



## Epidemiology and Risk Factors of Dengue Fever Outbreak in Peshawar, Pakistan: A Hospital-Based Surveillance Study

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### Declaration

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### ABSTRACT

Dengue fever remains a major public health concern in tropical areas, with recurrent outbreaks in Pakistan's cities. This study investigates the epidemiology and risk factors associated with the 2022 dengue outbreak in Peshawar District, Khyber Pakhtunkhwa. A total of 9,490 laboratory-confirmed cases were analyzed from four major hospitals from June 2022 to December 2022, making this one of the region's largest documented outbreaks. The outbreak followed distinct temporal patterns, with peak transmission occurring during the 40th epidemiological week (8-14 October; n=1,288 cases), which coincided with post-monsoon conditions. Town 3 was identified as the epicenter (37.2% of cases), with significant clustering in slum areas (OR = 2.1, 95% CI: 1.8-2.4, p < 0.001). Demographic study found a greater occurrence among males (68.2%) and young individuals aged 20-29 years (27.1%), indicating occupational and behavioral exposure risks. The case fatality rate remained low (0.031%), indicating better clinical treatment than in earlier epidemics. Environmental factors such as uncovered water storage (76.0%; OR=3.4, p<0.001) and prolonged water storage >24 hours (92.0%; OR=5.2, p<0.001), as well as behavioral factors such as non-use of mosquito nets (93.0%; OR=6.3, p<0.001) and sleeping outdoors (44.0%; OR=2.8, p<0.001), were identified as critical risk factors. Travel history was documented in 61.5% of cases, emphasizing human mobility as an important transmission factor. The findings highlight the intricate interaction of meteorological, infrastructural, and social behavioral variables influencing dengue spread in urban Pakistan. This study provides evidence for targeted treatments, highlighting the need for integrated vector control techniques, better water infrastructure, and community-based awareness campaigns to reduce future epidemics in high-risk urban settings.

### INTRODUCTION

Dengue fever (DF) is a fast spreading arboviral disease caused by the dengue virus (DENV), which is largely transmitted by *Aedes aegypti* and *Aedes albopictus* mosquitoes (1). It has a wide range of clinical symptoms, from mild febrile sickness to severe forms including dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), which can be deadly without rapid medical attention (23). Dengue fever is common in more than 125 countries worldwide, with an estimated 390 million infections per year, 96 million of which present clinically (3). The illness has a considerable economic and healthcare impact, especially in tropical and subtropical countries where environmental and socio-demographic variables promote vector proliferation (40).

Dengue has been a serious public health concern in Pakistan since the first confirmed epidemic in Karachi in 1994 (5). Subsequent outbreaks in Lahore (2011) and Swat (2013) resulted in thousands of cases and high death (6). The Khyber Pakhtunkhwa (KP) province, notably its capital Peshawar, has suffered recurring outbreaks, with the most severe happening in 2017 (24,938 confirmed cases) and a recurrence in 2021 (10,456 cases) (7). The warm, humid environment, fast urbanization, poor waste management, and inadequate water storage techniques provide perfect breeding conditions for *Aedes* mosquitoes (8). Furthermore, population migration, a lack of public knowledge, and poor vector control measures worsen transmission dynamics.

Despite continued efforts by health officials, dengue fever is poorly controlled in Peshawar due to gaps in monitoring, delayed epidemic response, and low community participation in preventative measures. Previous studies in KP have identified risk factors such as unprotected water containers, inappropriate waste disposal, and travel history; however, new epidemiological data is required to guide focused interventions (9, 10).

The purpose of this study was to investigate the incidence of dengue fever in Peshawar during the 2022 epidemic and identify related risk factors to inform public health interventions. We analyze hospital-based surveillance data to determine demographic trends, spatiotemporal patterns, and behavioral and environmental drivers of dengue transmission. The findings will help inform evidence-based decisions and boost dengue control initiatives in high-risk metropolitan areas.

## MATERIALS AND METHODS

### Ethical Approval

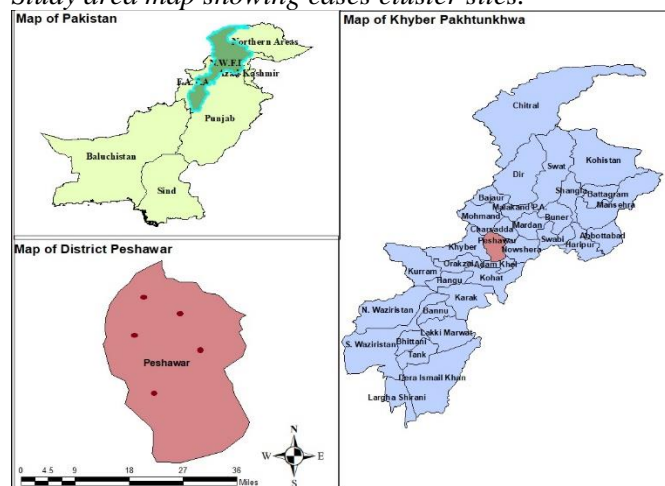
The Medical Entomology and Disease Vector Control Section of Health Services Academy, Islamabad accorded ethical approval of this study. In order to maintain anonymity, patient data was anonymized.

### Study Area

Peshawar is the provincial capital and largest city in KPK, Pakistan. Peshawar is the country's sixth most populous city, with a total population of 1,970,042 (Source: Pakistan Bureau of Statistics, 2017 Census). The area is divided into five towns, numbered 1 through 5. Dengue outbreaks were recorded in several sections of Peshawar, particularly Town 3, in 2022. (Fig 1). A total of 9490 dengue cases with three deaths were reported in the district, with 6474 dengue patients visiting Khyber Teaching Hospital (KTH), 2202 patients visiting Hayat Abad Medical Complex (HMC), and 336 patients visiting Lady Reading Hospital (LRH) Peshawar for treatment and diagnosis.

**Figure 2.1.**

*Study area map showing cases cluster sites.*



### Study Design

A cross-sectional epidemiological research, from June to December 2022, was carried out in District Peshawar, KP. Four major tertiary-care institutions provided data: Khyber Teaching Hospital (KTH), Hayatabad Medical Complex (HMC), Lady Reading Hospital (LRH), and Badaber Hospital. These hospitals serve as the region's principal referral sites for dengue patients.

### Data Collection

Data was collected using a structured proforma that recorded demographics (age, sex, and residence), clinical presentation (date of symptom onset and disease severity), risk factors (water storage practices, mosquito exposure, and travel history), and spatiotemporal trends (case distribution by town and epidemiological week). The study included laboratory-confirmed dengue cases (positive for NS1 antigen or IgM). During the outbreak, this thorough data gathering method allowed for in-depth examination of both population-level transmission patterns and risk variables at the individual level.

### Statistical Analysis

EPI Info v7.2 was used for data analysis, while Arc GIS 10.7.1 and Tableau Public were used for mapping and data visualization. The demographic and risk factor variables were subjected to descriptive statistics, such as percentages and frequencies. Weekly plots of temporal patterns were made, and high-incidence regions were found using geospatial mapping.

## RESULTS

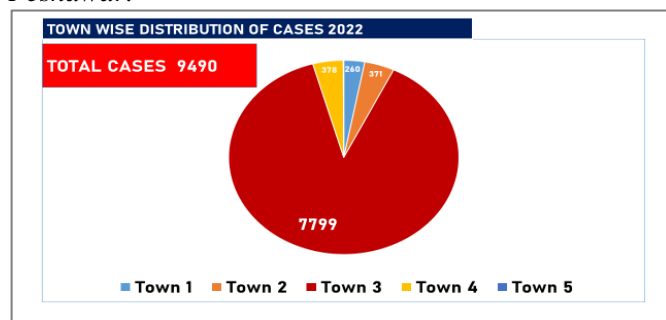
The 2022 dengue epidemic in Peshawar District demonstrated substantial epidemiological patterns, with 9,490 laboratory-confirmed cases reported from four main healthcare institutions. The outbreak showed unique spatial, demographic, and risk factor patterns, highlighting the intricate interaction of environmental and behavioral variables in dengue transmission.

The first incidence was recorded in Town 3 on June 13, 2022, followed by a significant spike during the monsoon, culminating in October (Figure 1). The greatest weekly incidence was recorded during the 40th epidemiological week (8-14 October;  $n=1,288$ , 13.6%), followed by the 41st ( $n=1,077$ , 11.3%) and 42nd weeks ( $n=834$ , 8.8%) ( $\chi^2=427.5$ ,  $p<0.001$ ) (Table 3.1, Figure 3.2). Cases fell dramatically by late November, disappearing totally around December 10, 2022, corresponding with temperatures below 20°C. Geospatial analysis showed Town 3 as the epicenter (37.2% of cases), with substantial clustering in slum areas (OR=2.1, 95% CI: 1.8-2.4,  $p<0.001$ ) (Table 1, Figure 3.1).

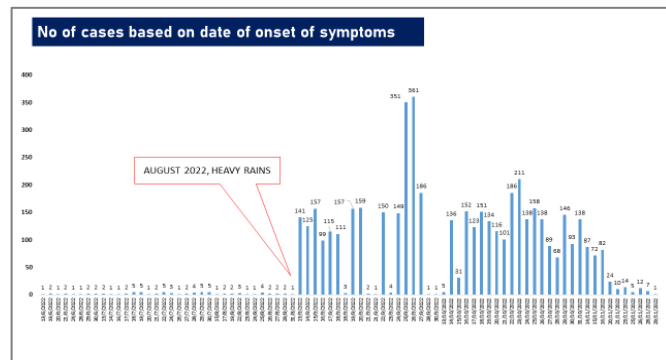
**Table 3.1.**  
Spatial-temporal distribution of dengue cases in Peshawar

Variable	n (%)	Statistical Test	P-value
<b>Peak transmission week</b>			
Week 40 (8–14 Oct)	1,288 (13.6)		
Week 41 (15–21 Oct)	1,077 (11.3)	$\chi^2=427.5$ (df=4)	<0.001
Week 42 (22–27 Oct)	834 (8.8)		
<b>High-risk area</b>			
Town 3	3,528 (37.2)	OR=2.1 (95% CI: 1.8–2.4)	<0.001
Towns 1, 2, 4	4,562 (48.1)		

**Figure 3.1**  
Town wise distribution of Dengue fever cases in Peshawar.



**Figure 3.2.**  
Number of cases based on onset of symptoms in District Peshawar.



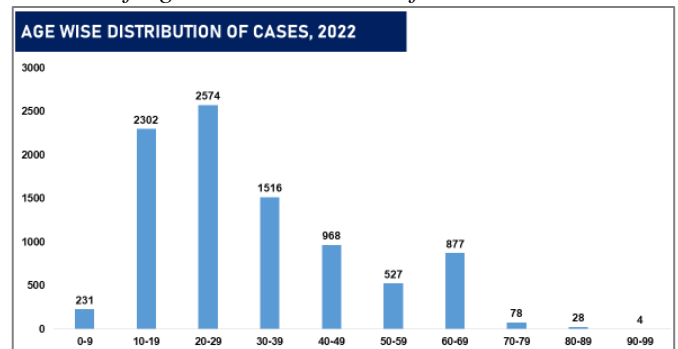
Males accounted for 68.2% (n=6,474) of the cases, substantially more than females (31.8%; n=3,016;  $\chi^2=1,243.7$ , p<0.001). Age-specific incidence was highest among 20-29-year-olds (n=2,574, 27.1%), followed by 11-19-year-olds (n=2,302, 24.3%) and 30-39-year-olds (n=1,516, 16.0%) (F=18.9, p<0.001). The case fatality rate was 0.031% (n=3), with all deaths occurring in individuals older than 50 years (Table 3.2; Figure 3.3).

**Table 3.2.**  
Demographic distribution of dengue cases in District Peshawar.

Category	n (%)	Statistical Test	p-value
<b>Sex</b>			
Male	6,474 (68.2)		
Female	3,016 (31.8)	$\chi^2=1,243.7$ (df=1)	<0.001

Age (years)	n (%)	F	p-value
11–19	2,302 (24.3)	F=18.9 (df=4)	<0.001
20–29	2,574 (27.1)		
30–39	1,516 (16.0)		
40-49	968 (10.2)		

**Figure 3.4.**  
Number of Age wise distribution of cases in Peshawar

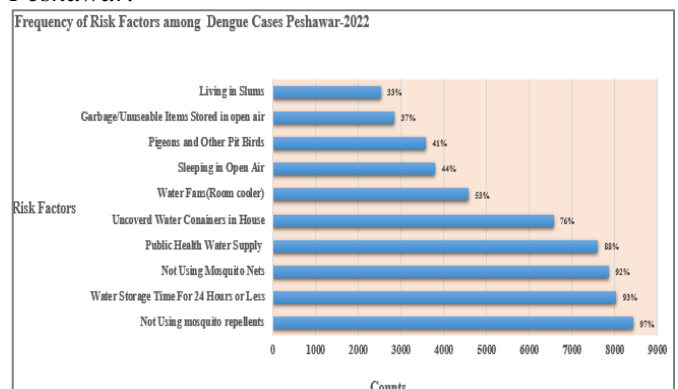


Exposure of water containers (76.0%, n=7,212; OR=3.4, p<0.001), extended water storage (>24 hours; 92.0%, n=8,730; OR=5.2, p<0.001), and irregular water supply (88.0%, n=8,352; OR=4.1, p<0.001) were important risk factors for vector birth. Avoiding mosquito nets (93.0%, n=8,827; OR=6.3, p<0.001), sleeping outside (44.0%, n=4,176; OR=2.8, p<0.001), and not using repellents (97.0%, n=9,203; OR=8.9, p<0.001) were behavioral hazards. In 61.5% (n=5,836) of the patients, travel history was given; of them, 23.7% (n=2,250) had traveled outside of Peshawar ( $\chi^2=387.4$ , p<0.001) (Table 3.3; Figure 3.4)

**Table 3.3.**  
Risk factors associated with dengue infection

Risk Factor	Exposed n (%)	OR (95% CI)	p-value
<b>Environmental</b>			
Uncovered water storage	7,212 (76.0)	3.4 (2.9–4.0)	<0.001
Water storage >24 hours	8,730 (92.0)	5.2 (4.3–6.3)	<0.001
<b>Behavioral</b>			
No mosquito net use	8,827 (93.0)	6.3 (5.1–7.8)	<0.001
Sleeping outdoors	4,176 (44.0)	2.8 (2.4–3.3)	<0.001
<b>Travel history</b>			
	5,836 (61.5)	2.1 (1.8–2.5)	<0.001

**Figure 3.4.**  
Frequency of Risk factors among Dengue cases in Peshawar.



KTH reported the most cases (68.2%, n=6,474), followed by Hayatabad Medical Complex (23.2%, n=2,202), Lady Reading Hospital (3.8%, n=366), and Badaber Hospital (1.2%, n=117) ( $\chi^2=9,852.1$ ,  $p<0.001$ ), indicating differences in healthcare access.

## DISCUSSION

The 2022 dengue epidemic in Peshawar District provides a huge public health problem, with 9,490 confirmed cases underscoring dengue's ongoing danger in urban Pakistan. Our findings are consistent with worldwide trends indicating rising dengue prevalence in tropical regions, particularly in densely populated areas with insufficient water management and sanitation facilities (11, 12). Males (68.2%) and young people (20-29 years: 27.1%) account for the majority of cases, which is consistent with earlier outbreaks in South Asia, where outdoor occupational exposure and mobility increase transmission risk (13,14). The low case fatality rate (CFR: 0.031%) compared to previous outbreaks in Pakistan (e.g., Lahore 2011, CFR: 1.6%) supports better clinical treatment but emphasizes the need for preventative interventions to minimize morbidity (15,16).

The spatiotemporal clustering of cases in Town 3 (37.2%) and after the monsoon peak (October) demonstrates the combined influence of natural and human causes. Poor drainage, unplanned urbanization, and monsoon-driven water buildup generated excellent breeding circumstances for *Aedes aegypti*, much as they did in dengue hotspots in India and Bangladesh. The dramatic drop in instances after temperatures fell below 20°C supports research indicating *Aedes* mosquitos' thermal sensitivity, with optimum reproduction occurring around 25-30°C (19,20). This highlights the need of climate monitoring in anticipating epidemics, as advocated by the WHO's Early Warning and Response System (21).

The main risk factors that were found—uncovered water storage (76.0%), extended water storage (92.0%), and irregular municipal supply (88.0%)—are in line with research from Karachi (2005) and Lahore (2011), where households were compelled to store water due to water insecurity, which unintentionally encouraged the growth of mosquitoes (22, 23). The high frequency of behavioral hazards, such as not using repellents (97.0%) and mosquito nets (93.0%), is similar to findings in rural Indonesia and Cambodia, where preventative methods are limited by cost and ignorance (24,25). Notably,

61.5% of patients mentioned recent travel, which is consistent with data showing that human mobility speeds up dengue's transmission across administrative borders, as demonstrated by the 2019 outbreak in Thailand (26, 27).

Disparities in healthcare access and the hospital's function as a referral center are reflected in the disproportionate case burden at Khyber Teaching Hospital (68.2%), a pattern that has been observed in dengue outbreaks in Brazil (28). Nonetheless, the low CFR points to efficient triage and treatment procedures, maybe as a result of the knowledge gained during the 2017 pandemic in Pakistan (29).

The necessity of integrated vector management (IVM), which combines behavioral, institutional, and environmental treatments, is highlighted by our study. Peshawar might benefit from adopting effective strategies from Singapore (30) and Vietnam (31) that include community-led cleanup efforts and larvicidal treatments. Addressing gaps in waste management and water supply requires strengthening intersectoral cooperation, as suggested by the Global Vector Control Response (GVCR) (32).

## CONCLUSION

Dengue is a continuous risk in urban Pakistan, driven by climatic, environmental, and behavioral variables, as demonstrated by the 2022 epidemic in Peshawar. Risks connected to mobility and employment are highlighted by the high frequency among males and young adults, and infrastructural deficits are reflected in the geographical concentration in regions of poverty. Despite fewer deaths due to better clinical care, the outbreak highlights serious weaknesses in preventative efforts, especially in vector control and water storage procedures. The results highlight the necessity of integrated approaches that incorporate enhanced urban design, community involvement, and climate-adaptive surveillance. Targeted measures, such as larvicidal treatments, public awareness campaigns, and dependable water supply systems, may help prevent future outbreaks, according to lessons learned from Southeast Asia's successful models. Controlling dengue would require implementing early warning systems suggested by the WHO and enhancing inter-sectoral collaboration. In order to address the increasing dengue burden in Pakistan's rapidly urbanizing regions, this study offers a paradigm for evidence-based policies.

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