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Original Research Article

AN IN-DEPTH ANALYSIS OF DENGUE MOSQUITO DYNAMICS IN LAHORE: UNRAVELING THE IMPACT OF DENGUE OUTBREAKS AND ENVIRONMENTAL FACTORS

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Abstract *Dengue fever, caused by the Aedes mosquito-borne dengue virus, is still a major public health concern in many parts of the world, including Lahore, Pakistan. Lahore region is regarded as a dengue fever hotspot due to the large number of cases reported each year. The purpose of this research is to give an in-depth analysis of dengue mosquito dynamics in Lahore, with a particular emphasis on determining the influence of dengue epidemics and environmental factors. The current study was based on survey comprising 240 individuals from Lahore. In the study findings, 82.08% were positive cases and 17.91% were negative cases. The majority of respondents, were aware of the symptoms of dengue infection (62.33%), its transmission (90.83%), the cause of dengue (61%), safety precautions (73.33%), and the organ infected by the dengue virus (66.25). However, the majority of people are still clueless. 70% of participants indicate that television is their primary information source. Dengue fever cases have been found to have a seasonal pattern, peaking during the monsoon season (45.41%) when mosquito breeding conditions are perfect. The study's findings revealed that Aedes mosquitos, particularly Aedes aegypti, were widespread and identified as the primary vectors (61.66%) of dengue transmission in Lahore. It was revealed that temperature (49.58%), and rainfall all affected the number of Aedes mosquitoes. Overall, 81.6% were satisfied with Governmental efforts against the spread of dengue fever. Improved public knowledge is necessary to reduce dengue virus incidence. The findings of this study can assist public health professionals and legislators in developing targeted measures to mitigate the consequences of dengue epidemics and protect the public from this terrible infection.*

Keywords*:* *Dengue; Mosquito dynamics; Dengue outbreak; Environmental factors; Analysis*

Introduction

Dengue fever is a viral illness disseminated by *Aedes* mosquitos (Wilder-Smith et al., 2019). Each viral serotype (DENV-1, DENV-2, DENV-3, DENV-4) results in a variety of clinical symptoms ranging from mild flu-like symptoms marked by high fever, excruciating headache, aching joints and muscles, rash, and, occasionally, dengue hemorrhagic fever (DHF) or dengue shock syndrome (Guzman and Harris 2015; Bhatt et al., 2013). It has a substantial global healthcare impact (World Health Organization, 2021). Dengue fever is found primarily in the tropics and subtropics, with approximately 3 billion people living in *Aedes*-infested areas, record more than 50 million cases of malaria, making it the most common vector-originated viral disease in humans (Burke et al., 1988; Kraemer et al., 2015). The annual frequency of dengue infections is estimated to be over 400 million (Beatty et al., 2011). Asia accounts for 75% of the dengue disorder burden, followed by Latin America, the United States, and Africa (Bhatt et al., 2013). The first dengue fever outbreak was noted in Pakistan in 1994. The most recent major outbreak resulted in 48,906 cases overall, comprising 183 fatalities, from four provinces in Pakistan between 1 January and 25 November 2021. As of November 25, the province of Punjab had the most cases, accounting for 49.4% of all cases and 69.4% of all deaths, with 24,146 cases and 127 deaths (CFR: 0.5%). Most of the deaths were recorded in the Lahore district (WHO, 2021). Lahore, Pakistan's second-largest city, has had recurring dengue outbreaks due to its geographic location, the weather, growing urbanisation, and financial factors that encourage *Aedes* mosquito growth and transmission (Malik, 2012). In Lahore, seasonal outbreaks occur during the monsoon and post-monsoon seasons, when mosquito activity is at its peak, potentially leading to epidemics (Qureshi et al., 2017; Ahmed et al., 2019). As a result, dengue poses a significant health risk to the community's medical services and individuals. The principal dengue vector, *Aedes*

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aegypti, is a daytime insect capable of biting multiple humans in a short period and has successfully adapted to human settings which increases its effectiveness at spreading the dengue virus (Agha et al., 2019; Nazir et al., 2020). Various environmental conditions for example temperature, rainfall, humidity, land use patterns, water storage techniques, and socioeconomic circumstances influence mosquito development, reproduction rates, and activity patterns (Chowdhury et al., 2016; Zahouli et al., 2017; Nazir et al., 2020). As a result, weather has a significant impact on how long vector-borne illness outbreaks last (WHO, 2009). Global warming encourages the geographic spread of *Aedes* mosquitos, raising the potential for dengue epidemics in temperate areas (Rocklov et al., 2016). Population expansion, rural-to-city immigration, a lack of reliable water supply via pipes, chaotic and underfunded mosquito control programmes and infected tourists are the primary causes of its spread and rising dengue incidence (Wilder-Smith, 2010). Controlling *Ae. aegypti*, which is a very widespread pest worldwide, is essential to preventing dengue (Wilder-Smith et al., 2019). By avoiding its bite and removing its breeding grounds, such as water sources, wine cans, tin cans, and abandoned tyres, we can control its infestation (Barreto, 2008). The use of insecticides and pesticides is particularly helpful when there is a virus outbreak, but the widespread use of these substances has serious downsides, such as insect resistance. (Luz, 2011). Increasing breeding sites as a result of changes in mosquito habitats and behavior brought on by rapid industrialization and climate change are some of the primary causes of the current management issues. Additionally, there is a lack of finance, a supply and equipment shortage, and inaccurate knowledge regarding the distinction between the mosquito vectors *Ae. Aegypti* and *Ae. Albopictus*. Without community cooperation, maintaining mosquito control becomes difficult. Timely and precise monitoring of mosquito populations and disease transmission is crucial for successful control measures. Research on vaccines and innovative vector control methods requires significant expenditure (Horstick, 2015). With an emphasis on determining the effects of dengue outbreaks and other environmental conditions, this study intends to undertake a thorough investigation of dengue mosquito dynamics in Lahore. Long-term prevention is heavily reliant on community engagement and health education (Kay, 2005). For community development, integrating local knowledge with contemporary scientific methodologies can result in more efficient and contextually relevant solutions (Smith et al., 2020).

Methodology

Area of Study

The primary Lahore district 31.5497° N, 74.3436° E is the location of the study. As the capital of the Punjab province and the largest city in Punjab in terms of population, it boasts the most diverse type of community where we can find people from a variety of backgrounds and perspectives. After briefly explaining the study's objectives, participants were verbally questioned about their desire to participate, with the results recorded on a questionnaire. Verbal consent was used to ensure anonymity and accommodate illiterate study subjects.

Study Design

According to the criteria outlined in (Armien et al., 2008), a questionnaire with closed-ended questions was created. Following the completion of the questionnaire, some of the respondents completed their forms on their own, while others did so during in-person interviews. Five sections make up the questionnaire: Socio-Demographic characteristics, Knowledge of Dengue Fever and Mosquitoes, Knowledge about Transmission and breeding, Knowledge of Environmental Factors and Knowledge of Dengue Treatment and Prevention.

Data Management

Each participant's survey data was collected and entered into an Excel spreadsheet (MS Office 2019) file. The file was twice verified and compared to the questionnaire surveys to reduce the chance of an error. All the collected data were analyzed by descriptive statistics using the software SPSS v16.0.

Results and Discussion

The current survey aims to assess the knowledge of people living in different areas of Lahore, Punjab, Pakistan. While there is no assurance that all answers in such surveys would precisely represent their real behaviour in practice, this study can provide vital insights into how people perceive and approach their actions (Matthews, 2008).

Demographic Profile of Survey Respondents

In this present study, 240 people from Lahore, Punjab, were interviewed. 35% were females, while 65% were males (Table 1). The majority of responders (39.16%) were between the ages of 20-30, with 19.58% between the ages of 31-40. The analyzed population's educational characteristics found that the majority of respondents were graduates, with 7.08% having no schooling. Professionals, housewives, and students comprised 40.83, 25.41, and 17.5% of the assessed population, respectively, while 16.30% were classified as others, including shopkeepers, entrepreneurs, students, and senior citizens who could not work for a living. These demographic characteristics such as (age, gender, and education level) play important roles in survey responses (Sauer et al., 2011).

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Table 1 Demographic Profile of Survey Respondents

Characteristics	Categories	Total n (%)
Gender		
	Male	156 (65)
	Female	84 (35)
Age		
	<20	63 (26)
	20-30	94 (39.16)
	31-40	47 (19.58)
	41-50	21 (8.75)
	>50	15 (6.25)
Education		
	Matric	23 (9.58)
	Intermediate	39 (16.25)
	Graduation	102 (42.5)
	Post-Graduation	59 (24.58)
	No Education	17 (7.08)
Profession		
	Student	42 (17.5)
	Teacher	27 (11.25)
	Housewife	61 (25.41)
	Professional	98 (40.83)
	Other	12 (5)

Knowledge of Dengue Fever and Mosquitoes

Knowledge of the respondents regarding dengue fever and mosquitoes is shown in (Table 2). The study revealed that 82% of the participants—reported seeing mosquitoes in their surroundings and 18% have not come into contact with mosquitoes. The majority of persons were able to distinguish between the mosquito species(61%). Approximately 44% of the sample agreed that dawn and dusk were the times of day when mosquitoes were most active. Nearly three-quarters (38%) of the participants, concurred that nighttime is when mosquitoes are most active. 5% of the sample, were of the smaller percentage that thought mosquitoes could bite at any time. 54.58% of respondents reported that they knew that it was a viral sickness in the largest amount of cases. 9.58% consider dengue only a disease. They didn't know the causal agent. 62% of the sample, agreed that dengue is a harmful sickness. 32 % selected Asia as dengue outbreak hotspots. Approximately 70% of respondents indicate that television is their primary information source. 62.33% of individuals are aware of the first sign of dengue fever, headache (Zhang et al., 2014), with only a small percentage being unaware of it. The largest number was roughly 66.25 percent of individuals in favour of the dengue virus attacking the liver.

Table 2 Knowledge of Dengue Fever and Mosquitoes

Characteristics	Categories	Total n (%)
Did you know what dengue is?		
	A disease	23 (9.58)
	A virus	131 (54.58)
	A mosquito	67 (27.91)
	A fungus	8 (3.33)
	A bacteria	11 (4.58)
Have you ever seen a dengue mosquito?		
	Yes	197 (82.08)
	No	43 (17.91)
Major outbreak in which region?		
	Asia	77 (32.08)

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	Europe	35 (14.58)
	America	48 (20)
	Africa	70 (29.1)
What is the source of information on dengue?		
	TV	168 (70)
	Magazine	21 (8.75)
	Friends	3 (1.25)
	Social media	42 (17.5)
	Posters	6 (2.5)
Did you know about the dengue-causing mosquito species?		
	Aedes aegypti/ Aedes albopictus	148 (61.66)
	Culex pipiens	19 (7.91)
	Anopheles	24 (10)
	Don't know	49 (20.41)
When do mosquito bites most often?		
	Yes	46 (19.16)
	No	157 (65.41)
	Don't know	37 (15.41)
When do mosquito bites most often?		
	Dawn and Dusk	106 (44.16)
	Morning	31 (12.91)
	Night	92 (38.33)
	Anytime	11 (4.58)
What are the symptoms of Dengue		
	Fever	45 (17.75)
	Muscle/joint /bone pain	23 (9.58)
	Nose, gum bleeding	17 (7.08)
	Headache	152 (62.33)
	Low platelets	3 (1.25)
Which organ is affected by dengue		
	Kidney	8 (3.33)
	Stomach	22 (9.16)
	Nose	19 (7.91)
	Liver	159 (66.25)
	Heart	32 (13.33)

Knowledge about Transmission and breeding

Knowledge of the respondents regarding transmission and breeding of mosquitoes is shown in (Table 3). According to findings from a study, 90.83% chose mosquitoes which was the subject of a popular perception among people concerning its transmission (Kularatne, 2015). Following that, 5.41% chose houseflies or 1.66% chose bugs. 71.66% of respondents strongly disagreed with such an assertion that the dengue mosquito serves as the necessary vector for the dengue virus to move from one person to another. 70.41% of people chose stagnant water (Nelson, 1986) and 58% chose garbage, making it the group with the second-highest percentage (24.16%) in the study. The survey's findings make it obvious that a significant number of respondents identified places with water, such as water containers and pools with standing water, with 33.8% and 26.7% respectively. Several participants identified specific containers like bird water pots and water in flower pots as suitable hatching places at 11.25% and 4.16%. In my survey monsoon season had 45.41%, which had the greatest percentage of respondents overall. The results revealed that it is important for communities to know the breeding habitats, biting mode or time and control measures to minimize the chances of vector-human contact (Singh et al., 2006).

Table 3 Knowledge about Transmission and breeding

Characteristics	Categories	Total n (%)
How dengue is transmitted?		
	Mosquito	218 (90.83)

	Housefly	13 (5.41)
	Bugs	4 (1.66)
	Cockroaches	2 (0.83)
	Ants	3 (1.25)
Can it be transferred from person to person?		
	Yes	41 (17.08)
	No	172 (71.66)
	Don't know	27 (11.25)
What are the breeding places for mosquitoes?		
	Stagnant water	169 (70.41)
	Garbage	58 (24.16)
	Rotten fruits	3 (1.25)
	Vegetables	2 (0.83)
What is the breeding place for mosquitoes in your house?		
	Old tyre	58 (22.91)
	Water Containers without lid	81 (33.75)
	Stagnant water in pools and containers	64 (26.66)
	Bird water pot	27 (11.25)
	Water in flower pots	10 (4.16)
What is the peak time of the population?		
	Winter	29 (12.08)
	Summer	68 (28.33)
	Monsoon	109 (45.41)
	All of them	26 (10.83)

Knowledge of Environmental Factors

The purpose of the survey was to assess participants' understanding of the environmental factors that contribute to dengue outbreaks (Table 4). According to the results, a significant number of participants (41.2%) selected temperature and humidity as the main environmental elements that influence dengue outbreaks. These elements are known to affect mosquito reproduction and survival, which helps spread dengue. Furthermore, 19.7% of the respondents acknowledged that rain as well as other elements could have a role in dengue outbreaks. The majority of responders (76.4%) agreed that the main cause of dengue outbreaks is undoubtedly the escalation of environmental conditions brought on by climate change. 16.4% of participants said they were doubtful or had no idea whether climate change has a substantial impact on dengue outbreaks.

Table 4 Knowledge of Environmental Factors

Characteristics	Categories	Total n (%)
What are the environmental factors involved in dengue eruption?		
	Rainfall	57 (23.75)
	Favourable temperature And Humidity	119 (49.58)
	Light	36 (15)
Do you think the increase in environmental factors due to climate change is the main factor of eruption?		
	Yes	191 (79.58)
	No	33 (13.75)
	Don't know	16 (6.66)

Knowledge of Dengue Treatment and Prevention

Increasing knowledge of the available diagnostic techniques will help in the early detection and timely care of dengue cases, ultimately improving health outcomes and disease control (Table 5). 37.5% of participants correctly identified that a blood test can confirm the presence of dengue. Additionally, ELISA was cited as a dengue diagnostic test by 28.75% of the respondents. Additionally, PCR was mentioned as a test to confirm dengue by 23.75% of the individuals. 73.3% indicated that they take all of the recommended preventive measures for dengue. 9.2% cited personal hygiene practices, 7.1%

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recommended covering water containers, and 5.4% highlighted the usage of mosquito repellent to fight off mosquitoes. 83.6% acknowledged honestly that dengue is an illness that can be treated. According to the survey results, the majority of participants (78.3%) seek medical care via visiting a doctor for dengue therapy. 16.3% of the respondents admitted to using home treatments and 5.4% of the participants said they use a "watch for some days" strategy to manage dengue. A significant number of participants (52.5%) turn to drinking fresh juices as a form of self-medication when they have dengue fever. 13.3% admitted to taking Paracetamol, 19.6% stated to consume a lot of water while suffering from dengue and 15% reported utilising net repellents as a kind of self-medication for dengue. In the survey research, when participants were questioned about the best technique to prevent dengue, a large percentage of participants (58.8%) said that killing the mosquitoes that serve as the disease's vector was the most effective strategy. 25.8%, selected "Medicine" as their answer and 10.8% chose Insecticides as a component of vector management strategies since they specifically target the *Aedes* mosquitoes that transmit dengue. The vast majority of respondents (82.5%) thought pesticide spray worked well to keep dengue mosquitoes in check (Van Den Berg et al., 2012).

Table 5 Knowledge of Dengue Treatment and Prevention

Characteristics	Categories	Total n (%)
By which test dengue can be confirmed?		
	PCR	57 (23.75)
	ELISA	69 (28.75)
	Blood test	90 (37.5)
	Don’t know	24 (10)
The spread of dengue can be prevented by?		
	Personal preventive practices	22 (9.16)
	Coverage of water containers	17 (7.08)
	Wearing long-sleeved clothing	13 (5.41)
	Mosquito repellent	12 (5)
	All	176 (73.33)
Is dengue a treatable disease?		
	Yes	201 (83.75)
	No	24 (10)
	Don’t know	15 (6.25)
For the treatment of dengue what you do?		
	Concern with doctor	188 (78.33)
	Use home remedy	39 (16.25)
	Watch for some days	13 (5.41)
What self-medication you had done in case of dengue?		
	Take a Paracetamol	32 (13.33)
	Drink a lot of water	47 (19.58)
	Intake of fresh juices	126 (52.5)
	Net repellents	36 (15)
What is the best way to control dengue?		
	Vector	141 (58.75)
	Medicine	62 (25.83)
	Insecticide	26 (10.83)
	Don’t know	11 (4.58)
Does insecticide spray control Dengue mosquito?		
	Yes	193 (80.41)
	No	41 (17.08)
	Don’t know	6 (2.5)

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Lack of knowledge about the disease and its vectors is an obstacle to adopting preventive measures and seeking early treatment (Khan et al., 2013). That is why understanding local community knowledge about health issues can be a valuable tool, particularly in regions like Pakistan where biomedical healthcare quality is weak (Khan et al., 2013). As a result, assessing local knowledge may be useful in closing the gap between the need for health care and its provision on-site (Vandebroek et al., 2011). Following significant dengue fever epidemics in Punjab, Pakistan, knowledge about dengue disease and its carrier mosquitoes was recently introduced to school textbooks (Khan et al., 2013). The presentation of such knowledge in syllabi or health education periodicals, particularly in the form of poetry, stories, and/or folk songs, could benefit the well-being of future generations and serve to place scientific learning in its traditional context (Kraipeerapun and Thongthew 2007; Mekbib, 2009).

Conclusion

The findings of the present survey revealed a lack of knowledge among communities related to dengue, its relationship in causing infection and its management. In Lahore, being an overcrowded city with a dense population, it is necessary to promote dengue control as a priority. The findings emphasize the need for health education campaigns to create awareness among communities about this disease and its vector and management practices to minimize its incidence. The educational interventions that could be conducted through studies can be very successful in raising correct awareness concerning the problem of dengue fever and encouraging to change their practices. Knowledge of symptoms is important to recognize the severity of dengue at an early stage because this can lead to proper case management. There is a direct link between knowledge about dengue preventive measures and protection practices.

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Author Contributions

HAAK and GS conceptualized the study. The methodology was designed by MA. Formal analysis was carried out by MA. The original draft was written by GS while HAAK and MA edited the draft. HAAK supervised the project.

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N/A

Ethical Approval

N/A

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Data availability statement

All data has been given in manuscript.

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