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Evolution of Dengue Serological Markers in 2023 among Patients Tested at Saint Camille Hospital, Ouagadougou, Burkina Faso

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Abstract

The 2023 dengue epidemic in Burkina Faso highlighted the severity of dengue fever as a major public health issue. This study aimed to determine the seroprevalence and evolution of dengue infection during 2023. The study involved 6474 suspected cases aged 0 to 98 years who attended general medicine consultations and were referred to the Saint Camille Hospital laboratory for serological diagnosis of dengue fever from January to December 2017. Using the Dengue Duo Bioline SD Kit (Standard Diagnostic Inc., Korea), the presence of NS1 antigen and IgM/IgG antibodies was detected in serum or plasma. The study population was predominantly female (57.3%, 3710/6474). An overall prevalence of 16.7% (1080/6474) for NS1Ag was observed, with 15.0% (556/3710) in females and 19.0% (524/2764) in males. Patients aged 16 - 25 years were significantly more affected, with 22.1% (321/1450) testing positive for NS1Ag and 5.7% (83/1450) for IgM, compared to children under 5 years, who showed 11.8% (83/703) positivity for NS1Ag and 2.6% (18/703) for IgM. IgG positivity was significantly more prevalent in the age group 41 - 60 years, with 17.0% (139/819) testing positive, compared to 5.8% (41/703) in children under 5 years. Triple-positive patients accounted for 0.4% (27/6474) of the study population, with males being twice as prevalent as females in this group. The peak of infections occurred between mid-October and mid-November, coinciding with the end of the rainy season in Burkina Faso. This study underscores the high seroprevalence of acute dengue virus infection in symptomatic patients. It highlights the need for effective vector control strategies, including the destruction of breeding sites, personal protection measures, and enhanced surveillance starting in August, to prevent future outbreaks of dengue fever in Burkina Faso.

Keywords

Seroprevalence, Dengue Fever, NS1 Antigen, IgM/IgG, Burkina Faso

1. Introduction

Dengue fever is a mosquito-borne viral disease that has emerged as a significant public health concern worldwide, particularly in tropical and subtropical regions [1]. According to the World Health Organization, about half of the world's population is now at risk of dengue, with an estimated 100 - 400 million infections occurring each year [1] [2]. The disease is caused by four distinct serotypes of the dengue virus (DENV-1 to DENV-4) with 65% genomic similarity, transmitted primarily by the Aedes aegypti mosquito [3]. Within each serotype of the dengue virus, there are multiple genotypes that are phylogenetically classified based on sequence variations in the envelope (E) gene. These genotypes include DENV-1 (Genotypes I to VI), DENV-2 (Genotypes Asia I, Asia II, Asia/America, America, Cosmopolitan, and Forest), DENV-3 (Genotype IV), DENV-4 (Genotypes Asian I, Asian II, Asian/American, American, Cosmopolitan, and Forest) [4].

The dengue virus genome consists of single-stranded RNA that encodes ten proteins: three structural proteins—membrane (M), envelope (E), and capsid (C)—which make up the virus's structural components, and seven non-structural proteins—NS1, NS2A, NS2B, NS3, NS4A, NS4B, and NS5—that are involved in RNA replication [5]. The increasing incidence of dengue is attributed to factors such as rapid urbanization, global travel, climate change, and inadequate vector control measures, which have facilitated the spread of the virus to new areas and populations [6]. In recent years, there has been a noticeable uptick in dengue outbreaks, both in frequency and severity, underscoring the need for comprehensive epidemiological data to inform public health strategies [1] [7]. Understanding the sociodemographic characteristics associated with dengue virus infection is crucial for identifying vulnerable groups, optimizing resource allocation, and tailoring intervention programs [8] [9].

Factors such as age, gender, and seasonal variations play a significant role in the transmission dynamics of the virus and can influence the effectiveness of control measures [7] [10] [11]. Despite the global burden of dengue, data on its seroprevalence and associated risk factors remain limited in many endemic regions. Dengue fever is a systemic infection with a broad spectrum of clinical presentations. While most cases are asymptomatic, clinical signs are not specific to any serotype [12]. Diagnosis relies on detecting the viral genome using RT-PCR within seven days of symptom onset or through serology from the fifth day. Additionally, the virus can be identified by detecting the NS1 antigen in the serum. Treatment is primarily symptomatic, including for severe forms such as hemorrhagic dengue or dengue shock syndrome [12] [13]. Serological markers, including NS1 antigen and dengue-specific IgM and IgG antibodies, are essential tools for diagnosing acute and past infections, assessing population immunity, and monitoring transmission trends [13]. Although most cases present with mild to moderate symptoms, approximately 5% of patients may develop severe disease. Studies have shown that triple positivity for NS1, IgM, and IgG is associated with severe dengue infection [12].

The first dengue epidemics in Africa were reported as early as the 19th century, with Burkina Faso experiencing its first outbreak in 1925 [9]. A second outbreak occurred between September and December 1982, with 30 cases reported in the country. Another significant outbreak was documented between October and November 2013, 2016, 2017 and 2023 [9] [14]. In Burkina Faso, all four dengue virus serotypes (DENV-1, DENV-2, DENV-3, and DENV-4) are present. Historically, DENV-1 has been the most frequently detected serotype in recent years [15]. However, during the 2023 outbreaks, DENV-3 emerged as the predominant serotype [14] [16].

Despite this shift in serotype prevalence, variations in seroprevalence related to demographic factors remain poorly documented, limiting the development of targeted prevention and control strategies. This study aims to bridge this knowledge gap by investigating the seroprevalence of dengue virus infection and its association with sociodemographic factors in a defined population. By analyzing data from individuals tested for dengue infection markers, we seek to determine the prevalence of NS1 antigen, IgM, and IgG antibodies among different gender and age groups, assess the temporal patterns of dengue infection throughout the year to identify peak transmission periods and explore the potential correlations between serological profiles and demographic characteristics to identify high-risk populations.

2. Material and Methods

2.1. Ethical Approval

This study was approved by the institutional ethics committee of Saint Camille Hospital of Ouagadougou (HOSCO) N˚ 2022-21/12-09 of 21 December 2022, ensuring ethical compliance in the use of patient data.

2.2. Type, Period and Area of Study

A descriptive analytical study was conducted to assess the seroprevalence and progression of dengue virus infection among patients at HOSCO, from January to December 2023. Ouagadougou has a tropical savanna climate characterized by a long dry season (October to May) and a rainy season (June to September), with average annual temperatures around 28˚C and marked variations in humidity. These climatic conditions, particularly the rainy season, favor the proliferation of

Aedes mosquitoes, the main vectors of dengue, and thus contribute to seasonal peaks in infection.

2.3. The Study Population

The study included 6474 patients of various ages and sexes who attended general medical consultations and were referred to the hospital's laboratory for dengue serological testing during the study period. Patients were eligible if they presented with clinical suspicion of dengue fever and were referred by a physician for serological confirmation. Individuals whose medical records were incomplete were excluded from the study. The individuals included were considered representative of the broader population of Ouagadougou, as HOSCO receives patients from all districts of the city as well as from surrounding areas.

2.4. Sample Collection

Venous blood samples were collected in dry tubes or EDTA tubes. After centrifuging at 4000 rpm for 5 minutes, serum or plasma was extracted and used for dengue testing. Serological tests were performed immediately after sample collection to ensure rapid availability of results.

2.5. Dengue Diagnosis

Dengue virus infection was diagnosed using the SD Bioline Dengue Duo Rapid Detection Kit (Standard Diagnostics Inc., Korea), following the manufacturer's protocol. This test detects nonstructural protein 1 (NS1) antigen and anti-dengue virus IgG/IgM antibodies in serum, plasma, or whole blood.

2.6. Statistical Analysis

Data were recorded in Microsoft Excel 2019 and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0 software (SPSS Inc., Chicago, IL, USA). Multivariate logistic regression was employed to examine the effects of age and gender on dengue infection. Statistical differences were considered significant at $p < 0.05$.3.

3. Results

3.1. Sociodemographic Characteristics

Define The study population consisted of 57.3% females (3710/6474) and 42.7% males (2764/6474). Patient ages ranged from 0 to 98 years, with a mean age of 27.14 years and a median of 26.0 ± 18.12 years. The most represented age group was 25 - 40 years, accounting for 31.4% (2034/6474) of the study population (Table 1).

3.2. Seroprevalence of Dengue Virus Infection

In the study population, 28.2% (1826/6474) of the subjects tested positive for at least one of the three serological markers of dengue infection. The prevalence of

Table 1. Sociodemographic characteristics and dengue seroprevalence.

Characteristics	Serological markers			
	Total	NS1 Ag^+	IgM^+	IgG^+
Gender	N (%)	n (%)	n (%)	n (%)
Female	3710 (57.3%)	556 (15.0%)	127 (3.4%)	424 (11.4%)
Male	2764 (42.7%)	524 (19.0%)	137 (5.0%)	334 (12.1%)
Total	6474 (100.0%)	1080 (16.7%)	264 (4.1%)	758 (11.7%)
Age group				
<5 years	703 (10.9%)	83 (11.8%)	18 (2.6%)	41 (5.8%)
5 - 15	1083 (16.7%)	182 (16.8%)	44 (4.1%)	115 (10.6%)
16 - 25	1450 (22.4%)	**321 (22.1%)**	**83 (5.7%)**	161 (11.1%)
25 - 40	2034 (31.4%)	332 (16.3%)	78 (3.8%)	242 (11.9%)
41 - 60	819 (12.7%)	120 (14.7%)	29 (3.5%)	**139 (17.0%)**
>60 years	385 (5.9%)	42 (10.9%)	12 (3.1%)	60 (15.6%)

NS1: Non-structural Protein 1, Immunoglobulin M (IgM), Immunoglobulin G (IgG).

dengue NS1 Ag was 16.7% (1080/6474), with a frequency of 15.0% (556/3710) in females compared to 19.0% (524/2764) in males ($p < 0.001$, OR = 0.754, 95% CI = [0.661 - 0.859]). The seroprevalence of IgM and IgG was 4.1% (264/6474) and 11.7% (758/6474) in the study population, respectively (**Table 1**). Multinomial logistic regression also revealed a sex difference in IgM positivity, with a prevalence of 5.0% in males compared to 3.4% in females ($p = 0.02$, OR = 0.680, 95% CI = [0.531 - 0.870]).

The age group 16 - 25 years showed the highest positivity rates for NS1 Ag (22.1%, 321/1450) and IgM (5.7%, 83/1450) compared to the <5-year age group ($p < 0.001$, OR = 2.124, 95% CI = [1.637 - 2.756] and $p = 0.02$, OR = 2.311, 95% CI = [1.377 - 3.878], respectively). The age group 41 - 60 years had the highest positivity rate for IgG (17.0%, 139/819) (**Table 2**). Individuals double positive for NS1 Ag/IgM and NS1 Ag/IgG represented 0.9% (56/6474) and 1.4% (92/6474) of the study population, respectively, while IgM^+/IgG^+ accounted for 1.1% (74/6474) (**Table 3**). Triple-positive patients accounted for 0.4% (27/6474) of the study population, with males being twice as numerous as females among this group (**Figure 1**).

Table 2. Multinomial logistic regression analysis of NS1 antigen and IgM frequencies in the study population.

Characteristics	NS1 Ag^+			IgM^+		
Gender	OR	CI 95%	p-value	OR	CI 95%	p-value
Female	0.754	[0.661 - 0.859]	**<0.001**	0.680	[0.531 - 0.870]	**0.002**
Male	Ref.	-	-	Ref.	-	-
Total						

Continued

Age group						
<5 years	Ref.	-	-	Ref.	-	-
5 - 15	1.509	[1.142 - 1.995]	**0.04**	1.612	[0.924 - 2.812]	0.093
16 - 25	2.124	[1.637 - 2.756]	**<0.001**	2.311	[1.377 - 3.878]	**0.02**
25 - 40	1.457	[1.126 - 1.885]	**0.04**	1.518	[0.902 - 2.552]	0.116
41 - 60	1.282	[0.950 - 1.731]	0.104	1.397	[0.769 - 2.538]	0.272
>60 years	0.915	[0.617 - 1.356]	0.657	1.224	[0.583 - 2.569]	0.593

NS1: Non-structural Protein 1, Immunoglobulin M (IgM), Immunoglobulin G (IgG).

Table 3. Serological profile of dengue virus infection in the study population.

Variables N = 6474			IgG		
		IgM	Negative	Positive	Total
NS1 Ag	Negative	Negative	4648 (71.8%)	565 (8.7%)	5213 (80.5%)
		Positive	107 (1.7%)	74 (1.1%)	181 (2.8%)
		Total	4755 (73.5%)	639 (9.9%)	5394 (83.3%)
	Positive	Negative	905 (14,0%)	92 (1.4%)	997 (15.4%)
		Positive	56 (0.9%)	27 (0.4%)	83 (1.3%)
		Total	961 (14,8%)	119 (1,8%)	1080 (16.7%)

NS1: Non-structural Protein 1, Immunoglobulin M (IgM), Immunoglobulin G (IgG).

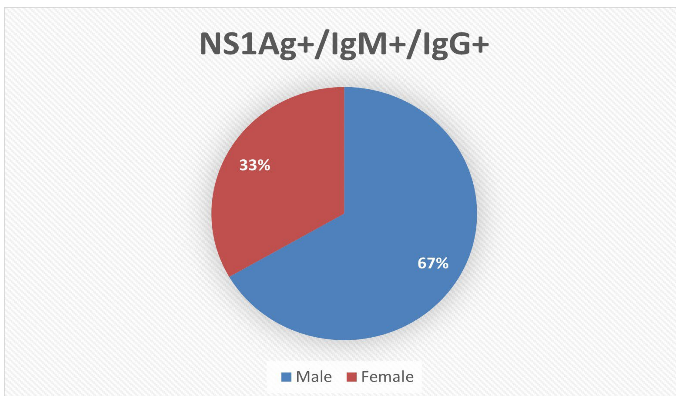

Figure 1. Sex-based distribution of triple-positive patients for NS1 Ag, IgM, and IgG.

3.3. Evolution of Dengue Virus Infection

No positive cases for dengue infection serological markers were recorded among the 241 individuals tested from January to March, representing 2.5% of the study population. In April, only 0.7% (2/270) of the cases tested positive for NS1Ag. The number of suspected cases tested in October accounted for 35.4% (2290/6474) of the study population, with a positivity rate of 24.8% (567/2290) for NS1 Ag. Overall, 78.4% of the study population was tested for dengue virus infection between September and November, with the peak of infections observed in October (**Figure 2**)

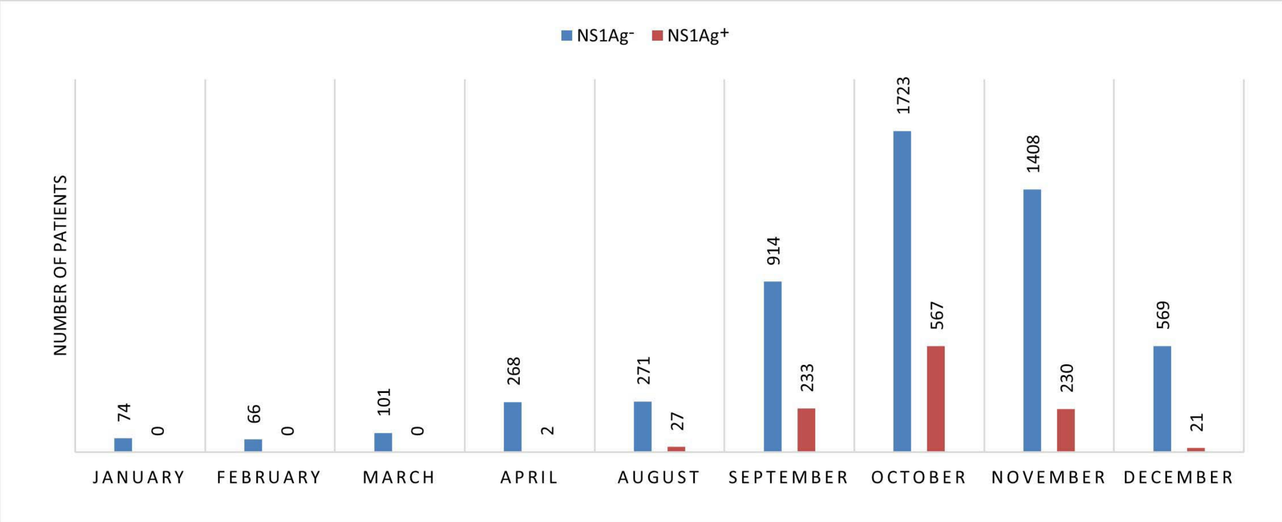

Figure 2. Evolution of dengue infection in the year 2023.

4. Discussion

This study provides a comprehensive analysis of the seroprevalence and epidemiological characteristics of dengue virus infection within the examined population. The findings reveal significant insights into the gender and age dynamics of dengue infection, as well as the temporal patterns of disease prevalence. The overall prevalence of 16.7% (1080/6474) for DENV NS1Ag observed in the present study is consistent with findings from previous studies conducted in Ouagadougou [16]-[18].

4.1. Gender Differences in Dengue Seroprevalence

Females were predominant in our study population, consistent with previous studies conducted in the same setting [15] [17]-[20]. A key observation from the data is the higher prevalence of dengue infection markers among males compared to females. Specifically, males exhibited higher positivity rates for NS1 antigen and IgM antibodies compared to females. Multinomial logistic regression analysis confirmed that females had significantly lower odds of being NS1 Ag^+ and IgM^+ than males. A similar trend was observed in previous studies, where men were significantly more likely to be infected with dengue virus (NS1 Ag^+) than women [17]-[19]. These gender disparities may be attributed to behavioral and occupational factors. Males might be more engaged in outdoor activities or occupations that increase exposure to mosquito vectors [21]. Similar patterns have been documented in other regions where cultural and social roles lead to differing exposure risks between genders [22]. However, it is important to acknowledge that other potential confounding factors such as socioeconomic status, access to healthcare, and pre-existing health conditions were not fully assessed in this study. Including such variables in future analyses would help to better isolate the independent effect of gender and other demographic characteristics on dengue infection risk. Understanding these differences is crucial for tailoring public health interventions that address specific risk factors associated with male populations.

4.2. Age-Related Trends in Infection Rates

The age group of 16 - 25 years demonstrated the highest positivity rates for both NS1 antigen and IgM antibodies. Compared to the reference group (<5 years), individuals in this age bracket had significantly higher odds of recent infection (NS1 Ag^+/IgM^+). Previous studies in Burkina Faso have found a higher prevalence of DENV infection among individuals aged 20 - 29 years [19] and 15 - 30 years [17] compared to children under five years. This heightened risk could be due to increased mobility, social interactions, and occupational exposures that are common in late adolescence and early adulthood. Conversely, the highest IgG positivity was observed in the 41 - 60 years age group (17.0%), indicating a greater accumulation of past exposure and potential immunity in older individuals. This pattern suggests that long-term exposure over the lifespan contributes to seroconversion and the development of protective antibodies [23].

4.3. Temporal Patterns and Seasonal Peaks

The temporal distribution of dengue cases highlights a pronounced seasonal trend. No positive cases were detected from January to March, and only minimal positivity was observed in April. A sharp increase in both testing and positivity rates occurred between September and November, with the peak in October. Specifically, 35.4% of the study population was tested in October, with a positivity rate of 24.8% for NS1 antigen. Previous studies reported that the peak of DENV infection in Burkina Faso generally occurred between October and November [17]-[19]. This seasonality aligns with environmental conditions favorable for mosquito breeding, such as increased rainfall and humidity during certain months [7]-[9]. The clustering of cases during this period underscores the need for seasonal preparedness in dengue surveillance and control efforts [10]. Public health strategies should intensify vector control measures and community awareness campaigns ahead of peak transmission seasons.

4.4. Serological Profiles and Co-Infections

The study also examined the distribution of serological markers and their combinations. Individuals positive for both NS1 antigen and IgM antibodies represented 0.9% of the population, indicating acute infection with active viral replication and an immune response. Those positive for NS1 antigen and IgG antibodies (1.4%) suggest a recent infection in individuals with prior exposure. Triple-positive individuals (0.4%) were more prevalent among males, further emphasizing the gender disparity in infection rates. Previous studies have shown that men face a higher risk of death from severe dengue compared to women [24] [25]. Triple positivity was found to be predictive of severe thrombocytopenia due to dengue infection and was associated with a higher risk of mortality [12].

While the study provides valuable insights, several limitations should be acknowledged. First, selection bias may be present, as the data were derived from individuals who sought testing, which may not represent the general population. Those tested might have had symptoms or concerns prompting testing, potentially leading to overestimation of prevalence rates. Second, the cross-sectional design of the study limits the ability to infer causality or temporal changes at the individual level. Longitudinal studies would be necessary to track infection progression and immunity development. Third, serological tests can cross-react with other flaviviruses, potentially affecting specificity. Moreover, NS1 antigen levels decline after the early phase of infection, which could result in underestimation of acute cases if testing is delayed. Finally, although the study reports the seroprevalence of different markers, data on clinical outcomes (e.g., hospitalization rates, severe dengue cases, or mortality) were not collected. Including such information in future studies would enhance the clinical relevance of the findings and provide a more comprehensive picture of the dengue burden.

This study nevertheless reveals a substantial burden of dengue virus infection within the population, with distinct gender- and age-related patterns. The higher seroprevalence among males and young adults points to specific groups at increased risk, necessitating targeted public health interventions. The seasonal peak in October emphasizes the influence of environmental factors on transmission dynamics and the critical timing for preventive measures. Future research should aim to include broader population samples, integrate clinical outcome data, and employ longitudinal designs to enhance understanding of dengue epidemiology. Incorporating climatic data and vector surveillance could further improve predictive models and guide effective control strategies. Collaborative efforts between health authorities, communities, and researchers are essential to reduce the impact of dengue and protect vulnerable populations.

5. Public health and policy implications

The findings of this study underscore the substantial burden of dengue in Ouagadougou and highlight important demographic disparities, with higher seroprevalence observed among males and young adults. These results have several implications for public health interventions and policy. First, vector control strategies should be intensified during the rainy season, particularly in October when cases peak, by targeting mosquito breeding sites through community-based clean-up campaigns, larviciding, and improved waste and water management. Second, the higher infection rates among males suggest that workplace and occupational health interventions may be warranted, especially for men engaged in outdoor labor, such as construction or agriculture. Providing protective measures such as repellents, education on personal protection, and targeted awareness campaigns could reduce exposure in these groups.

Additionally, integrating routine dengue surveillance into existing healthcare services would improve early detection and outbreak preparedness. Strengthening laboratory diagnostic capacity, particularly at the primary care level, could reduce delays in identifying acute infections. Policymakers should also consider incorporating dengue education programs into schools and community health activities to improve awareness of symptoms, prevention measures, and the importance of timely care-seeking.

Finally, the observed seasonal and demographic patterns suggest that predictive models combining seroprevalence, climatic variables, and vector surveillance could help anticipate outbreaks and guide resource allocation. Public health authorities should foster collaboration between meteorological services, entomologists, and healthcare providers to build such models.

Author Contribution

conceptualization, A.K.O and J.S.; methodology, A.K.O, D.P.I., O.D., A.T.Y., and A.K.YA.; software, A.K.O., D.P.I and O.D.; validation, D.P.I., O.D. and J.S.; formal analysis, A.K.O, D.P.I. and O.D.; investigation, A.K.O, D.P.I. and O.D.; resources, A.T.Y., A.K.YA and J.S.; data curation, A.K.O, D.P.I., O.D. and J.S; writing—original draft preparation, A.K.O, D.P.I. and O.D.; writing—review and editing, A.K.O, D.P.I., O.D., A.T.Y., A.K.YA. and J.S.; visualization, D.P.I., O.D., and J.S.; supervision, J.S.; project administration, J.S.; funding acquisition, this research received no external funding.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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