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West Nile Virus Exposure in Sudan: A Cross-Sectional Study (2019–2022)

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Abstract

West Nile virus (WNV) is a mosquito-borne pathogen responsible for West Nile fever and, in rare cases, severe neuroinvasive disease (WNND) with an estimated 10% fatality rate. This study aimed to assess WNV exposure among residents of Gezira State, Sudan, from 2019 to 2022. Blood samples were collected from 400 participants and tested for WNV-specific IgG and IgM antibodies using ELISA. The results showed that 62.3% (249/400) were positive for WNV-IgG antibodies, indicating previous exposure, whereas no participants tested positive for WNV-IgM, suggesting no recent active infections. Statistical analysis revealed no significant association between WNV-IgG seropositivity and age or gender, but significant correlations were observed with marital status and education level. These findings highlight the substantial level of past WNV exposure in Gezira State and underscore the need for ongoing surveillance, mosquito control measures, and community education to mitigate potential outbreaks.

Keywords: West Nile Virus; Seroprevalence; ELISA; Sudan; Vector-Borne Diseases

1. Introduction

West Nile virus (WNV) is a mosquito-borne flavivirus that typically causes mild or asymptomatic infections, but can occasionally lead to severe neurological disease, with a case fatality rate of approximately 10% (Petersen et al., 2013). First identified in Uganda in 1937, WNV spread to North America in 1999 and has since been reported across Europe, Africa, Asia, Australia, and North America (CDC, 2017; WHO, 2011). In the U.S., thousands of cases are reported annually, peaking in late summer and early autumn, sometimes causing outbreaks (CDC, 2017; WHO, 2011). In Sudan, a notable outbreak occurred in Ngorban County, South Kordofan, between May and August 2002.

WNV is primarily transmitted through the bite of infected mosquitoes that feed on infected birds. Rare human-to-human transmission can occur through blood transfusions, organ transplants, or vertical transmission from mother to child during pregnancy, birth, or breastfeeding (CDC, 2017). Direct person-to-person transmission does not occur (WHO, 2011).

All age groups are susceptible to WNV, though individuals over 60 years old and those with underlying health conditions face a higher risk of severe neurological complications (Campbell et al., 2002; Solomon et al., 2003). Disease severity is influenced by viral virulence, population immunity, and host factors (Hubálek, 2001; Petersen and Marfin, 2002). Diagnosis relies on clinical assessment supported by serological and molecular testing (CDC, 2017).

Previous studies in Sudan indicate ongoing WNV activity. For instance, 44.4% of blood donors in Khartoum tested positive for WNV-IgG in 2016, while 2.2% had IgM antibodies, suggesting recent infection (Yasir et al., 2022). This study aims to evaluate WNV exposure in Gezira State and examine associations with demographic factors such as age, gender, marital status, and education level. Findings may improve diagnostic accuracy and inform public health interventions.

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2. Materials and Methods

2.1. Study Design and Population

This cross-sectional, laboratory-based study was conducted in eight localities of Gezira State, Sudan, from February to December 2022. Both symptomatic and asymptomatic individuals were included based on predefined inclusion and exclusion criteria.

2.2. Sample Collection and Processing

Venous blood (5 mL) was collected aseptically from each participant. Two mL were placed in EDTA tubes for plasma separation, and three mL were collected in plain tubes for serum. Plasma was obtained by centrifugation at 3000 rpm for 5 minutes, while serum was separated after allowing the blood to clot for 10 minutes followed by centrifugation. Samples were stored at –20°C until analysis.

2.3. Sample Size Determination

Using standard epidemiological formulas to achieve high confidence and minimal error, 384 participants per locality were targeted to ensure representative results.

2.4. Data Collection and Analysis

Structured questionnaires were used to collect demographic data, clinical symptoms, and potential risk factors. Data were analyzed using SPSS Version 22, with significance set at a 95% confidence interval.

2.5. Ethical Considerations

Ethical approval was obtained from the Faculty of Medical Laboratory Sciences, University of Gezira, and the Gezira State Ministry of Health. Written informed consent was obtained from all participants, and confidentiality was maintained.

2.6. Serological Testing (ELISA)

WNV-specific IgM and IgG antibodies were detected using a semi-quantitative ELISA kit (EUROIMMUN). The assay involved two steps

- **Antigen Binding:** Samples incubated in WNV antigen-coated wells formed antigen-antibody complexes if antibodies were present.
- **Detection:** An enzyme-labeled anti-human IgM/IgG conjugate produced a colorimetric signal measured as optical density (OD).

Results were expressed as a ratio of sample OD to calibrator OD

- Negative: <0.8
- Borderline: 0.8–1.1
- Positive: ≥1.1

3. Results

3.1. WNV Antibody Prevalence

Among 400 participants, 62.3% were WNV-IgG positive, indicating prior exposure, while 37.7% were negative. WNV-IgM antibodies were absent in 97% of participants, with only 3% showing borderline results (Table 1, Figure 1).

3.2. Participant Demographics

- Age: 1–19 years (34%), 20–39 years (47.3%), 40–59 years (16%), 60–80 years (2.8%)
- Gender: 62% male, 38% female
- Marital status: 54% single, 46% married
- Education: 48% illiterate, 36% high school, 11% university, 5% primary school

3.3. Demographic Associations with WNV Seropositivity

- **IgG Antibodies:** No significant association with age (P = 0.060) or gender (P = 0.117). Significant associations were found with education level (P < 0.001) and marital status (P < 0.001). Illiterate participants had higher negative IgG rates, while university graduates showed higher positivity. Single participants had higher IgG positivity than married participants.
- **IgM Antibodies:** No significant associations were observed with any demographic factors.

4. Discussion

This study demonstrates high WNV-IgG seroprevalence (62.3%) among Gezira State residents, suggesting widespread past exposure. The absence of IgM antibodies indicates minimal recent transmission during the study period, consistent with RT-PCR results showing no active infections.

Age distribution revealed the highest IgG positivity among 20–39-year-olds (43.4%), followed by 1–19-year-olds (39%). These results align with previous reports indicating higher WNV incidence among young adults and children (Yasir et al., 2022; WHO, 2021).

Gender did not influence seropositivity, whereas education and marital status were significantly associated with IgG prevalence. Illiterate individuals had lower IgG positivity, potentially reflecting reduced exposure or differences in health-seeking behavior. Comparison with prior studies indicates our findings are consistent with recent Sudanese data (Yasir et al., 2022), though slightly lower than pooled estimates for Africa (70.3%).

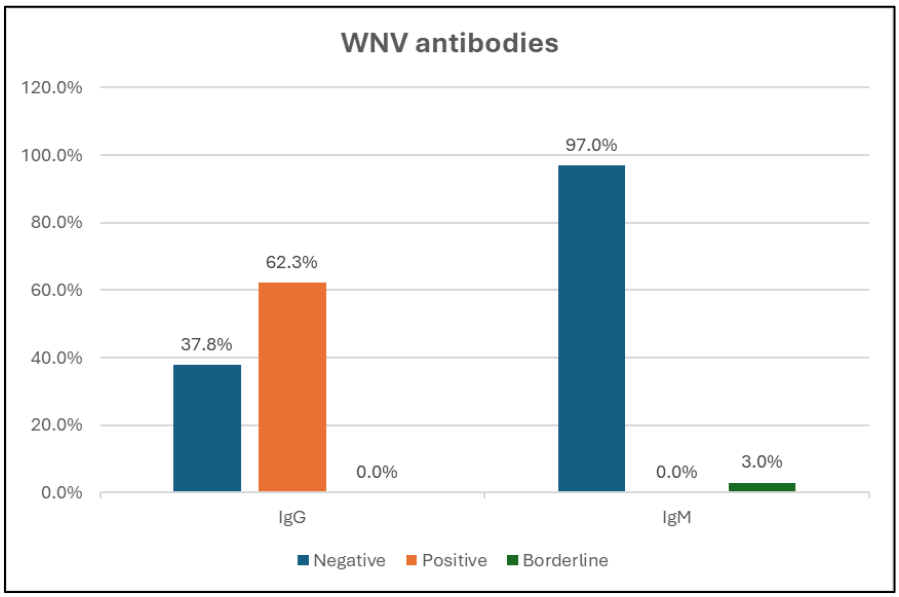

Figure 1 The characteristics and patterns of WNV IgG and IgM antibodies in the study population

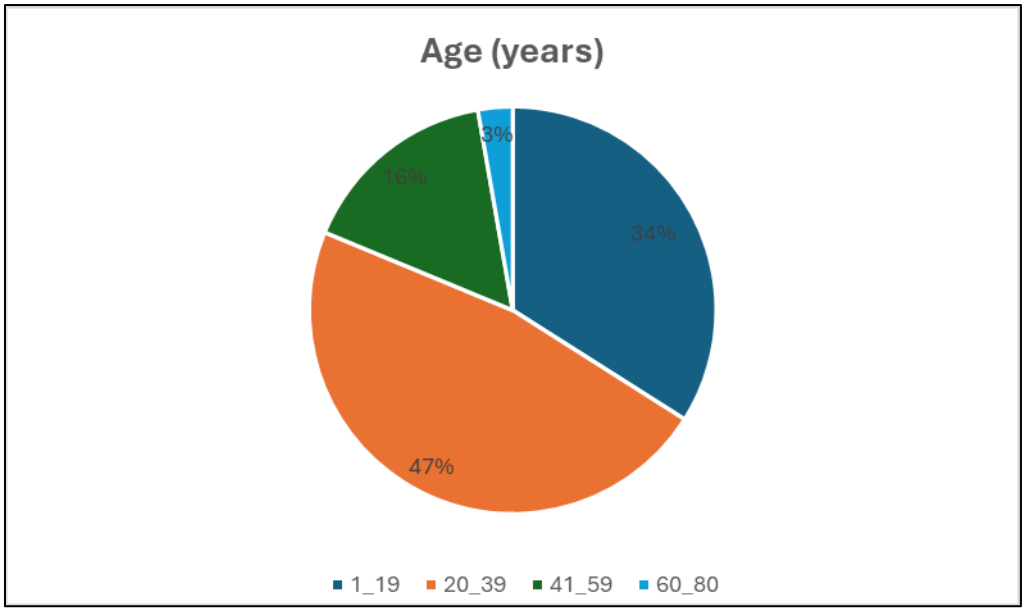

Figure 2 The age distribution within the study population

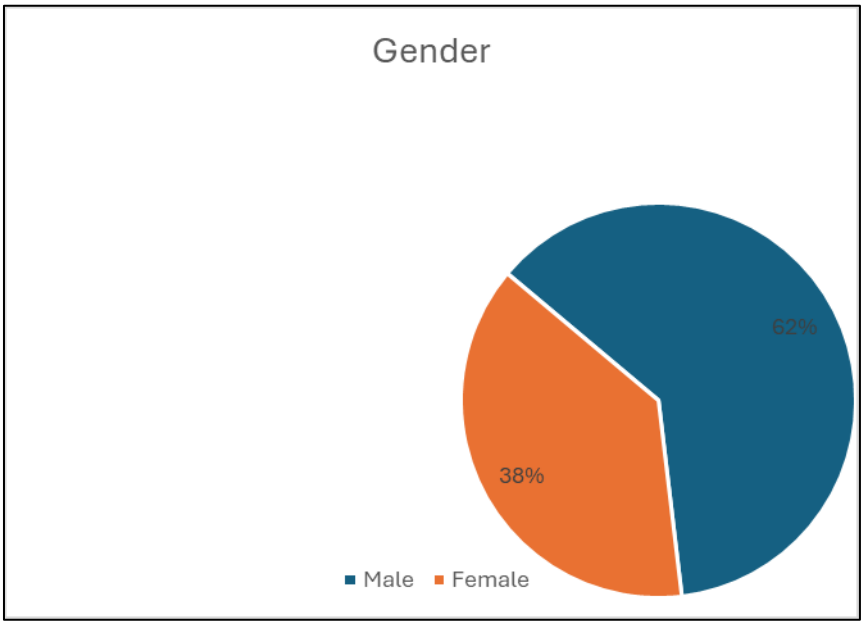

Figure 3 The distribution of genders in the study population

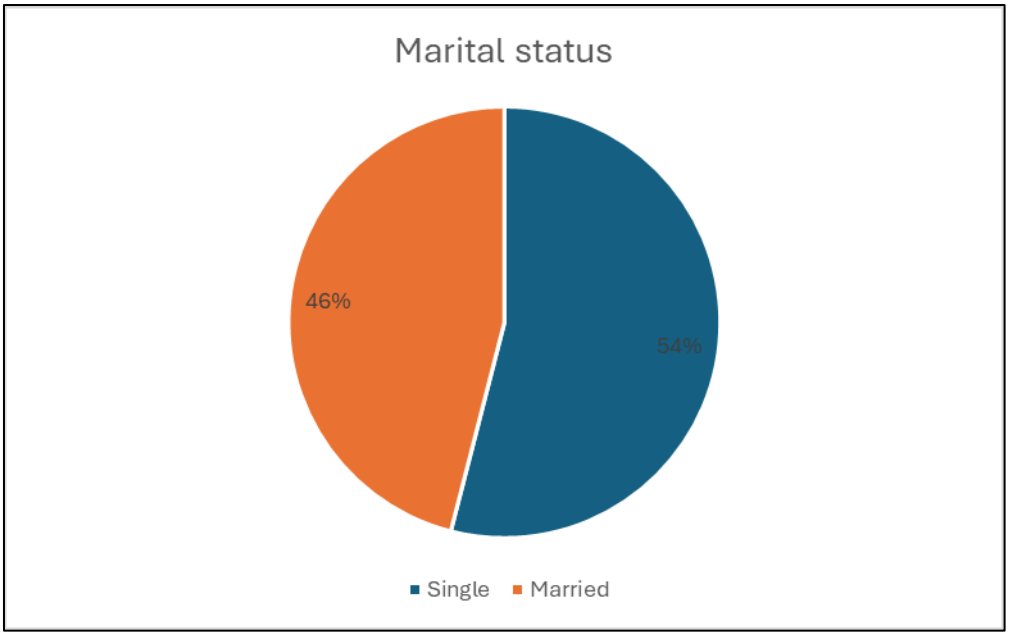

Figure 4 The marital status distribution among the study population

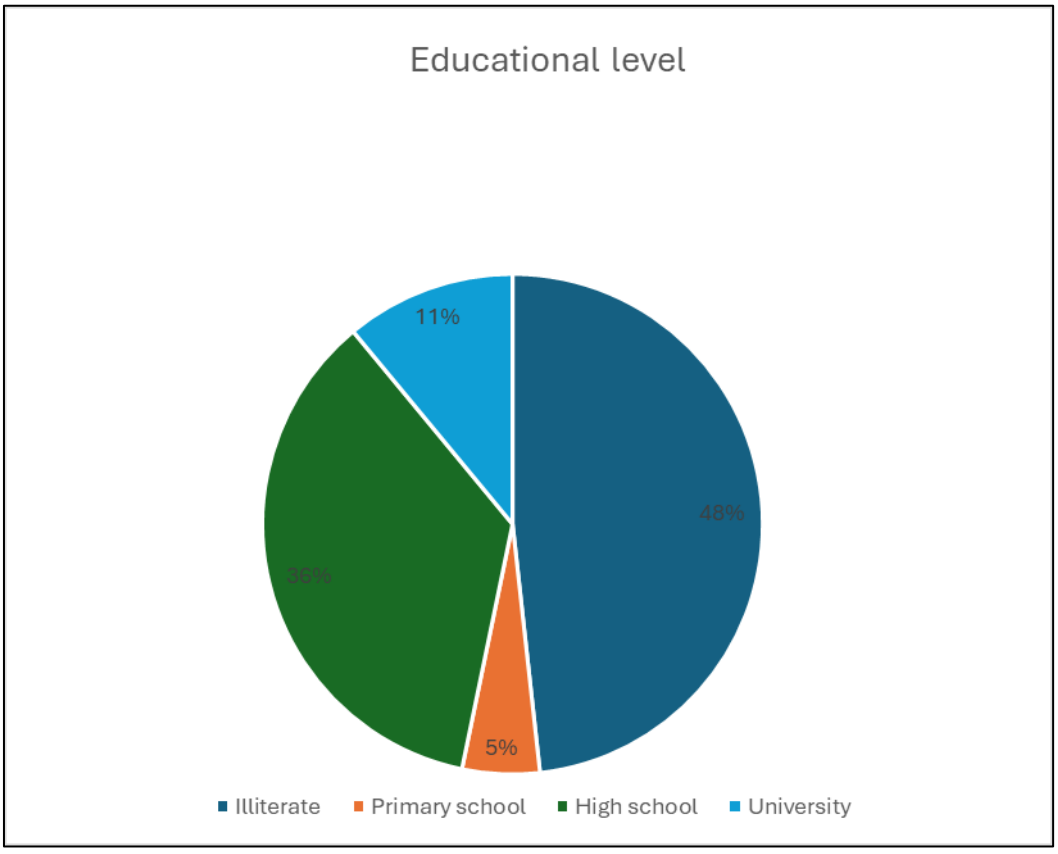

Figure 5 The educational attainment levels within the study population

Table 1 The characteristics and patterns of WNV IgG and IgM antibodies in the study population

WNV antibodies (n=400)		**Frequency**	**Percent**
IgG antibodies	Negative	151	37.7
	Positive	249	62.3
	Borderline	0	0.0
IgM antibodies	Negative	388	97.0
	Positive	0	0.0
	Borderline	12	3.0

Table 2 The correlation between WNV-IgG antibodies and population characteristics

Demographic Variables		**WNV-IgG antibodies**				**Chi-Square**	**P. value**
		Negative (n=151)		Positive (n=249)			
		n	%	N	%		
Age	1-19 (n=136)	39	25.8%	97	39.0%	7.408	0.060
	20-39 (n=189)	81	53.6%	108	43.4%		
	40-59 (n=64)	27	17.9%	37	14.9%		
	60-80 (n=11)	4	2.6%	7	2.8%		
Gender	Male (n=248)	101	66.9%	147	59.0%	2.459	0.117
	Female (n=152)	50	33.1%	102	41.0%		
Educational level	Illiterate (n=193)	96	63.6%	97	39.0%	23.352	<.001**
	Primary school (n=20)	4	2.6%	16	6.4%		
	High school (n=143)	40	26.5%	103	41.4%		
	University (n=44)	11	7.3%	33	13.3%		
Marital status	Single (n=216)	61	40.4%	155	62.2%	18.69[a]	<.001**
	Married (n=184)	90	59.6%	94	37.8%		

**. significant at the 0.01 level

Table 3 The correlation between WNV-IgM antibodies and population characteristics

Demographic Variables		**WNV-IgM antibodies**				**Chi-Square**	**P. value**
		Negative (n=388)		Borderline (n=12)			
		n	%	N	%		
Age	1-19 (n=136)	132	34.0%	4	33.3%	1.118	0.773
	20-39 (n=189)	182	46.9%	7	58.3%		
	40-59 (n=64)	63	16.2%	1	8.3%		
	60-80 (n=11)	11	2.8%	0	0.0%		
Gender	Male (n=248)	242	62.4%	6	50.0%	0.756	0.385
	Female (n=152)	146	37.6%	6	50.0%		

Educational level	Illiterate (n=193)	188	48.5%	5	41.7%	1.512	0.679
	Primary school (n=20)	20	5.2%	0	0.0%		
	High school (n=143)	137	35.3%	6	50.0%		
	University (n=44)	43	11.1%	1	8.3%		
Marital status	Single (n=216)	211	54.4%	5	41.7%	0.758	0.384
	Married (n=184)	177	45.6%	7	58.3%		

5. Conclusion

The study reveals substantial past exposure to WNV among Gezira State residents. Despite widespread seropositivity, recent active infections were not detected. These findings emphasize the need for enhanced WNV surveillance, vector control, and public health education to reduce the risk of future outbreaks.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Ethical approval attached.

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