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Seroepidemiology of Dengue Fever and the Associated Sociodemographic, Clinical, and Environmental Factors in Lahore, Pakistan

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A B S T R A C T

Dengue fever constitutes a major public health threat that predominantly affects warm-climate regions. The disease poses a threat due to its rapid transmission and potential for severe complications. In Pakistan, dengue outbreaks have become increasingly frequent, necessitating comprehensive studies to understand their epidemiological patterns. This study aimed to examine the Seroepidemiological profile of dengue fever in Lahore, Pakistan, focusing on the association between sociodemographic, clinical, and environmental factors among patients. A cross-sectional study was conducted at the Social Security Teaching Hospital, Lahore, from June to November 2024. A total of 225 suspected or confirmed dengue patients were enrolled through convenience sampling. Sociodemographic, clinical, and environmental data was collected using a structured questionnaire. Five milliliters of venous blood were drawn aseptically and tested for dengue-specific IgM and IgG antibodies using ELISA (Panbio, Australia). The overall dengue seroprevalence was 55.6%, with 36% testing positive for IgM, 23.2% for IgG, and 40.8% for both. Male gender (AOR = 2.83; 95% CI: 1.41–5.67), age 21–30 years (AOR = 19.56; 95% CI: 3.26–117.33), and secondary education (AOR = 0.263; 95% CI: 0.014–4.81) were significantly associated with seropositivity. Middle-income status (AOR = 0.01; 95% CI: 0.002–0.08) showed a protective effect. Fever (AOR = 4.00; 95% CI: 1.76–9.08) and joint pain (AOR = 2.08; 95% CI: 1.05–4.14) were significant clinical predictors. Environmental risk factors included mosquito presence (AOR = 4.19; 95% CI: 2.37–7.40), irregular water supply (AOR = 9.78; 95% CI: 2.00–47.7), and absence of sewage network (AOR = 0.098; 95% CI: 0.018–0.539). The findings underscore significant associations among male gender, young adult age, secondary education, and dengue seropositivity, while middle-income status appeared protective. These insights support targeted awareness and prevention strategies tailored to demographic and socioeconomic contexts.

Keywords: Dengue Fever, Seroprevalence, Risk Factors.

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INTRODUCTION

Dengue fever (DF) is a deadly, emerging and re-emerging viral disease, caused by the dengue virus (DENV), which is a positive-sense, single-stranded, non-segmented RNA virus of the genus Flavivirus and is transmitted primarily by Aedes aegypti and Aedes albopictus mosquitoes (Zohra et

al, 2024). Humans serve as the primary carriers of the virus and act as the amplifying host, while non-human primates significantly contribute to the sylvatic cycle (Elduma et al, 2020). DENV is classified into four antigenically distinct serotypes: DENV-1, DENV-2, DENV-3, and DENV-4 (Khattak et al, 2023). Primary infection with a specific serotype grants enduring immunity against that respective serotype. Conversely, secondary infection with the heterologous serotype might lead to more severe complications of the disease, such as Dengue Hemorrhagic Fever (DHF) or Dengue Shock Syndrome (DSS), via a process referred to as antibody-dependent enhancement (ADE) (Iqbal et al, 2023).

The World Health Organization (WHO) in 2023 recorded a substantial increase in the global incidence of DF over recent decades, with an estimated 100-400 million cases of active infection reported annually. Of these, around 96 million dengue infections result in clinical manifestation, putting 3.9 billion world's population at risk (WHO, 2024). Pakistan is endemic for DF, with frequent outbreaks leading to high morbidity and mortality rates (Venjhraj et al, 2024). The country's first outbreak was documented in Karachi in 1994, with 4,500 confirmed cases (Umair et al, 2023).[7] The National Institutes of Health (2023) reported 52,929 dengue cases and 224 deaths in 2021, followed by a surge to approximately 79,007 confirmed cases and 149 deaths in 2022 (NIH, 2023). Dengue infections vary from asymptomatic to mild or severe. It is categorized by the abrupt onset of flu-like symptoms, including pyrexia, muscle pain, headache, skin rashes, and mild mucosal bleeding (Namirimu et al, 2024). Factors contributing to the incidence of dengue, such as rapid population expansion and urban development, particularly in tropical cities with inadequate sanitation and water systems, as well as insufficient vector control, (Doum et al, 2020), (Mukhtar et al, 2021)' which led to the prolific increase in the domestic and peri-domestic mosquito species that transmit the DENV (Grange et al, 2014). Additionally, socioeconomic, demographic, and infrastructure characteristics are increasingly recognized as important determinants of local dengue risk (Doum et al, 2020).

There is a lack of demographic-based epidemiological data, which is essential for directing mitigation methods against the disease as well as optimizing resources to combat the transmission of the virus and its vector effectively (Bhatt et al, 2013). Therefore, a comprehensive study was designed to assess the seroepidemiology of dengue and to identify key risk factors to support targeted interventions, improve resource allocation, and strengthen public health strategies.

METHODS

A cross-sectional study was conducted at the Social Security Teaching Hospital, Lahore, from June to November 2024. A total of 225 participants were selected using a non-probability convenience sampling technique to recruit suspected or confirmed dengue patients of both genders. Ethical approval was obtained from the Institutional Review Board (IRB) of Superior University, Lahore, and written informed consent was obtained from all participants. Confidentiality and anonymity were strictly maintained under ethical guidelines for research involving human subjects.

Data was collected through a questionnaire-based interview or a self-administered questionnaire at the time of blood sampling. A trained phlebotomist aseptically collected 5 ml of venous blood, which was centrifuged to separate serum, and stored at 2–8°C or frozen at –20°C until testing. Dengue-specific IgM and IgG antibodies were identified using sensitive ELISA kits (Panbio, Australia), following the manufacturer's instructions. The collected data was entered and analyzed with IBM SPSS, version 27. The seroprevalence of dengue was calculated as the proportion (95% CI) of participants testing positive for IgM and IgG. Associations between dengue seroprevalence and study factors were evaluated using Fisher's exact test, with odds ratios (ORs) and 95% confidence intervals reported relative to the category exhibiting the lowest seroprevalence. Multivariable binary logistic regression was performed to identify independent predictors, incorporating all demographic, socioeconomic, and environmental factors found significant in univariate analyses. Statistical significance was determined at a p-value <0.05.

RESULTS

Dengue Seroprevalence

The overall seroprevalence of dengue antibodies was 55.6% in the study population. Among these, 36.0% (n = 45) had IgM antibodies, 23.2% (n = 29) had IgG, and 40.8% (n = 51) tested positive for both (Figure 1).

Factors Associated with Dengue Seroprevalence

In the univariate analysis, gender, age group, education level, socioeconomic status, and type of residence were significantly associated with dengue seroprevalence. Clinical symptoms such as fever, headache, ocular pain, joint pain, and vomiting were also significantly linked with seropositivity, while skin rash was not. Environmental factors, including irregular water supply, lack of sewage networks, absence of pest control, and presence of

mosquitoes, were significantly associated with increased risk (Tables 1, 2, 3).

Factors Predicting Positive Dengue Serology

On multivariate logistic regression, males had significantly higher odds of dengue seropositivity than females (AOR 15.12; 95% CI: 3.33–68.59; *P* < .001). Participants aged 21–30 (AOR 19.56; 95% CI: 3.26–117.33; *P* = .001) and 31–50 years (AOR 6.27; 95% CI: 0.97–40.17; *P* = .053) had increased odds compared to those aged ≤20 years, while those >51 had lower odds (AOR 0.11; 95% CI: 0.01–0.76; *P* = .025). Those with primary (AOR 11.85; 95% CI: 1.27–110.51; *P* = .030) and secondary education (AOR 15.49; 95% CI: 2.77–86.35; *P* = .002) had higher odds than those with higher education. Middle socioeconomic status was protective (AOR 0.01; 95% CI: 0.002–0.08; *P* < .001), while low status showed no significant association. Type of residence showed no significant link. Fever was strongly associated (AOR 20.24; 95% CI: 3.62–131.09; *P* < .001), while headache and joint pain were not. Irregular water supply (AOR 52.01; 95% CI: 2.43–1109.23; *P* = .011) and absence of sewage system (AOR 435.71; 95% CI: 22.55–8415.51; *P* < .001) were significantly associated. The presence of mosquitoes at home increased odds but was not statistically significant (Table 4).

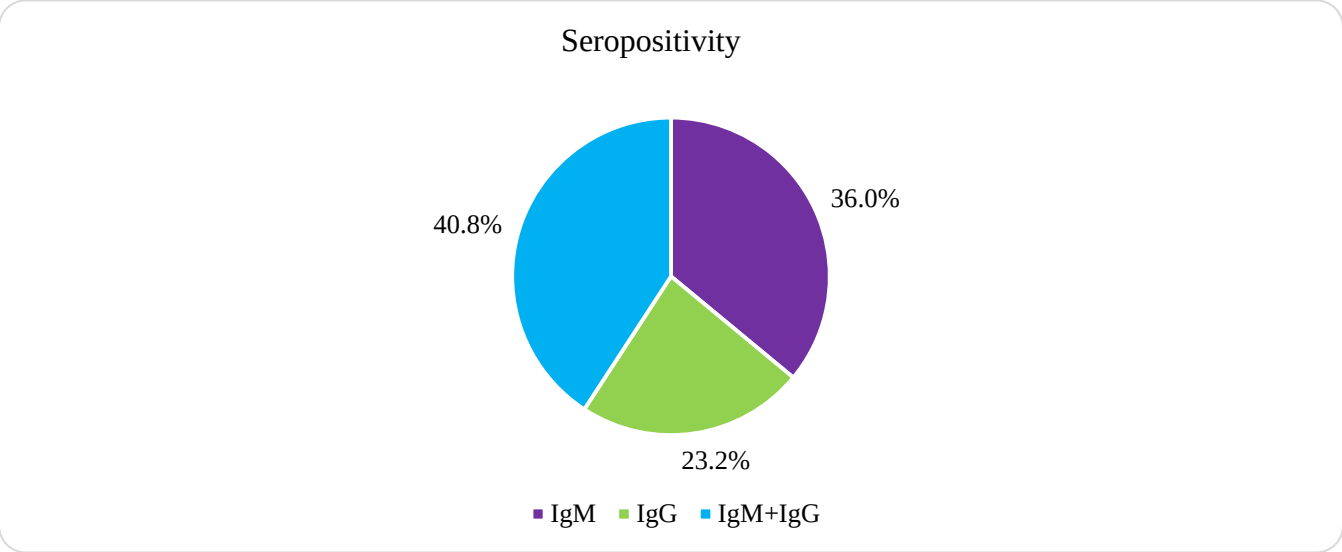

Figure 1: Distribution of Dengue Seropositivity among Participants with overall seroprevalence (55.6%).

Table 1: Sociodemographic Factors Associated with Dengue Seroprevalence.

Sociodemographic Factors	Category	OR (95%Cl)	p-value
Gender	Male	2.28(1.29,4.03)	.004
	Female	*Ref*	
Age groups (years)	<20	*Ref*	.002
	21 – 30	3.21(1.54,6.72)	
	31 – 40	1.37(0.59,3.20)	
	>41	0.55(0.26,1.17)	
Education level	Primary education	2.13(1.14,3.99)	<.001
	Secondary education	5.44(2.61,11.34)	
	Higher education	*Ref*	
Socioeconomic status	Low	2.97(1.47,5.99)	.002
	Middle	0.67(0.32,1.39)	
	Upper	*Ref*	
Residency type	House with lawn	*Ref*	.019
	House without a lawn	1.02(0.51,2.01)	
	Row house	2.14(1.13,4.04)	

*OR: Odds Ratio; CI: Confidence Interval; ref: reference category; p < .05 considered statistically significant.

Table 2: Clinical Factors Associated with Dengue Seroprevalence.

Clinical Factors	Category	OR (95%Cl)	p-value
Fever	Yes	3.03(1.75,5.25)	<.001
	No	*Ref*	
Headache	Yes	2.70(1.57,4.65)	<.001
	No	*Ref*	
Ocular pain	Yes	0.49(0.28,0.87)	.015
	No	*Ref*	
Joint pain	Yes	2.78(1.61,4.80)	<.001
	No	*Ref*	
Vomiting	Yes	2.30(1.33,3.98)	.003
	No	*Ref*	
Skin Rash	Yes	1.25(0.72,2.16)	.422
	No	*Ref*	

*OR: Odds Ratio; CI: Confidence Interval; ref: reference category; p < .05 considered statistically significant.

Table 3: Environmental Factors Associated with Dengue Seroprevalence.

Environmental Factors	Category	OR (95%Cl)	p-value
Water interruption	Regular	2.06(1.06,3.98)	0.03
	Irregular	*Ref*	
Sewage Network (sanitation)	Present	2.33(1.35,3.99)	.002
	Absent	*Ref*	
Pest control Works	Yes	6.19(3.45,11.09)	<.001
	No	*Ref*	
Presence of mosquitoes at home	Yes	4.19(2.37,7.40)	<.001
	No	*Ref*	

*OR: Odds Ratio; CI: Confidence Interval; ref: reference category; p < .05 considered statistically significant.

Table 4: Factors predicting positive serology in the overall research population.

Sociodemographic Factors	Category	OR	(95%Cl)	p-value
Gender	Male	15.12	(3.33,68.59)	<.001
	Female	*Ref*	-	-
Age groups (years)	≤20	*Ref*	-	-
	21 – 30	19.56	(3.26,117.33)	.001
	31 – 50	6.27	(0.97,40.17)	.053
	>51	0.11	(0.01,0.76)	.025
Education level	Primary education	11.85	(1.27,110.51)	.030
	Secondary education	15.49	(2.77,86.35)	.002
	Higher education	*Ref*	-	-
Socioeconomic status	Low	1.01	(0.18,5.72)	.984
	Middle	0.01	(0.002,0.08)	<.001
	Upper	*Ref*	-	-
Residency type	House with lawn	*Ref*	-	-
	House without a lawn	0.23	(0.02,2.60)	.236
	Row house	0.11	(0.01,1.44)	.095
Fever	Yes	20.24	(3.62,131.09)	<.001
	No	*Ref*	-	-
Headache	Yes	1.98	(0.39,10.04)	.409

	No	*Ref*	-	
Joint pain	Yes	0.13	(0.01,1.07)	.058
	No	*Ref*	-	-
Water interruption	Regular	52.01	(2.43,1109.23)	.011
	Irregular	*Ref*	-	-
Sewage Network (sanitation)	Present	435.71	(22.55,8415.51)	<.001
	Absent	*Ref*	-	-
Presence of mosquitoes at home	Yes	3.79	(0.78,18.37)	.097
	No	*Ref*	-	-

*OR: Odds Ratio; CI: Confidence Interval; ref: reference category; p < .05 considered statistically significant.

DISCUSSION

The objective of this research was to investigate the seroepidemiology of dengue fever in Lahore, Pakistan, focusing on identifying the sociodemographic, clinical, and environmental factors associated with the disease. Dengue is a mosquito-transmitted viral disease affecting an estimated 100 to 400 million people worldwide each year (Khan et al 2008). The overall adjusted prevalence of 55.6% (n = 125) was observed for dengue-specific IgM and IgG antibodies. Anti-DENV IgM was positive in 20.0% (n = 45), indicating recent primary infection. Typically, IgM becomes detectable within five days post-infection, peaking around 14 days, and can persist for up to three months. IgG was positive in 15.1% (n = 34), suggesting past secondary infection. Our seroprevalence is lower than reported by Mahmood K et al (Bhatt et al, 2013), in Lahore (IgM: 48.66%, IgG: 39.5%) but higher than (Khaskheli et al, 2010) in Hyderabad, Sindh (IgM: 16.47%, IgG: 12.35%). These differences could reflect variation in study populations, methodologies, or shifts in transmission patterns over time.

The likelihood of seropositivity was significantly higher in males (OR: 15.12; 95% CI: [3.33, 68.59]; p = <.001), consistent with Ahmad et al, 2018; however, this contradicts with research conducted in South America by (Anker et al, 2011). The higher male infection rate may stem from greater outdoor exposure, while females may be less exposed due to modest clothing and staying indoors. Further studies should explore these gender disparities to guide targeted interventions Khan et al, 2022). This study also found that the age group 21–30 had the highest infection risk (OR: 19.56; 95% CI: [3.26, 117.33]; p = .001), consistent with (Zahra et al, 2024), in Pakistan. Younger adults may have more exposure to mosquito habitats due to increased outdoor activity, academic or work-related travel, and greater participation in social or recreational gatherings, often during peak mosquito activity hours. Those with a secondary education level showed increased odds of dengue fever (OR: 15.49; 95% CI: [2.77, 86.35]; p = .002). This finding aligns with Abdullah et al (Luqman et al, 2013), in Yemen, though it contrasts with Khan J. in Khyber Pakhtunkhwa. Individuals with secondary education may face higher dengue risk due to greater exposure in urban areas with poor sanitation and dense mosquito breeding sites (Abdullah et al, 2020).

Our study found that individuals from the middle socioeconomic class had significantly lower odds of dengue seropositivity compared to those from the upper class (AOR = 0.01; 95% CI: 0.002–0.08; p < .001). This finding may appear unexpected, as higher income is often assumed to be protective. However, (Wijayanti et al, 2016), highlighted that in urbanized areas, individuals with better jobs and higher socioeconomic status may face an increased risk of dengue infection due to environmental and lifestyle factors. Clinically, fever (OR: 20.24; 95% CI: [3.62, 131.09]; p < .001) was significantly associated with dengue seropositivity in our study. This finding is consistent with previous research by (Low et al, 2006), which also reported fever as one of the common clinical manifestations of dengue, although they observed associations with other symptoms as well. In our data, other symptoms such as headache and joint pain were not statistically significant.

This variation may be due to differences in sample size, population immunity, or the timing of symptom reporting. Key environmental predictors in our study included irregular water supply (AOR: 52.01; 95% CI: [2.43, 1109.23]; p = .011), absence of a sewage network (AOR: 435.71; 95% CI: [22.55, 8415.51]; p < .001), and presence of mosquitoes at home (AOR: 3.79; 95% CI: [0.78, 18.37]; p = .097), although the latter was not statistically significant. These findings are in line with (Jamjoom et al, 2016), who also reported strong links between poor sanitation and dengue incidence. However, unlike their study, which lacked multivariate analysis, our research provides evidence of independent environmental risk factors, strengthening the case for targeted interventions such as improved water

management and sanitation infrastructure.

CONCLUSION

In conclusion, this study highlights the seroepidemiology of dengue fever and predictors related to seropositivity in Lahore. A seroprevalence of 55.6% was observed, with 36% of participants with IgM antibodies, 23.2% exhibiting IgG antibodies, and 40.8% of participants showing both antibodies. Demographic risk factors included male gender, age group 21–30 years, and secondary education, while middle-income participants had significantly lower risk than the upper class. Clinically, fever and joint pain were notable predictors. Environmental risk predictors included mosquito presence at home, irregular water supply, and lack of sewage network. These findings highlight the necessity for targeted public health interventions focused on awareness, vector control, and improved living conditions to reduce dengue transmission.

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