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(RESEARCH ARTICLE)

West Nile Virus Exposure in Gezira State, Sudan: An ELISA-Based Study

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Abstract

West Nile Virus (WNV) is a mosquito-borne flavivirus responsible for West Nile fever. Although most infections are asymptomatic or mild, fewer than 1% progress to West Nile neuroinvasive disease (WNND), which has an estimated fatality rate of 10% (Petersen et al., 2013).

This cross-sectional study assessed WNV exposure among 400 residents of Gezira State, Sudan (2019–2022). Blood samples were collected and analyzed for WNV-specific IgG and IgM antibodies using ELISA, while RT-PCR was performed on IgG-positive samples to detect active viral RNA.

Overall, 62.3% (249/400) of participants were positive for WNV-IgG antibodies, indicating past exposure, whereas all samples were negative for WNV-IgM antibodies, suggesting the absence of recent infection. No significant correlations were observed between common risk factors and IgG positivity ($P > 0.05$), except for neck stiffness, which showed a significant association ($P < 0.05$).

The high prevalence of WNV-IgG antibodies, coupled with the absence of IgM positivity, highlights widespread prior exposure and a lack of current infection in the population. These findings underscore the need for sustained surveillance and public health initiatives focusing on mosquito control and community awareness to prevent future WNV outbreaks.

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

1. Introduction

West Nile Virus (WNV) is a globally distributed mosquito-borne flavivirus that primarily causes asymptomatic or mild infections, collectively termed West Nile fever (WNF). Severe neurological complications, including meningitis and encephalitis, occur in less than 1% of cases and are associated with a mortality rate of approximately 10% (Petersen et al., 2013).

The virus was first isolated in Uganda in 1937 (Smith burn et al., 1940) and later spread to North America in 1999 (CDC, 2017; WHO, 2011). Since then, outbreaks have been reported across Europe, Africa, Asia, Australia, and the Americas. In the United States, seasonal outbreaks typically peak in late summer (CDC, 2017). Approximately 80% of WNV infections are asymptomatic, 20% result in WNF, and fewer than 1% develop neuroinvasive disease characterized by neck stiffness, confusion, or seizures (Campbell et al., 2002; CDC, 2017).

Transmission occurs mainly through bites from infected Culex mosquitoes, which acquire WNV after feeding on viremic birds. Rare transmission routes include blood transfusion, organ transplantation, and vertical transmission from mother to child (WHO, 2011; CDC, 2019). Elderly individuals and those with comorbidities are at greater risk of severe outcomes.

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Historically, early epidemics were characterized by febrile illness with rash and lymphadenopathy (Marberg et al., 1956; Hayes, 1989), while more recent outbreaks in Romania (1996), Russia (1999), the United States (1999), and Israel (2000) have been dominated by neurological symptoms (Tsai et al., 1998; Platonov et al., 2001; Chowers et al., 2001).

Culex mosquitoes are abundant in Sudan, particularly in Gezira State, suggesting a potentially high WNV transmission risk. However, limited epidemiological data exist, as most previous studies have focused on specific populations such as blood donors (Ahmed et al., 2011). This study aimed to determine the seroprevalence of WNV antibodies and associated risk factors among residents of Gezira State using ELISA-based detection of IgM and IgG.

2. Materials and Methods

2.1. Study Design and Population

A cross-sectional, laboratory-based study was conducted in Gezira State, Sudan, between February and December 2022. Both symptomatic and asymptomatic individuals were recruited according to predefined inclusion and exclusion criteria.

2.2. Sample Collection and Processing

Five milliliters of venous blood were collected aseptically from each participant—2 mL in EDTA tubes (for plasma) and 3 mL in plain tubes (for serum). Plasma was separated immediately, while serum was obtained after clotting by centrifugation at 3000 rpm for 5 minutes. Samples were stored at −20°C until analysis.

2.3. Sample Size

A total of 400 participants were enrolled, exceeding the minimum calculated sample size of 384 to ensure representativeness.

2.4. Serological Testing

WNV-specific IgM and IgG antibodies were detected using EUROIMMUN ELISA kits following manufacturer instructions. Samples with a ratio ≥1.1 were considered positive, 0.8–1.1 borderline, and <0.8 negative.

2.5. Data Collection and Statistical Analysis

Demographic and clinical data were collected using structured questionnaires. Statistical analysis was performed with SPSS (version 22) using chi-square and logistic regression tests. A p-value <0.05 was considered statistically significant.

2.6. Ethical Considerations

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

3. Results

3.1. Seroprevalence of WNV

Among 400 participants, 62.3% (249) tested positive for WNV-IgG, while 37.8% (151) were negative. All samples were negative for WNV-IgM, although 12 yielded borderline results.

3.2. Symptomatology

Commonly reported symptoms included headache (16.3%), flu-like symptoms (13.8%), and fever (13.5%). Less frequent symptoms were vomiting (6.8%), rash (5.5%), and neck stiffness (2.5%).

3.3. Medical History

Most participants (95.3%) reported no chronic diseases, and 98.8% had no history of blood transfusion or organ transplantation.

3.4. Association Analyses

No significant associations were found between WNV-IgG positivity and most symptoms ($P > 0.05$), except for neck stiffness ($P = 0.005$). Logistic regression revealed significant associations between IgG positivity and gender (female, OR = 1.82), educational level (OR = 1.42), marital status (OR = 0.33), and neck stiffness (OR = 0.08).

4. Discussion

The high WNV-IgG seroprevalence (62.3%) observed in Gezira State indicates widespread past exposure, consistent with previous Sudanese studies reporting rates between 60% and 75% (Ahmed et al., 2011; Mohammed et al., 2019). The absence of IgM positivity confirms the lack of ongoing transmission during the study period.

No significant associations were detected between IgG positivity and most symptoms, which supports the typically asymptomatic course of WNV infection (Campbell et al., 2002). The observed correlation with neck stiffness aligns with reports linking neuroinvasive manifestations to prior exposure (Sejvar et al., 2003).

Environmental and ecological factors, including mosquito abundance and climatic conditions, likely play a major role in sustaining WNV circulation in Gezira State. Limited laboratory capacity and low public awareness further hinder early detection and control. Strengthening surveillance and incorporating WNV screening into blood donation programs are therefore critical (WHO, 2011; CDC, 2019).

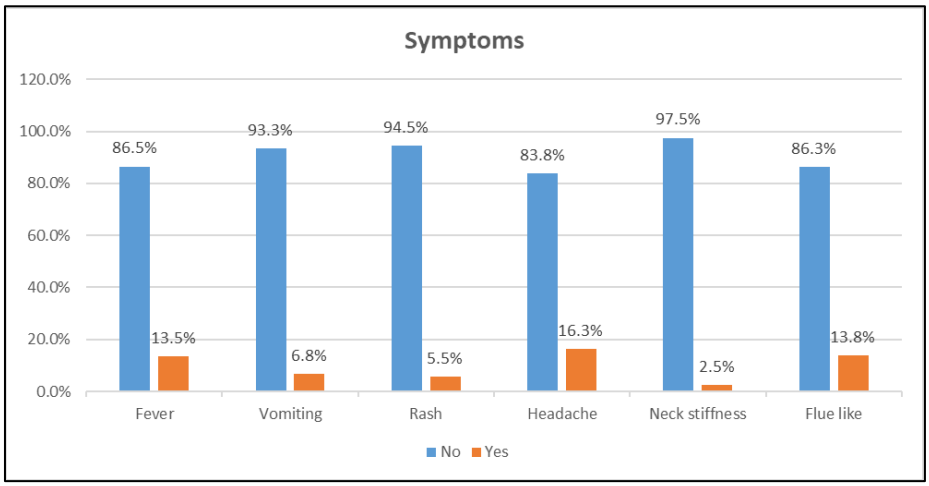

Figure 1 Symptoms distribution of the study population

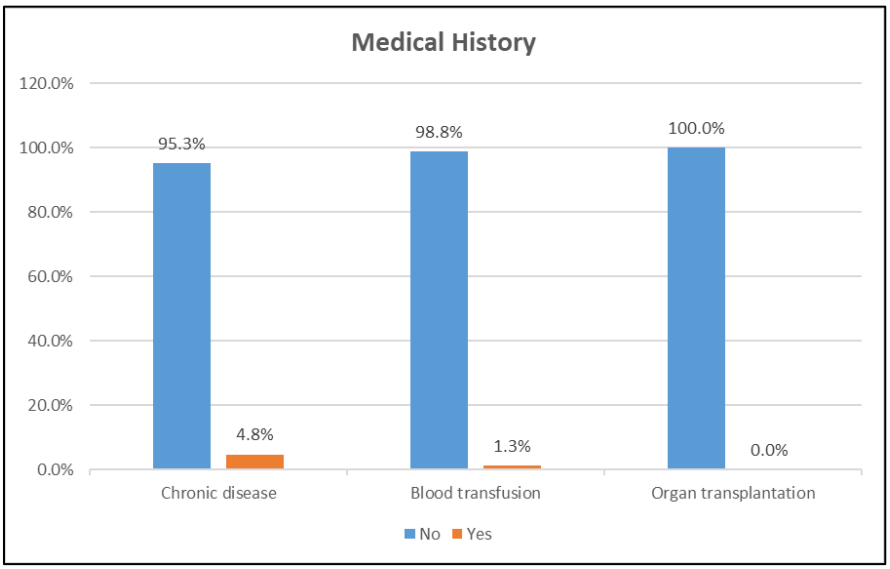

Figure 2 The medical background of the study population

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 distribution of symptoms among the study population

Symptoms (n=400)	**No**		**Yes**	
	Frequency	Percent	Frequency	Percent
Fever	346	86.5	54	13.5
Vomiting	373	93.3	27	6.8
Rash	378	94.5	22	5.5
Headache	335	83.8	65	16.3
Neck stiffness	390	97.5	10	2.5
Flue like	345	86.3	55	13.8

Table 3 The medical background of the study population

Medical History (n=400)	**No**		**Yes**	
	Frequency	Percent	Frequency	Percent
Chronic disease	381	95.3	19	4.8
Blood transfusion	395	98.8	5	1.3
Organ transplantation	400	100.0	0	0.0

Table 4 Correlation between WNV-IgG antibodies and clinical symptoms

		WNV-IgG antibodies				**Chi-Square**	**P. value**
		Negative (n=151)		**Positive (n=249)**			
		n	**%**	**N**	**%**		
Fever	No (n=346)	136	90.1%	210	84.3%	2.642	0.104
	Yes (n=54)	15	9.9%	39	15.7%		
Vomiting	No (n=373)	139	92.1%	234	94.0%	0.552	0.457
	Yes (n=27)	12	7.9%	15	6.0%		
Rash	No (n=378)	146	96.7%	232	93.2%	2.236	0.135

	Yes (n=22)	5	3.3%	17	6.8%		
Headache	No (n=335)	128	84.8%	207	83.1%	0.185	0.667
	Yes (n=65)	23	15.2%	42	16.9%		
Neck stiffness	No (n=390)	143	94.7%	247	99.2%	7.791	0.005*
	Yes (n=10)	8	5.3%	2	0.8%		
Flue like	No (n=345)	134	88.7%	211	84.7%	1.270	0.260
	Yes (n=55)	17	11.3%	38	15.3%		

*. significant at the 0.05 level

Table 5 Correlation between WNV-IgM antibodies and clinical symptoms

		WNV-IgM antibodies				**Chi-Square**	**P. value**
		Negative (n=388)		**Borderline (n=12)**			
		n	**%**	**n**	**%**		
Fever	No (n=346)	335	86.3%	11	91.7%	0.283	0.595
	Yes (n=54)	53	13.7%	1	8.3%		
Vomiting	No (n=373)	361	93.0%	12	100.0%	0.895	0.344
	Yes (n=27)	27	7.0%	0	0.0%		
Rash	No (n=378)	367	94.6%	11	91.7%	0.191	0.662
	Yes (n=22)	21	5.4%	1	8.3%		
Headache	No (n=335)	323	83.2%	12	100.0%	2.400	0.121
	Yes (n=65)	65	16.8%	0	0.0%		
Neck stiffness	No (n=390)	378	97.4%	12	100.0%	0.317	0.573
	Yes (n=10)	10	2.6%	0	0.0%		
Flue like	No (n=345)	334	86.1%	11	91.7%	0.306	0.580
	Yes (n=55)	54	13.9%	1	8.3%		

Table 6 Correlation between WNV-IgG antibodies and medical history

		WNV-IgG antibodies				**Chi-Square**	**P. value**
		Negative (n=151)		**Positive (n=249)**			
		n	**%**	**n**	**%**		
Chronic disease	No (n=381)	143	94.7%	238	95.6%	0.161	0.688
	Yes (n=19)	8	5.3%	11	4.4%		
Blood transfusion	No (n=395)	151	100.0%	244	98.0%	3.071	0.080
	Yes (n=5)	0	0.0%	5	2.0%		

Table 7 Correlation between WNV-IgM antibodies and medical history

		WNV-IgM antibodies				Chi-Square	P. value
		Negative (n=388)		Borderline (n=12)			
		n	%	n	%		
Chronic disease	No (n=381)	369	95.1%	12	100.0%	0.617	0.432
	Yes (n=19)	19	4.9%	0	0.0%		
Blood transfusion	No (n=395)	383	98.7%	12	100.0%	0.157	0.692
	Yes (n= 5)	5	1.3%	0	0.0%		

Table 8 Logistic regression analysis of factors associated with WNV-IgG seropositivity

Factors	P. value	Odds ratio	95% confidence interval	
			Lower	Upper
Fever	0.278	1.527	0.711	3.283
Vomiting	0.140	0.499	0.198	1.256
Rash	0.628	1.355	0.397	4.632
Headache	0.846	1.071	0.534	2.151
Neck stiffness	0.006*	0.082	0.014	0.486
Flue like	0.314	1.466	0.696	3.087
Chronic disease	0.365	1.818	0.499	6.630
Blood transfusion	0.999	0.000	0.000	.

*. significant at the 0.05 level

Table 9 Logistic regression analysis of factors associated with WNV-IgM seropositivity

Factors	P. value	Odds ratio	95% confidence interval	
			Lower	Upper
Fever	0.806	0.731	0.060	8.841
Vomiting	0.998	0.000	0.000	.
Rash	0.295	4.088	0.293	56.939
Headache	0.997	0.000	0.000	.
Neck stiffness	0.999	0.000	0.000	.
Flue like	0.960	0.939	0.084	10.498
Chronic disease	0.998	0.000	0.000	.
Blood transfusion	0.999	0.000	0.000	.

5. Conclusion

This study demonstrates a high prevalence of WNV-IgG antibodies among residents of Gezira State, reflecting extensive past exposure but no current infection. These findings highlight the urgent need for enhanced vector surveillance, mosquito control programs, and integration of WNV diagnostics into national health strategies. Increasing public and healthcare awareness is vital to reduce misdiagnosis and morbidity associated with WNV in Sudan.

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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