40	23	08	10	05
41 – 50	10	03	07	0
51 – 60	07	02	03	01
61 – above	03	0	0	0
Total	**50**	**15**	**25**	**06**

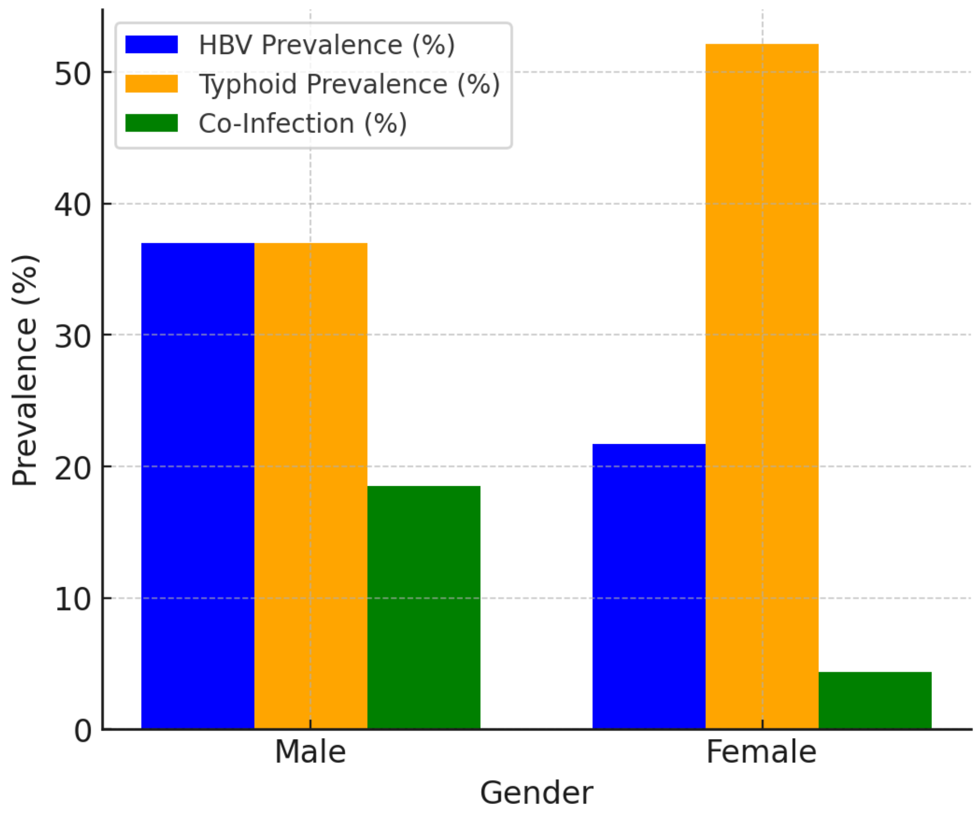

Figure 2: Prevalence of Hepatitis B Co-Infection with *Salmonella typhi* According to Sex

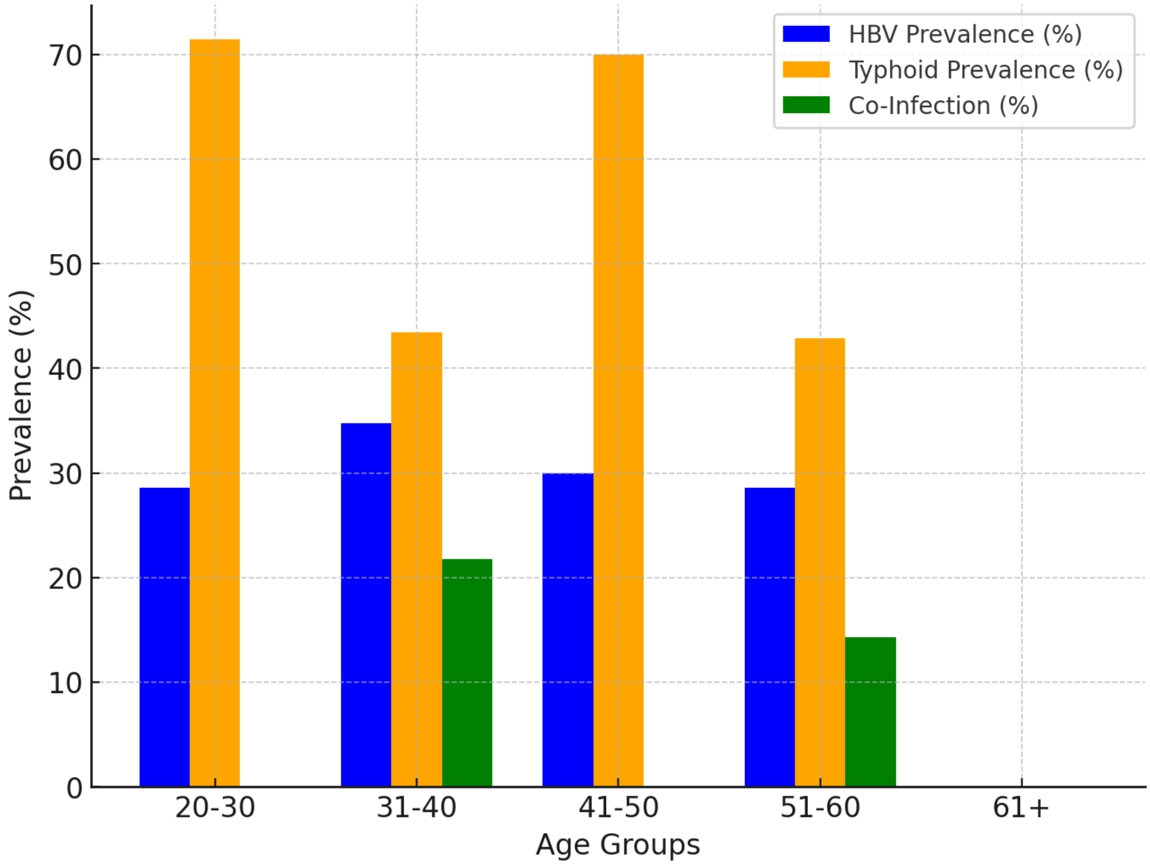

Figure 3: Prevalence of Hepatitis B Co-Infection with *Salmonella typhi* According to Age

DISCUSSION

The overall prevalence of HBV among the studied population was 30%**,** with males (37%) showing a higher infection rate than females (21.7%). This aligns with studies such as Musa *et al.* [13], who reported a higher prevalence of HBV among males, likely due to increased exposure to risk factors such as unsafe sexual practices, intravenous drug use, and traditional surgical procedures like scarification and tattooing. The lower prevalence in females may be attributed to better healthcare-seeking behavior and lower exposure to risk factors.

The study found a higher prevalence of HBV in males (37%) compared to females (21.7%), which is consistent with findings from Musa *et al.* [13] who reported that men are at higher risk due to greater exposure to risk factors such as unsafe sexual practices, body scarification, and occupational exposure. Similarly, Olayinka *et al.* [14] reported a male dominance in HBV prevalence, attributing it to higher engagement in social behaviors that increase transmission risk. Some studies, such as Su *et al.* [15], reported a higher prevalence of HBV in females due to maternal transmission and healthcare exposure. However, in our study, females had a lower prevalence, possibly due to increased vaccination rates and better healthcare-seeking behavior among women.

The total prevalence of *Salmonella typhi* was 44%, with females (52.2%) having a higher infection rate than males (37%). This contrasts with previous studies that often report higher prevalence in males [16]. The higher prevalence among females in this study may be due to factors such as increased exposure to contaminated food and water sources during household activities. Poor hygiene, especially in areas with inadequate sanitation, has been identified as a major driver of typhoid fever transmission [17].

The total prevalence of *Salmonella typhi* (44%) in this study aligns with Akinyemi *et al.* [18], who reported a high prevalence of typhoid fever in areas with poor sanitation and unsafe water sources. This study also found that females had a higher prevalence (52.2%) compared to males (37%), which supports Okonko *et al.* [19], who found that women, particularly those handling food, are more susceptible due to frequent exposure to contaminated food and water. Several studies, such as Awol *et al.* [16], found higher prevalence among males, which they attributed to greater outdoor activities, consumption of street food, and poor personal hygiene among men. The reversal of this trend in our study suggests that sociocultural differences and environmental factors play a role in gender-related typhoid prevalence.

The co-infection of HBV and *Salmonella typhi* was 12%, with males having a higher co-infection rate (18.5%) compared to females (4.3%). Co-infections with HBV and typhoid have been reported in previous studies, where chronic HBV carriers have been found to be more susceptible to Salmonella infections due to immune modulation by the virus [20]. This may explain the higher prevalence among males, who also had a higher HBV infection rate.

The overall co-infection rate (12%) was similar to findings by Lemoine *et al.* [20], who suggested that chronic HBV carriers have altered immune responses that increase susceptibility to bacterial infections such as typhoid. The higher co-infection rate in males (18.5%) compared to females (4.3%) aligns with Okonko *et al.* [19], who found a higher male susceptibility to co-infections due to a higher HBV prevalence in men. Brown *et al.*

[21] found no significant gender difference in HBV-typhoid co-infection, suggesting that co-infection rates are more influenced by environmental and occupational factors rather than sex-specific differences.

The age group 31–40 years recorded the highest HBV prevalence (34.7%), followed by 41–50 years (30%). These findings are consistent with Beste *et al.* [22], who reported a higher prevalence of HBV in middle-aged individuals due to prolonged exposure to risk factors such as unprotected sexual intercourse, multiple sexual partners, and occupational exposure (e.g., healthcare workers). The low prevalence in younger individuals (0–10 years and 61+ years) suggests a reduced risk of transmission in childhood and the protective effects of vaccination.

The highest prevalence was in the 31–40 years age group (34.7%), followed by 41–50 years (30%), which is consistent with Beste *et al.* [22], who reported that middle-aged individuals are at the highest risk due to prolonged exposure to risk factors such as sexual transmission and occupational hazards**.** Musa *et al.* [13] also found that older adults had a lower HBV prevalence due to reduced exposure and possible development of immunity over time**.** Olayinka *et al.* [14] found a higher prevalence in younger adults (20–30 years), attributing it to early sexual activity and lack of vaccination coverage. However, in our study, this age group had a lower prevalence (28.5%), possibly due to improved vaccination efforts in recent years.

The highest prevalence of *Salmonella typhi* was observed in the 20–30 years (71.4%) and 41–50 years (70%) age groups. This may be attributed to increased outdoor activities, consumption of street food, and poor personal hygiene, which are common among younger adults [18]. The lower prevalence in older individuals may be due to the development of immunity over time or reduced exposure to contaminated sources.

The highest prevalence in the 20–30 years (71.4%) and 41–50 years (70%) age groups aligns with Akinyemi *et al.* [18], who found that working-age adults are at the greatest risk due to increased movement, outdoor activities, and exposure to contaminated food and water**.** Unlike Okonko *et al.* [19], who found that older individuals had higher prevalence due to weakened immunity, our study found a lower prevalence in individuals aged 51 and above, possibly due to lifestyle changes and reduced exposure.

Co-infection was highest in the 31–40 years age group (21.7%), followed by the 51–60 years group (14.3%). The findings suggest that middle-aged adults, who are at the peak of their economic and social activities, may be at higher risk of dual infections due to increased exposure to both HBV and *Salmonella typhi* pathogens. This is in agreement with research by Okonko *et al.* [19], which highlighted the burden of co-infections in active working-age populations.

The highest co-infection rate in the 31–40 years (21.7%) group supports Brown *et al.* [21], who found that active working-age individuals are at greater risk of multiple infections due to increased exposure. Su *et al.* [15] reported that co-infection rates were highest among younger age groups (20–30 years), possibly due to higher rates of unprotected sex and unsafe healthcare practices. The lower co-infection rate in this age group in our study suggests possible differences in risk behaviors between populations.

The findings of this study highlight the need for targeted preventive interventions, including:

Public Health Awareness Campaigns – Educating communities on the risks of HBV and typhoid, emphasizing safe practices, and encouraging vaccination. Hepatitis B Vaccination Strengthening routine HBV immunization, particularly among high-risk groups such as healthcare workers and young adults. Improved Sanitation and Hygiene – Enhancing access to clean water and sanitation to reduce typhoid transmission, especially in endemic areas. Screening and Early Diagnosis – Regular screening for HBV and typhoid in high-risk populations to enable early treatment and prevent complications.

These findings align with previous research but also present some variations that could be attributed to sociocultural behaviors, vaccination rates, and environmental factors. The findings from this study contribute to the growing body of literature on infectious disease epidemiology and emphasize the need for preventive strategies, including vaccination, improved sanitation, and public health awareness campaigns. The subsequent discussion compares these results with findings from previous studies and highlights possible explanations for the observed trends.

Moreover, this study aligns with many previous findings, particularly regarding HBV prevalence in males, co-infection risk in middle-aged adults, and higher typhoid prevalence in urban populations. However, it also contrasts with some studies that reported higher HBV prevalence in females and higher co-infection rates in younger adults. These differences may be attributed to sociocultural factors, vaccination coverage, and differences in environmental exposure. Further research is needed to explore regional differences in risk factors and improve preventive measures to reduce the burden of both HBV and *Salmonella typhi* infections.

CONCLUSION

This study provides valuable insights into the prevalence and risk factors associated with HBV, typhoid fever, and their co-infection among patients in Wukari, Taraba State. The findings reveal a high burden of both infections, with males showing a higher prevalence of HBV and co-infection, while females had a higher prevalence of typhoid fever. Middle-aged individuals (31–40 years) had the highest HBV burden, while younger adults (20–30 years) and middle-aged individuals (41–50 years) were most affected by typhoid fever.

The higher prevalence of HBV in males aligns with studies linking male susceptibility to highrisk behaviors, such as unsafe sexual practices and body scarification. Conversely, the higher typhoid prevalence in females may be due to greater exposure to contaminated food and water through household activities. The findings on co-infection (12%) further highlight the vulnerability of HBV carriers to secondary bacterial infections like typhoid, likely due to immune modulation by chronic HBV infection.

Given the public health implications of these infections, this study highlights the urgent need for targeted intervention strategies, including public health awareness, vaccination, improved sanitation, and early screening to reduce transmission rates and associated complications. Further research is recommended to explore the environmental and socio-behavioral factors contributing to these infections in different population groups.

Recommendations

Based on the findings of this study, the following recommendations are proposed to mitigate the burden of HBV, typhoid fever, and co-infections:

1. Public Health Awareness Campaigns: Community education on HBV transmission, risk factors, and prevention. Sensitization on typhoid fever prevention, proper food hygiene, and sanitation practices.
2. Hepatitis B Vaccination Programs: Strengthen routine HBV vaccination coverage, especially among high-risk groups (healthcare workers, sexually active adults, and

individuals undergoing traditional scarification or tattooing). Encourage catch-up vaccination programs for unvaccinated adults**.**

3. Improved Sanitation and Hygiene: Ensure access to clean and safe drinking water to curb typhoid fever transmission. Promote proper food handling and hygiene to reduce the risk of Salmonella infections. Implement waste management strategies to minimize environmental contamination.
4. Early Screening and Diagnosis: Regular HBV screening for at-risk populations (e.g., blood donors, pregnant women, and healthcare workers). Encourage early testing for typhoid fever in febrile patients to ensure prompt treatment.
5. Integrated Disease Control Strategies**:** Combine HBV and typhoid control programs to improve resource utilization. Enhance surveillance and data collection on co-infections for better policy formulation.

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