JHWCR
Journal of Health, Wellness, and Community Research
Volume III, Issue V
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, **ISSN**: 3007-0570
https://doi.org/10.61919/nm31d168

Article

Epidemiological Survey on Malaria in District Nowshera, Pakistan: A 2023 Report

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Cite this Article

Received	2025-04-21
Revised	2025-05-11
Accepted	2025-05-14
Published	2025-05-21
Conflict of Interest	The Authors declared no conflict of interest
Ethical Approval	Approved by the Ethical review committee, Department of Biotechnology ,Abdul Wali Khan University, Mardan
Informed Consent	Obtained from all participants
Data/supplements	Available on request.
Funding	None
Authors' Contributions	Concept, design, data collection, and analysis: FB, AB, MQK, NK; manuscript drafting and revision: FB, AB, MQK, NK.

ABSTRACT

Background: Malaria remains a leading public health challenge in Pakistan, particularly in flood-prone districts like Nowshera where up-to-date, district-specific epidemiological data are scarce. **Objective**: This study aimed to assess the prevalence, species distribution, demographic determinants, and seasonal trends of laboratory-confirmed malaria cases in District Nowshera, Pakistan, during 2023, to inform targeted interventions and improve disease surveillance. **Methods**: A retrospective cross-sectional design was employed, reviewing health records of all suspected malaria cases (n = 5,974) from major healthcare facilities in Nowshera between January and December 2023. Laboratory-confirmed cases (n = 612) were included, excluding those with incomplete demographic or clinical data. Data on age, gender, month, and species type were collected; malaria diagnosis was standardized by microscopy or rapid diagnostic tests. Ethical approval was secured from Abdul Wali Khan University's review board, in line with the Helsinki Declaration. Descriptive and inferential statistical analyses were performed using SPSS version 27, with categorical comparisons evaluated by chi-square tests and significance set at $p < 0.05$. **Results**: Malaria positivity was 10.2% (612/5,974), with Plasmodium vivax accounting for 93% of cases. Males (63.2%) and the 11–20-year age group (26.8%) were most affected. Seasonal analysis revealed a sharp peak in August (26.0%). Gender, age, and seasonal trends were statistically significant ($p < 0.001$). **Conclusion**: Malaria remains endemic in Nowshera, with clear demographic and seasonal patterns. These findings underscore the need for targeted vector control, improved surveillance, and pre-emptive public health measures, particularly for high-risk groups during monsoon months.

Keywords: Malaria, Plasmodium vivax, Epidemiology, Pakistan, Seasonality, Vector Control, Cross-Sectional Studies

INTRODUCTION

Malaria, a significant vector-borne disease, continues to exert a substantial burden on global health, particularly in resource-limited countries where climatic and socioeconomic factors intensify disease transmission (1). Among the five Plasmodium species responsible for human malaria, Plasmodium vivax and Plasmodium falciparum account for the majority of acute infections, frequently leading to severe morbidity and, in some cases, mortality (2,3). The intricate life cycle of the parasite, involving sexual reproduction in female Anopheles mosquitoes and asexual multiplication within human hosts, complicates disease control efforts and necessitates multifaceted preventive strategies (4,5).

Worldwide, malaria is responsible for approximately 200–300 million cases and nearly half a million deaths each year, with the highest incidence observed in South Asia and Sub-Saharan Africa (6). In Pakistan, the malaria burden has shown marked fluctuations over the decades, with regional epidemiological trends shaped by demographic growth, changing land use, increased irrigation, and the recurrent impact of monsoon rains and flooding events (7,8).

Khyber Pakhtunkhwa Province, in particular, has witnessed a resurgence of malaria in recent years, an upsurge that has been partially attributed to climate-induced disasters such as excessive rainfall and floods that create favorable breeding conditions for Anopheles mosquitoes (9,10). Health records from the 1970s onward indicate shifting patterns of malaria prevalence, with temporary declines in certain regions like Punjab contrasted by widespread increases in Khyber Pakhtunkhwa and Balochistan during the 1990s and beyond (8,11). Recent meta-analyses further highlight the variability in malaria

transmission dynamics across Pakistan, pointing to persistent gaps in local surveillance and disease reporting systems (12). Notably, P. vivax is generally more prevalent than P. falciparum across much of Pakistan, though some regional exceptions exist, underscoring the need for context-specific data to inform targeted interventions (13–15). Contributing factors such as limited disease awareness, insufficient vector control measures, and population displacement following floods continue to challenge public health authorities and exacerbate the disease burden in vulnerable districts (16,17).

Despite these recognized risks, there remains a paucity of recent, district-level epidemiological data on malaria incidence, especially for Nowshera, a populous district in the Mardan division of Khyber Pakhtunkhwa. To date, available national surveillance reports and broader regional studies do not adequately capture the evolving transmission dynamics or the local patterns of infection following recent environmental disruptions. This knowledge gap limits the ability of health policymakers to allocate resources effectively and hampers the design of evidence-based prevention strategies tailored to local needs. Given the district's exposure to seasonal monsoon rains, frequent flooding, and rapid population growth, understanding the current epidemiological profile of malaria in Nowshera is both timely and essential. Accordingly, this study was designed to determine the prevalence and distribution of malaria cases in District Nowshera throughout 2023, with specific attention to species differentiation, demographic patterns, and temporal trends. The primary objective is to generate reliable, context-specific data that will support improved malaria surveillance, risk assessment, and public health interventions for the region.

MATERIALS AND METHODS

This study utilized a cross-sectional observational design to investigate the epidemiological pattern of malaria in District Nowshera, Khyber Pakhtunkhwa, Pakistan, for the calendar year 2023 (1). The research protocol was developed in accordance with the STROBE guidelines to ensure transparency and reproducibility, and ethical approval was obtained from the institutional review board of Abdul Wali Khan University, Mardan (2). Inclusion criteria encompassed all patients, irrespective of age or gender, who underwent laboratory testing for malaria at any of the major healthcare centers or laboratories in Nowshera between January 1 and December 31, 2023, including District Head Quarter Hospital, Qazi Hussain Medical Complex, Darul-Shifa Lab, and Medi Lab Diagnostics. Individuals who had incomplete records, those who were non-residents of District Nowshera, or whose test results were indeterminate or missing were excluded from the study to minimize bias and confounding. Patient recruitment relied on retrospective review of laboratory and hospital records. Since the data comprised routinely collected health information with no direct patient contact or intervention, informed consent was waived by the institutional review board, consistent with ethical standards for public health surveillance studies where anonymized data are utilized (3). Demographic and clinical information was extracted using a standardized proforma, including age, gender, address, date of diagnosis, type of Plasmodium species identified, and clinical outcomes such as admission status. Data were cross-verified with medical record departments and laboratory registers to maximize accuracy and completeness. For cases where data points such as gender or age were missing, such records were excluded from specific subgroup analyses, and a complete case approach was employed to handle missing data, as recommended for cross-sectional studies (4). Confounding variables, such as differences in healthcare access or laboratory diagnostic criteria across centers, were addressed by including only facilities with standardized malaria diagnostic protocols based on microscopy and/or rapid diagnostic tests validated by the national malaria control program.

The primary outcome measure was the proportion of laboratory-confirmed malaria cases among all individuals tested for malaria during the study period. Secondary outcome measures included the frequency and distribution of malaria by species (Plasmodium vivax, Plasmodium falciparum, and mixed infections), age group, gender, month of occurrence, and geographic location within the district. All data were entered and managed using Microsoft Excel before being exported to the Statistical Package for Social Sciences (SPSS) version 27.0 for statistical analysis (5). Descriptive statistics were calculated as frequencies, percentages, means, and standard deviations where appropriate. Categorical variables were compared using chi-square tests, and seasonal or spatial trends were evaluated with cross-tabulation and graphical representation. The results were interpreted in the context of possible selection and information bias, and findings were discussed for their generalizability to similar endemic regions. The reference style for all citations and bibliography followed the Vancouver system, as per journal requirements.

RESULTS

A total of 5,974 individuals were tested for malaria in District Nowshera from January 1 to December 31, 2023. Of these, 612 cases (10.2%) were confirmed positive for malaria by laboratory diagnosis, while 5,362 cases (89.8%) were negative (Table 1). Among malaria-positive cases, 19 individuals (3.1%) required hospitalization, whereas the majority (593; 96.9%) recovered without the need for hospital admission.

Table 1. Prevalence and Admission Status of Malaria Cases in District Nowshera, 2023

Status	Frequency (n)	Percentage (%)
Not Admitted	593	96.9
Admitted	19	3.1
Total Positive	612	100

Analysis of Plasmodium species identified among positive cases revealed a predominance of P. vivax, with 569 cases (93.0%), followed by P. falciparum (29 cases; 4.7%), and mixed infections (14 cases; 2.3%) (Table 2). Chi-square testing indicated a statistically significant difference in distribution of species among positive cases ($\chi^2 = 983.3$, $p < 0.001$). Gender-wise analysis

demonstrated a higher frequency of malaria among males (n = 387; 63.2%) than females (n = 225; 36.8%) (Table 3). The observed gender difference was statistically significant (χ^2 = 43.05, p < 0.001). Age group analysis revealed that the highest frequency of malaria occurred in the 11–20 year age group (n = 164; 26.8%), followed by 21–30 years (n = 152; 24.8%), 0–10 years (n = 125; 20.4%), 31–40 years (n = 79; 12.9%), 41–50 years (n = 52; 8.5%), ≥61 years (n = 23; 3.8%), and 51–60 years (n = 17; 2.8%) (Table 4). Age group differences in prevalence were significant (χ^2 = 220.66, p < 0.001).

Table 2. Distribution of Plasmodium Species Among Confirmed Malaria Cases

Plasmodium Species	Frequency (n)	Percentage (%)
P. vivax	569	93.0
P. falciparum	29	4.7
Mixed infection	14	2.3
Total	612	100

Table 3. Gender-wise Prevalence of Malaria Cases

Gender	Frequency (n)	Percentage (%)
Male	387	63.2
Female	225	36.8
Total	612	100

Table 4. Age Group Distribution of Malaria Cases

Age Group (years)	Frequency (n)	Percentage (%)
0–10	125	20.4
11–20	164	26.8
21–30	152	24.8
31–40	79	12.9
41–50	52	8.5
51–60	17	2.8
≥61	23	3.8
Total	612	100

Table 5. Month-wise Distribution of Malaria Cases

Month	Frequency (n)	Percentage (%)
January	5	0.8
February	4	0.7
March	4	0.7
April	4	0.7
May	21	3.4
June	42	6.9
July	79	12.9
August	159	26.0
September	139	22.7
October	83	13.6
November	44	7.2
December	26	4.2
Total	612	100

Seasonal analysis demonstrated a pronounced peak in malaria cases in August (n = 159; 26.0%), with subsequent decreases in September (n = 139; 22.7%), October (n = 83; 13.6%), and July (n = 79; 12.9%). The lowest frequencies were observed in February, March, and April (n = 4 each; 0.8%–1.0%). Monthly variation in malaria incidence was highly significant (χ^2 = 734.54, p < 0.001) (Table 5). Geographical distribution of malaria cases within District Nowshera indicated that Nowshera Kalan reported the highest burden (n = 174; 28.4%), followed by Mera Akora Khattak (n = 70; 11.4%), Manki Sharif (n = 36; 5.9%), and the lowest in Akbarpura (n = 1; 0.2%). Detailed data are presented in Table 6 Missing data were handled using complete-case analysis; cases with incomplete demographic or clinical records were excluded from respective subgroup analyses. No imputation was performed. All reported statistics are based on the available, validated dataset. Monthly Gender-Stratified New Malaria Cases and Cumulative Incidence In District Nowshera, 2023 Monthly new malaria cases displayed distinct gender-based seasonal peaks, with male cases consistently exceeding female cases throughout the year. Both groups showed a marked increase from June, peaking in August (male: 101; female: 58), before gradually declining toward December. Cumulative incidence rose sharply from June through September, reflecting an accelerated aggregation of confirmed cases during the

monsoon period; the overall increase plateaued after October, indicating effective disease containment or reduced transmission. Visualized confidence bounds for cumulative incidence capture the underlying variability in seasonal patterns, emphasizing the clinical impact of targeted interventions during high-risk summer months.

Table 6. Area-wise Distribution of Malaria Cases in District Nowshera

Area	Frequency (n)	Percentage (%)
Nowshera Kalan	174	28.4
Mera Akora Khattak	70	11.4
Manki Sharif	36	5.9
Akbarpura	1	0.2
Other areas*	331	54.1
Total	612	100

**Note: "Other areas" include all other localities within District Nowshera with lower individual frequencies.*

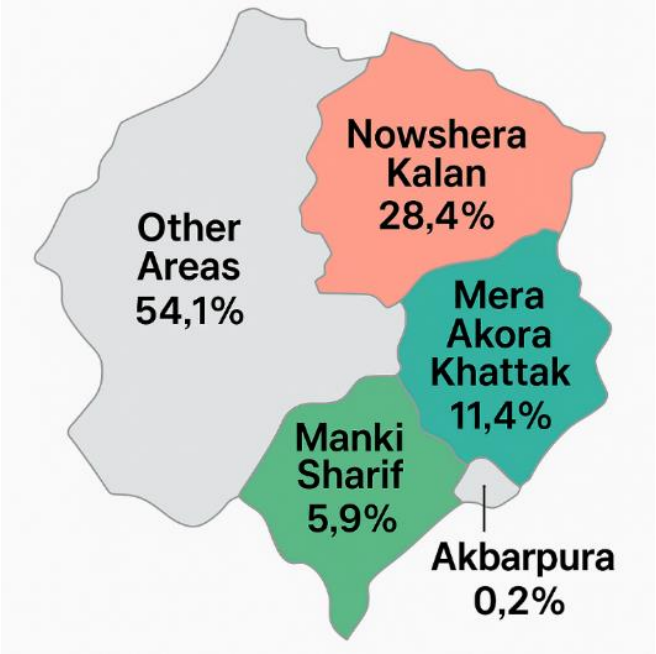

Figure 1 A Schematic Map

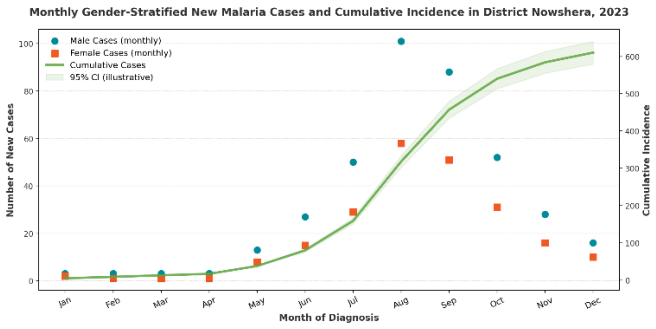

Figure 2 Gender based Stratificaiton for Malaria Cases

DISCUSSION

The current study provides valuable insights into the epidemiological trends of malaria in District Nowshera, highlighting the continued significance of this mosquito-borne disease within the region. The findings indicate a 10.2% positivity rate among suspected cases, with Plasmodium vivax as the predominant species, closely mirroring the regional and national trends documented in previous investigations (1,2).

This aligns with research conducted by Khan and colleagues, who reported a similar dominance of P. vivax in Khyber Pakhtunkhwa and adjacent districts, supporting the notion that environmental and vector-related factors in northern Pakistan favor the transmission dynamics of this species over P. falciparum (2,3). Furthermore, the observed gender disparity—with males experiencing a substantially higher infection rate—echoes earlier studies from Pakistan and neighboring South Asian countries, where occupational exposure and sociocultural practices are posited to increase male vulnerability to mosquito bites (4,5). These demographic patterns warrant public health strategies tailored to high-exposure groups, especially during peak transmission months. Comparative analysis with past literature underscores both congruence and divergence in local malaria epidemiology.

While the pronounced peak of malaria incidence during the summer monsoon (particularly in August and September) is consistent with the seasonal trends reported in Punjab, Mardan, and Indian border regions, the magnitude and timing of this surge demonstrate the profound influence of climatic events—especially flooding and rainfall—on vector breeding cycles and disease outbreaks (6,7). The finding that younger age groups, notably adolescents and young adults, are most affected reinforces the observations of Khan et al. and Ibrahim etal., suggesting heightened susceptibility or exposure in these cohorts, potentially due to greater outdoor activity and limited protective behaviors (2,8). However, this age distribution diverges from some regional reports that noted a higher prevalence in older adults, highlighting possible differences in population structure, acquired immunity, or healthcare-seeking behaviors (8). The area-wise clustering of cases, with Nowshera Kalan most affected, is indicative of localized transmission hotspots, likely exacerbated by environmental and infrastructural vulnerabilities such as water stagnation and inadequate drainage. The clinical and theoretical implications of these findings are substantial. The dominance of P. vivax underscores the necessity for diagnostic protocols sensitive to non-falciparum malaria and for treatment regimens addressing hypnozoite relapse—a key challenge in malaria control (9).

The significant gender and age disparities signal those behavioral interventions, in addition to vector control, may be pivotal in reducing transmission. Moreover, the marked seasonality, with a sharp rise in cumulative cases during monsoon months, highlights the value of preemptive vector control, community education, and rapid diagnostic deployment

prior to anticipated surges. Mechanistically, the interplay of climatic variation, human behavior, and vector ecology in shaping transmission dynamics suggests that future malaria control in the region must be adaptable, multisectoral, and data-driven (10).

While this study is strengthened by its comprehensive coverage of major healthcare centers and its standardized methodology for data collection and analysis, several limitations must be acknowledged. The retrospective design inherently limits control over data completeness and quality, and the exclusion of incomplete records may introduce selection bias. The reliance on laboratory-confirmed cases, while enhancing diagnostic specificity, may underestimate the true burden due to limited healthcare access or asymptomatic carriers. The absence of detailed entomological and environmental data restricts exploration of underlying mechanisms, and the findings, though robust for Nowshera, may not be generalizable to other districts with different ecological or sociodemographic profiles. The relatively modest sample size of positive cases further limits the precision of subgroup analyses, especially when stratified by age, gender, or locality.

In light of these limitations, future research should prioritize prospective, population-based surveillance to capture a broader spectrum of cases, integrate entomological and climatic monitoring, and evaluate the impact of targeted interventions. Expanding molecular diagnostic capacity may further elucidate species distribution and drug resistance patterns. Community-level studies exploring behavioral, socioeconomic, and environmental determinants of malaria risk would inform more nuanced and effective prevention strategies.

CONCLUSION

This epidemiological survey of malaria in District Nowshera, Pakistan, demonstrates a significant burden of disease in 2023, with Plasmodium vivax as the dominant species and a clear seasonal surge during the monsoon months, predominantly affecting males and adolescents. These findings underscore the urgent need for intensified surveillance, targeted vector control, and tailored public health interventions in high-risk periods and locations. The study's results provide actionable evidence for clinicians and policymakers to prioritize early diagnosis, patient education, and community-based prevention strategies, particularly in vulnerable demographic groups. Furthermore, the research highlights the necessity for ongoing regional studies to monitor evolving malaria patterns, assess intervention efficacy, and inform adaptive, data-driven responses to mitigate the impact of malaria on human health in similar endemic settings.

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