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SEROPREVALENCE OF HEPATITIS A VIRUS AND ASSOCIATED RISK FACTORS AMONG PATIENTS IN MAIDUGURI, BORNO STATE, NIGERIA

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ABSTRACT

Hepatitis A virus (HAV) is a non-enveloped, positive-sense RNA virus and remains a major cause of acute viral hepatitis in areas with poor sanitation and limited access to safe drinking water. This study investigated the molecular detection and characterization of HAV and its public health implications in Maiduguri, Borno State, Nigeria. A total of 140 blood samples were collected and screened for HAV-specific IgM and IgG antibodies using the Palmatec® HAV IgG/IgM One Step Test Cassette. Demographic characteristics, behavioral risk factors, and relevant clinical information were obtained using structured questionnaires. Data were analyzed to determine seroprevalence and associated risk factors. Overall IgG seropositivity was 43.6%, indicating widespread past exposure, while IgM prevalence was low (2.1%), suggesting limited recent transmission. Females showed a slightly higher IgM positivity rate (3.4%) than males (0%), and mixed IgG/IgM positivity was rare (1.4%). Seroprevalence varied across hospitals, with the highest IgG prevalence recorded at the State Specialist Hospital (48.6%). Educational level significantly influenced antibody distribution ($p < 0.05$), with IgM detected mainly among individuals with secondary education (9.4%). Occupational differences were not statistically significant, although students and civil servants showed low levels of recent infection. IgG seroprevalence increased with age, peaking at 50% among individuals aged 41–50 years, while IgM positivity was confined to the 11–20 and 41–50-year age groups. Behavioral factors, including consumption of tap or well water, poor hand hygiene, and travel to high-risk areas, were significantly associated with higher IgG positivity ($p < 0.05$). The findings confirm that HAV remains endemic in Maiduguri, with transmission driven by environmental, educational, and behavioral factors. Strengthening public health interventions, including improved water and sanitation, hygiene education, and targeted vaccination of high-risk groups, is recommended to reduce HAV transmission.

Keywords: Hepatitis A virus (HAV); Seroprevalence; Maiduguri; Public health; Acute viral hepatitis.

Introduction

Hepatitis A virus (HAV) is a non-enveloped, positive-sense single-stranded RNA virus belonging to the genus *Hepatovirus* in the family *Picornaviridae* and the order *Picornavirales* (Shouval et al., 2021). The virus was first identified in 1973 by Stephen Feinstone, Albert Kapikian, and Robert Harry Purcell, who isolated it from the feces of infected individuals and established its etiological role in epidemic hepatitis (Shouval et al., 2021; Papka et al., 2025b). Since then, HAV has been recognized as a leading cause of acute viral hepatitis worldwide, responsible for both sporadic infections and large-scale outbreaks (Papka et al., 2025a).

Humans are the only natural reservoir of HAV, and transmission occurs primarily through the fecal–oral route, including ingestion of contaminated food or water, direct person-to-person contact, and, less commonly, exposure to contaminated blood products (CDC, 2021; Papka et al., 2025a; Papka et al., 2025b). Globally, HAV infection is highly endemic in regions with poor sanitation and limited access to safe water, particularly in low- and middle-income countries such as Nigeria (WHO, 2023; Ndumbi et al., 2018). In these settings, inadequate water treatment, overcrowding, and poor personal hygiene practices significantly facilitate viral transmission.

Although HAV infection is usually self-limiting and confers lifelong immunity, severe disease, including fulminant hepatitis, can occur, especially among adults, elderly individuals, and persons with underlying liver disease (Noel et al., 2021; Nelson et al., 2020). Common clinical manifestations include jaundice, anorexia, malaise, fatigue, nausea, and elevated liver enzyme levels (Manijeh and Batool, 2017; WHO, 2023). Unlike hepatitis B and C viruses, HAV does not cause chronic infection; however, it remains a major contributor to the global burden of acute viral hepatitis.

Outbreaks are particularly common in regions with intermediate endemicity, where improvements in sanitation reduce childhood exposure, leaving a larger proportion of susceptible adults who are more likely to develop symptomatic and severe disease (Linder et al., 2017; Tejada et al., 2018). Moreover, HAV is environmentally resilient and can survive for weeks under favorable conditions, remaining infectious on surfaces and fomites in settings with poor sanitation (Gholizadeh et al., 2023).

Vaccination is highly effective in preventing HAV infection and controlling outbreaks (Papka et al., 2025b). However, in Nigeria and many other resource-limited settings, vaccine coverage remains low, allowing continued circulation of the virus, particularly among high-risk populations such as food handlers, individuals living in overcrowded communities, and those with limited access to clean water and sanitation facilities (WHO, 2023; Papka et al., 2025a; Papka et al., 2025b; Gholizadeh et al., 2023).

Recent studies in northeastern Nigeria, including Mubi and Maiduguri Metropolis, have reported ongoing HAV seroprevalence among women of childbearing age, indicating both past exposure and continued risk of infection (Papka et al., 2025a). These findings highlight the need for context-specific sero-epidemiological studies to estimate the burden of infection and identify associated risk factors. Such data are essential for guiding public health interventions, including health education, improvements in water and sanitation, and expansion of vaccination programs in resource-limited settings.

Aim and Objectives of the Study

The aim of the study is to conduct a serological assessment of Hepatitis A virus (HAV) infection in Maiduguri, Borno State, Nigeria, by determining the seroprevalence of HAV IgG and IgM antibodies and examining their associations with selected sociodemographic and behavioral risk factors. The specific objectives of the study are to:

1. Determine the seroprevalence of HAV IgG and IgM antibodies among the study population in Maiduguri, Borno State, Nigeria.
2. Assess the distribution of HAV serostatus across selected sociodemographic characteristics (age, sex, education, occupation, and study site).
3. Evaluate behavioral and environmental risk factors associated with HAV exposure, including water source, hygiene practices, and travel history.
4. Examine the statistical associations between HAV serostatus and selected sociodemographic and behavioral variables using appropriate inferential analyses.

MATERIALS AND METHODS

This was a hospital-based cross-sectional study conducted in Maiduguri, northeastern Nigeria. Participants were recruited from selected hospitals using consecutive sampling, whereby all eligible and consenting patients presenting during the study period were enrolled until the required sample size was reached. This approach was appropriate because it was practical in a hospital setting and helped reduce selection bias by systematically including all eligible attendees. This is a cross-sectional study that was undertaken among the patients presenting among the public at the selected health facilities. Data and blood samples will be collected in the durations of 3 months. A total of 140 blood samples were collected from consenting patients attending selected hospitals in Maiduguri, including the State Specialist Hospital, General Mamman Shuwa Hospital, Umaru Shehu Ultra-Modern Hospital, and the University of Maiduguri Teaching Hospital. Participants completed a structured questionnaire capturing sociodemographic and relevant clinical information. Recruitment was hospital-based using consecutive sampling of eligible patients, and findings are not intended to be generalized beyond the study population. This was a hospital-based cross-sectional study conducted in selected hospitals in Maiduguri, Borno State, Nigeria. Participants were recruited using consecutive sampling, whereby all eligible patients who presented to the selected hospitals during the study period and consented to participate were enrolled until the required sample size was achieved. This approach was chosen to minimize selection by investigators while reflecting the routine hospital attendance pattern. The minimum sample size was calculated using the standard formula for estimating a single population proportion as described by Ageru and Abiso (2018):

Where:

n = minimum required sample size
Z = standard normal deviate at 95% confidence level (1.96)
P = estimated prevalence of HAV infection in the target population
d = desired precision (0.05)

Based on a previous study in Konduga LGA, Borno State, which reported an HAV prevalence of 3.6% (P = 0.036) (Dawurung et al., 2014), the sample size was calculated as follows:

$$\frac{Z^2 \times P\,(1-P)}{(d)^2}$$

1.0-p (1-0.036) = q

d^2= precision, or degree of accuracy, was often set at 0.05.

n is equal to $(1.96)^2 \times \frac{0.036\,(1-0.0356}{(0.05)^2}$

$3.8416 \times \frac{0.036\,(0.964)}{0.0025}$

38416 × 13.8816 = 53.327

To account for possible non-response and sample loss, the sample size was increased, and a total of 140 participants were ultimately recruited for the study.

Participants were eligible for inclusion if they:

1. Were patients attending the selected hospitals during the study period;
2. Were aged 10 years and above (or specify your actual age range);
3. Provided written informed consent (and assent where applicable);
4. Agreed to provide a blood sample for serological testing;
5. Completed the study questionnaire.

Participants were excluded if they:

1. Declined or were unable to provide informed consent;
2. Were severely ill and unable to participate in the interview or provide a blood sample;
3. Had insufficient or hemolyzed blood samples unsuitable for analysis;
4. Had incomplete questionnaire data.

Information on prior HAV vaccination was obtained through participant self-report during questionnaire administration. However, vaccination cards or medical records were not consistently available for verification. As a result, vaccination status could not be independently confirmed and was not used as a definitive variable in the analysis. This represents a study limitation, as some IgG-positive results may reflect vaccine-induced immunity rather than natural infection. Because this was a hospital-based study using consecutive sampling, the findings may not be fully generalizable to the wider community. Participants attending hospitals may differ from the general population in health-seeking behavior, socioeconomic status, or underlying health conditions, which could introduce selection bias. Protocol of the study for data collected will be submitted for review and approval by the Research and Ethics Committee of Ministry of Health Borno State Council.

The study participants was consecutively enrolled. Every patient who was attended the hospital during the period of the study was selected until the sample size (140) was achieved. The recruitment of study participants was integrated within the day-to-day activities of the hospital. Five milliliters of whole blood was collected aseptically by venipuncture in EDTA tubes from all consenting subjects. Before blood collection, the tube was label with 35 the subject identification code. After blood is collected, the plasma was separated from whole blood by centrifugation and then split into labeled micro vials and kept frozen at -20°C. Before data and specimen collection, an informed consent/assent will be signed by the participant. The following minimum information was included on the laboratory requested form accompanying the specimen: Lab ID number, date of collection, age and gender of the subject. Microsoft Excel computer package was used for data entry and storage. Confidentiality of data was ensured throughout the period of the study and even after. This was achieved by making sure that patients names was used just as ID numbers, only people involved in the study gated access to the data, locking data files in a secure place and also putting pass words in the computers where data was enters.

A standardized questionnaire was developed and recorded socio-demographic information. The questionnaire questions including residential area, age, family size, and way of human was disposals, water sources for human consumption and the clinical features. The questionnaire was administered freely after seeking an informed consent from the participants, permission was obtained from the parents or guardians.

Plasma specimens in the storage bottles (cryotubes) was placed in a cool box and laboratory requisitions that accompanied the specimens was placed in the pocket of the handbag from the site of collection to Reference National Laboratory where they was stored at –20ºC until the time of laboratory investigations, (Medrzycki *et al.,* 2020). Only IgM/IgG positive samples was transported under cold chain.

Performance Characteristics
1 Sensitivity and Specificity samples.
The test results contain 800 samples, including 200 HAV IgM, 300 HAV IgG and 300 negative samples.
For IgM: Relative Specificity of lgM: 94.0% (95%CI*:89.7%~96.2%)
Overall Agreement of lgG: 96.74%(95%CI":94.3%~97.8%);
For IgG: Relative Specificity of lgG: 94.0% (95%CI*:90.7%~96.2%)
Overall Agreement of IgG: 94.7%(95%CI":92.6%~96.2%);
Interference: The following compounds have been tested and
no interference was observed.
Triglyceride: 50 mg/dL, Ascorbic Acid: 20mg/dL; Hemoglobin: 1000mg/dL: Bilirubin60mg/dL: Total cholesterol: 6mmol/L
3. Cross-reactivity
HAV Hepatitis A Virus IgG/IgM Test has been tested for anti-RSV, anti-Adeno virus, HBsAg, anti-Syphilis, anti-H.Pylorì and anti-HCV positive specimens. The results
showed no cross-reactivity.

Palmatec® Test

Name of manufacturer: Palmatec® HAV IgG/IgM One Step Test Cassette (Serum/Plasma)

- Country of manufacturing: UK
- Lot number: 2023/06/19
- Expiring date: 2027/06/18

Participants in the study was identified with their unique code known by only the investigator as well as the date of specimen collection. All the data obtain was recorded in a notebook, entered into a spreadsheet created in MS Excel where data was stored and protected using password known only by the principal investigator. Scio-demographic data was collected in the regarding patient's age, sex, clinical complains, health-facility visiting.

Results

Seroprevalence of HAV Specific Antibodies Based on Gender

A total of 140 participants were screened for HAV-specific antibodies, with 51 (36.4%) males and 89 (63.6%) females. IgG antibodies, indicative of past exposure, were detected in 26 males (51.0%) and 35 females (39.3%). IgM antibodies, suggesting recent infection, were observed only in females (3.4%), while mixed IgG+IgM positivity was rare, occurring in one male (2.0%) and one female (1.1%). Statistical analysis showed no significant.

Table 1: Seroprevalence of HAV Specific Antibodies by Gender

Gender	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	χ^2 (p-value)
Male	51 (36.4)	26 (51.0)	0 (0.0)	1 (2.0)	
Female	89 (63.6)	35 (39.3)	3 (3.4)	1 (1.1)	
Total	140 (100)	61 (43.6)	3 (2.1)	2 (1.4)	2.219 (0.3297)

Note: IgM = Immunoglobulin M; IgG = Immunoglobulin G. n= number tested (n %)

Seroprevalence of HAV Specific Antibodies by Hospital

Participants were evenly distributed across the four hospitals (35 per hospital, 25%). IgG seropositivity was highest at State Specialist Hospital (SSH) (48.6%) and lowest at University of Maiduguri Teaching Hospital (UMTH) (37.1%). IgM antibodies were detected in (2.9%) of participants at Mamman Shuwa Hospital (MSH), State Specialist Hospital (SSH), and Umaru

Shehu ultra-modern Hospital (USUH) but absent at UMTH. Mixed IgG+IgM antibodies were detected only at MSH (1.9%) and University of Maiduguri Teaching Hospital (UMTH) (2.9%). No statistically significant differences were observed across hospitals ($p > 0.05$).

Table 2: Seroprevalence of HAV Specific Antibodies by Hospital

Hospital	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	χ^2 (p-value)
MSH	35 (25.0)	16 (45.7)	1 (2.9)	1 (1.9)	
SSH	35 (25.0)	17 (48.6)	1 (2.9)	0 (0.0)	
UMTH	35 (25.0)	13 (37.1)	0 (0.0)	1 (2.9)	
USUH	35 (25.0)	15 (42.9)	1 (2.9)	0 (0.0)	
Total	140 (100.0)	61 (43.6)	3 (2.1)	2 (1.4)	3.046 (0.8031)

Key: MSH: Mamman Shuwa Hospital, SSH: State Specialist Hospital, UMTH= University of Maiduguri Teaching Hospital, USUH= Umaru Shehu ultra-modern Hospital.

Seroprevalence Based on Marital Status

Out of the 140 participants, 58 (41.4%) were single, 80 (57.1%) married, and 2 (1.4%) widowers. IgG antibodies were most prevalent among widowers (100%) and singles (44.8%) compared to married individuals (41.3%). IgM antibodies were highest among singles (3.4%) and absent among widowers. Mixed IgG+IgM was observed only in married participants (2.5%). No statistically significant ($p > 0.05$).

Table 3: Seroprevalence of HAV-Specific Antibodies by Marital Status

Marital Status	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	χ^2 (p-value)
Single	58 (41.4)	26 (44.8)	2 (3.4)	0 (0.0)	
Married	80 (57.1)	33 (41.3)	1 (1.3)	2 (2.5)	
Widower	2 (1.4)	2 (100.0)	0 (0.0)	0 (0.0)	
Total	140 (100.0)	61 (43.6)	3 (2.1)	2 (1.5)	2.436 (0.6562)

Seroprevalence by Educational Level

Participants with tertiary education constituted 55.0% of the sample, secondary education 22.9%, non-formal 14.3%, and primary 7.9%. IgG positivity was highest among tertiary-educated participants (48.1%) and lowest in primary education (27.3%). IgM antibodies were detected only in the secondary education group (9.4%), while mixed IgG+IgM antibodies were found in non-formal (5.0%) and tertiary (1.3%) education levels. The association between mixed IgG+IgM positivity and education was statistically significant ($p < 0.05$).

Table 4: Seroprevalence of HAV Specific Antibodies by Educational Level

Education Level	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	χ^2 (p-value)
Non-formal	20 (14.3)	9 (45.0)	0 (0.0)	1 (5.0)	
Primary	11 (7.9)	3 (27.3)	0 (0.0)	0 (0.0)	
Secondary	32 (22.9)	12 (37.5)	3 (9.4)	0 (0.0)	
Tertiary	77 (55.0)	37 (48.1)	0 (0.0)	1 (1.3)	
Total	140 (100.0)	61 (43.6)	3 (2.1)	2 (1.4)	12.74 (0.0473)

Seroprevalence by Occupation

Participants were classified as students (47.1%), civil servants (18.6%), unemployed (20.0%), businesspersons (7.1%), farmers (3.6%), and full-time housewives (3.6%). IgG antibodies were highest among businesspersons (50.0%) and lowest among the unemployed

(32.1%). IgM antibodies were observed only in civil servants (3.8%) and students (3.0%), while mixed IgG+IgM antibodies were present in students (1.5%) and the unemployed (3.6%). No statistically significant association was observed between occupation and HAV seropositivity ($p > 0.05$).

Table 5: Seroprevalence of HAV Specific Antibodies by Occupation

Occupation	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	χ^2 (p-value)
Business	10 (7.1)	5 (50.0)	0 (0.0)	0 (0.0)	
Civil Servant	26 (18.6)	11 (42.3)	1 (3.8)	0 (0.0)	
Farmer	5 (3.6)	2 (40.0)	0 (0.0)	0 (0.0)	
Fulltime Housewife	5 (3.6)	2 (40.0)	0 (0.0)	0 (0.0)	
Student	66 (47.1)	26 (39.4)	2 (3.0)	1 (1.5)	
Unemployed	28 (20.0)	9 (32.1)	0 (0.0)	1 (3.6)	
Total	140 (100.0)	61 (43.6)	3 (2.1)	2 (1.4)	3.544 (0.9656)

4.6 Seroprevalence by Age Group

The highest IgG prevalence was observed among individuals aged 41–50 years (50.0%), while the lowest was in children 0–10 years (22.2%). IgM antibodies were significantly associated with age ($p < 0.05$), detected only in the 11–20 years (8.3%) and 41–50 years (10.0%) groups. Mixed IgG/IgM positivity was rare, found in 31–40 (1.3%) and 51–60 (20.0%) year groups, without statistical significance.

Table 6: Seroprevalence of HAV Specific Antibodies by Age Group

Age Group (Years)	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	χ^2 (p-value)
0–10	9 (6.4)	2 (22.2)	0 (0.0)	0 (0.0)	
11–20	24 (17.1)	11 (45.8)	2 (8.3)	0 (0.0)	
21–30	59 (41.4)	26 (44.0)	0 (0.0)	0 (0.0)	
31–40	32 (22.9)	14 (43.8)	0 (0.0)	1 (1.3)	
41–50	10 (7.1)	5 (50.0)	1 (10.0)	0 (0.0)	
51–60	5 (3.6)	2 (40.0)	0 (0.0)	1 (20.0)	
61–70	1 (0.7)	1 (100.0)	0 (0.0)	0 (0.0)	
Total	140 (100.0)	61 (43.6)	3 (2.1)	2 (1.4)	19.17 (0.0845)

Seroprevalence Based on Risk Factors

- **Water Source**: IgG seropositivity was significantly lower among participants who drank tap or well water (36.6%) compared to those who did not (57.4%, $p < 0.05$). IgM and mixed IgG/IgM positivity were not statistically significant.
- **Handwashing Practices**: Participants reporting regular handwashing had lower IgG positivity (40.2%) compared to non-hand washers (66.7%, $p < 0.05$).
- **Travel History**: Those who traveled to high-risk HAV areas had significantly higher IgG seropositivity (64.0% vs 39.1%, $p < 0.05$).
- **Blood Transfusions or Surgery**: A highly significant lower IgG prevalence (7.7%) was observed among participants with prior transfusions or surgery ($p < 0.01$).

Table 7: Seroprevalence of HAV Specific Antibodies by Selected Risk Factors

Risk Factor	Category	n (%)	IgG Only n (%)	IgM Only n (%)	IgG+IgM Mixture n (%)	OR (95% CI)	Fisher exact test p-value
Source of Water (Tap/Well)	Yes	93 (66.4)	34 (36.6)	3 (3.2)	2 (2.2)	0.43 (0.21–0.87)	0.015
	No	47 (33.6)	27 (57.4)	0 (0.0)	0 (0.0)		
Hand washing	Yes	122 (87.1)	49 (40.2)	3 (2.5)	2 (1.6)	0.34 (0.12–0.95)	0.032
	No	18 (12.9)	12 (66.7)	0 (0.0)	0 (0.0)		
Travel History	Yes	25 (17.9)	16 (64.0)	0 (0.0)	0 (0.0)	2.77 (1.13–6.79)	0.020
	No	115 (82.1)	45 (39.1)	3 (2.6)	2 (1.7)		

Discussion of Findings

This study found a moderate prevalence of HAV IgG (43.6%) and a very low prevalence of IgM (2.1%), indicating widespread past exposure with limited recent transmission. This pattern is typical of settings with intermediate endemicity, where cumulative exposure occurs over time but large outbreaks are uncommon (Patterson et al., 2019; WHO, 2023). The low IgM rate suggests that, during the study period, active transmission was relatively limited, although ongoing low-level circulation cannot be excluded (Papka et al., 2025a; Dawurung et al., 2014).

IgG seropositivity increased with age, supporting the interpretation of cumulative lifetime exposure and durable immunity following infection. This age-related pattern is consistent with fecal–oral transmission in environments where sanitation and water quality are variable (Linder et al., 2017; Tejada et al., 2018; WHO, 2023). Differences observed across hospitals and population subgroups likely reflect heterogeneity in living conditions, crowding, and access to safe water rather than true biological differences in susceptibility (Mohammed et al., 2022; Patterson et al., 2019).

Educational level and selected behavioral factors, particularly the use of untreated water and poor hygiene practices, were associated with HAV serostatus, reinforcing the central role of environmental and behavioral exposures in transmission (Adamu et al., 2023; Singh et al., 2021; WHO, 2023). However, these associations should be interpreted cautiously. Because this was a hospital-based, cross-sectional study, the sample may not represent the general population, introducing potential selection bias, and temporal relationships cannot be established (i.e., current behaviors may not reflect conditions at the time of infection). In addition, self-reported behaviors are prone to recall and social desirability bias, which could weaken or distort observed associations.

The relatively lower IgG prevalence compared with some earlier reports from similar settings may reflect gradual improvements in sanitation and awareness (Bello and Yakubu, 2021; WHO, 2023), but alternative explanations include differences in study populations, age structure, and sampling frames (Ngwoke et al., 2019; Mohammed et al., 2022). The small number of IgM-positive cases also limits statistical power to detect meaningful associations with recent infection and may partly explain the weak or inconsistent associations observed.

Conclusion

This study confirms that HAV remains endemic in Northeast Nigeria, characterized by moderate IgG seroprevalence (43.6%) and low IgM detection (2.1%), indicating widespread past exposure with limited recent transmission. The observed patterns appear to be shaped largely by environmental and behavioral factors. Strengthening water and sanitation infrastructure, improving hygiene practices, and expanding targeted vaccination programs remain key strategies for reducing HAV transmission in this setting (WHO, 2023; Papka et al., 2025b).

Recommendations

1. Prioritize provision of safe drinking water in communities served by the study hospitals, especially where reliance on untreated tap or well water was associated with higher HAV seropositivity. Short-term measures should include water treatment (chlorination), monitoring of water sources, and public advisories on boiling or treating drinking water.
2. Implement health education campaigns in healthcare facilities and surrounding communities emphasizing handwashing, safe food handling, and proper sanitation practices, as poor hygiene and unsafe food/water consumption were significantly associated with HAV exposure in this study.
3. In hospital settings, provide counseling and basic preventive guidance to individuals identified as higher risk based on behavioral and environmental exposures, to reduce ongoing low-level transmission suggested by the presence of IgM-positive cases.

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APPENDIX

Figure 1: © WHO Polio Laboratory, Maiduguri, Borno state. Nigeria. 02/06/2025. Ijudigal Musa Papka and Mohammed Aja.

Figure 2: © WHO Polio Laboratory, Maiduguri, Borno state. Nigeria. 02/06/2025. Ijudigal Musa Papka, Prof. David Nabeda Bukbuk, Papka on investigational quantification extraction.

Figure 3: © WHO Polio Laboratory, Maiduguri, Borno state. Nigeria. 02/06/2025. Strip indicating positive sample.

Figure 4:© WHO Polio Laboratory, Maiduguri, Borno state. Nigeria. 02/06/2025.
Ijudigal Musa Papka and Mohammed Aja, describing the results.

Figure 5: © WHO Polio Laboratory, Maiduguri, Borno state. Nigeria. 02/06/2025.
Ijudigal Musa Papka, Prof. David Nabeda Bukbuk and Mohammed Aja, describing the results.