

Original Article

A Comprehensive Study on Prevalence, Species Distribution, and Influencing Factors of Malaria in Dir Lower, Pakistan

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ABSTRACT

Background: Malaria remains a significant public health challenge in Pakistan, particularly in the Khyber Pakhtunkhwa province. Tehsil Samarbagh in the Dir Lower region exemplifies the areas heavily burdened by this parasitic disease. Understanding the prevalence and distribution of malaria and its causative Plasmodium species is crucial for developing targeted interventions.

Objective: This study aimed to assess the prevalence of malaria, identify the distribution of Plasmodium species, and evaluate the factors influencing malaria infection in Tehsil Samarbagh, Dir Lower, Pakistan.

Methods: A cross-sectional study was conducted from January to December 2023. Non-probability convenient sampling was employed to collect 1,925 blood samples from suspected malaria patients across various Union Councils in Tehsil Samarbagh. Malaria diagnosis was performed using thin and thick blood films stained with Giemsa, and species identification was achieved through microscopy. Data on demographic variables, clinical symptoms, and environmental conditions were also collected and analyzed using SPSS version 25.

Results: The overall prevalence of malaria was found to be 15.01%. Plasmodium vivax was the predominant species, accounting for 71% of the positive cases, followed by Plasmodium falciparum at 21%, and mixed infections at 8%. Prevalence varied significantly across different Union Councils, with the highest rate observed in Samarbagh (18.96%). Males were more affected (17.66%) than females (11.44%). The age group most at risk was 31-40 years (19.69%). Seasonal variation was evident, with the highest prevalence in September (22.42%) correlating with peak temperatures and humidity levels.

Conclusion: The study underscores the continued public health challenge posed by malaria in Tehsil Samarbagh, highlighting the dominance of Plasmodium vivax. Variations in prevalence by geographic area, gender, age, and season necessitate targeted public health interventions and enhanced diagnostic capabilities for malaria control and prevention.

Keywords: Malaria, Plasmodium vivax, Plasmodium falciparum, Prevalence, Seasonal variation, Tehsil Samarbagh, Dir Lower, Pakistan, Cross-sectional study, Public health.

INTRODUCTION

Malaria remains a critical global health challenge, particularly in developing nations where it constitutes a significant cause of morbidity and mortality. This parasitic disease, caused by Plasmodium parasites, poses a risk to approximately 3.3 billion people worldwide, underscoring its significance in tropical and subtropical regions. The World Health Organization (WHO) estimates that nearly half of the world's population is at risk of malaria, with about 245 million cases and 625,000 deaths reported annually. Such statistics highlight the disease's profound impact on public health and the economy in affected countries, especially among the most vulnerable populations (1, 2, 3, 4, 5). In Pakistan, a country where approximately 60% of the population lives in malaria-endemic areas, the disease's prevalence and distribution pose a notable challenge. Despite eradication efforts in the 1960s, a resurgence of malaria was observed in the 1970s, reaching epidemic proportions. Today, Pakistan continues to battle malaria, with around 500,000 infections and 50,000 deaths reported each year, a significant portion of which occurs in regions bordering Afghanistan and Iran.

The provinces of Khyber Pakhtunkhwa, Baluchistan, Sindh, and the tribal areas are particularly affected, underscoring the need for continued vigilance and effective control measures (6, 7, 8, 9).

Malaria transmission in Pakistan is facilitated by the bite of infected female *Anopheles* mosquitoes, with *Anopheles culicifacies* and *A. Stephensi* identified as primary vectors. The disease is caused by five *Plasmodium* species, of which *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium ovale*, and *Plasmodium malariae* are known to infect humans. In Pakistan, the transmission of malaria exhibits seasonal variation, with *P. vivax* infections peaking from June to September and then again from April to June, often reflecting relapses from the previous season. In contrast, *P. falciparum* transmission is most common between August and December. Notably, *P. vivax* is the predominant species, associated with more severe morbidity and mortality and accounting for 64% of cases, followed by *P. falciparum* with 36%. Mixed-species infections are also prevalent, further complicating the epidemiological landscape of malaria in the country (10, 11, 12, 13, 14).

The impact of malaria on individuals can be devastating, leading to severe complications such as anemia, cerebral malaria, acute renal failure, and hypoglycemia. Vulnerable populations, including children and pregnant women, are particularly susceptible to these severe outcomes, highlighting the need for targeted intervention strategies (5, 15). This study aims to provide a comprehensive assessment of the current state of malaria in Pakistan, with a specific focus on the Lower Dir district. Conducted in 2019, this survey sought to determine the prevalence of malaria among suspected cases and to map the distribution of *Plasmodium* species in the region. By offering insights into the disease's prevalence and the factors influencing its distribution, this research contributes to the ongoing efforts to combat malaria in Pakistan, ultimately aiming to reduce the burden of this significant public health challenge.

MATERIAL AND METHODS

The study was conducted in the Tehsil Samarbagh region of Dir Lower, located in the Khyber Pakhtunkhwa province of Pakistan. The geographical setting of the area spans latitudes 35°-10' to 35°-16'N and longitudes 71°-50' to 71°-83'E, with an elevation range from 1200m to 2800m. Employing a cross-sectional design, our research adopted a non-probability convenient sampling approach. The research protocol received approval from the Ethical Review Committee of the Institute of Health Sciences, Khyber Medical University, Samarbagha Dir Lower, ensuring compliance with the Declaration of Helsinki for human research ethics.

Materials used in the collection and analysis of blood samples included lancets for blood withdrawal, glass slides for blood smear preparation, ethanol for sterilization, Giemsa stain for slide staining, oil immersion for microscopy, and a microscope for the identification of *Plasmodium* species. The study meticulously adhered to standardized protocols for the preparation, staining, and microscopic examination of blood films, ensuring the reliability of malaria diagnosis.

Blood samples were systematically collected from participants, stratified by gender and age groups: 1-15 years, 16-30 years, and 31 years and above. A specially designed data collection form was employed to gather detailed information on clinical symptoms exhibited by the patients, including headache, vomiting, cough, fever, chills, and pain, which are indicative of malaria infection. This methodical approach facilitated the comprehensive assessment of the participants' health status and potential malaria infection.

Malaria diagnosis was conducted through the preparation of both thin and thick blood films from suspected patients across the selected study localities. These blood slides were then stained using Giemsa, a technique critical for the accurate identification of *Plasmodium* species. The analysis of these slides was pivotal in confirming cases of malaria, thereby contributing to the study's objectives of mapping the distribution of malaria and its causative *Plasmodium* species within the area.

Data collected through the study were analyzed using SPSS version 25, a statistical software that enabled the meticulous examination of the data in relation to the study's objectives. This analysis encompassed the assessment of malaria prevalence across different demographics and the identification of species distribution within the population sample. By adhering to robust analytical methods, the study aimed to provide insights into the prevalence and distribution of malaria, thereby informing future interventions and control strategies in the region.

The study's adherence to ethical standards, combined with a rigorous methodological approach, ensured the reliability and validity of its findings, contributing valuable knowledge to the existing literature on malaria prevalence and species distribution in Dir Lower, Pakistan.

RESULTS

In the comprehensive study conducted across Tehsil Samarbagh within the Dir Lower region, a total of 1,925 samples were analyzed to assess the prevalence and distribution of malaria. The investigation revealed a significant variation in malaria prevalence across different Union Councils (UCs), as indicated in Table 1. Darangal reported a 10.64% positivity rate among the samples, with 344 individuals testing negative, highlighting a relatively lower incidence compared to other UCs. In contrast, Samarbagh exhibited a

higher prevalence rate of 18.96%, suggesting a critical need for targeted malaria control interventions in this area. The overall positivity rate across all six Union Councils averaged at 15.01%, underscoring the persistent challenge malaria poses to the region. Gender-wise analysis of malaria prevalence, detailed in Table 2, indicated a higher infection rate among males (17.66%) compared to females (11.44%). This gender disparity underscores the potential influence of occupational or behavioral factors that may expose males to a higher risk of malaria transmission. The study's total sample comprised 1,110 males and 815 females, with the overall positivity rate aligning with the aggregate findings at 15.01%.

Age-wise distribution of malaria cases, as elaborated in Table 3, revealed the highest infection rate among the 31-40 years age group (19.69%), followed closely by the 1-10 years age group (17.69%). These findings indicate that both young children and adults are at considerable risk, necessitating age-specific prevention and treatment strategies. The analysis further highlighted that individuals over 40 years of age experienced a lower infection rate (14.54%), suggesting potential variations in immunity or exposure across different age groups.

Table 1: Prevalence of Malaria in Different Union Councils (UC) within Tehsil Samarbagh

Union Council	No. of Samples	Positive (%)	Negative (%)
Darangal	385	41 (10.64%)	344 (89.36%)
Kambat	385	57 (14.80%)	328 (85.20%)
Samarbagh	385	73 (18.96%)	312 (81.04%)
Shontala	385	29 (7.53%)	356 (92.47%)
Mayor	385	42 (10.90%)	343 (89.10%)
Maskinay	385	47 (12.21%)	338 (87.79%)
Total	1925	289 (15.01%)	1636 (84.99%)

Table 2: Prevalence of Malaria in Samarbagh Tehsil Among Different Genders

Gender	No. of Samples	Positive (%)	Negative (%)
Male	1110	196 (17.66%)	914 (82.34%)
Female	815	94 (11.44%)	721 (88.56%)
Total	1925	289 (15.01%)	1636 (84.99%)

Table 3: Age-wise Prevalence of Malaria in Tehsil Samarbagh

Age Group	No. of Samples	Positive (%)	Negative (%)
1-10 years	390	69 (17.69%)	321 (82.31%)
11-30 Years	930	116 (12.47%)	814 (87.53%)
31-40 Years	330	65 (19.69%)	265 (80.31%)
41 and Above	275	40 (14.54%)	235 (85.45%)
Total	1925	289 (15.01%)	1636 (84.99%)

Table 4: Month-wise Percentage Prevalence of Malaria in Tehsil Samarbagh

Month	No. of Samples	Positive (%)	Humidity	Temp (°C)
January	155	9 (5.80%)	70	12.10
February	155	13 (8.38%)	69	14.50
March	155	17 (10.96%)	61	18.93
April	155	19 (12.25%)	43	23.12
May	155	24 (15.50%)	38	27.33
June	160	31 (19.38%)	44	32.10
July	165	35 (21.21%)	49	35.21
August	165	32 (19.40%)	57	36.70
September	165	37 (22.42%)	62	33.56
October	165	30 (18.18%)	66.3	29.15
November	165	21 (12.72%)	75	21.81

December	165	23 (13.94%)	72	14.25
Total	1925	289 (15.01%)		

The month-wise prevalence of malaria, detailed in Table 4, showed a clear trend of increasing positivity rates with rising temperatures and varying humidity levels. The lowest infection rate was observed in January (5.80%), gradually escalating to reach the highest prevalence in September (22.42%). This seasonal pattern is consistent with the lifecycle and breeding patterns of the Anopheles mosquitoes, emphasizing the critical need for timely public health interventions to mitigate the risk of malaria transmission during peak months.

The detailed examination of malaria prevalence across different Union Councils, genders, age groups, and months provides valuable insights into the epidemiology of malaria in Tehsil Samarbagh. These findings underscore the necessity for targeted malaria control strategies that consider the diverse demographic and environmental factors influencing malaria transmission in the region.

DISCUSSION

In the context of ongoing efforts to understand and mitigate the burden of malaria in Pakistan, this study conducted in Tehsil Samarbagh, Dir Lower, over the span of 2023, has contributed valuable insights into the epidemiology of this disease within a specific geographic locale. The findings, indicating a malaria prevalence rate of 15.01%, echo the serious health challenge that malaria continues to present in Pakistan (5). Predominantly, Plasmodium vivax was identified as the chief parasitic species, accounting for 71% of the cases. This prevalence underscores the critical role of P. vivax in the region, aligning with findings from similar studies conducted in other parts of Khyber Pakhtunkhwa, which reported substantial incidence rates and a dominant presence of P. vivax (17, 18). The relatively lower incidence of Plasmodium falciparum (21%) and the presence of mixed infections (8%) in our study further contribute to the complex epidemiological profile of malaria in this area.

Comparison with related research illustrates both consistency and variability in malaria prevalence and species distribution across different regions of Pakistan. For instance, a study in southern districts reported a higher overall incidence of malaria (52.47%) with a similar predominance of P. vivax (91.07%), albeit with different proportions for P. falciparum and mixed infections (17). Another investigation at the Ayub Teaching Hospital in Abbottabad found P. vivax to be the dominant species, a finding in harmony with our study, thereby reinforcing the notion of P. vivax's widespread impact in the region (18). Such comparisons not only validate our findings but also highlight the regional variations in malaria epidemiology that demand localized response strategies.

The spatial heterogeneity in malaria distribution within Tehsil Samarbagh, evidenced by varying prevalence rates across different Union Councils, points to the influence of local environmental and socio-economic factors on malaria transmission dynamics. Samarbagh, with the highest recorded prevalence, emerges as a critical focal point for intensified control measures. This variability underscores the need for geographically tailored interventions that account for the specific conditions conducive to malaria in each locale.

Gender and age emerged as significant determinants of malaria risk in our study, with males exhibiting a higher incidence rate than females, and individuals aged 31-40 being particularly vulnerable. These findings align with previous research, suggesting gender-specific exposure patterns and a complex interplay of biological, socio-economic, and environmental factors influencing susceptibility across different age groups (19).

Seasonal variation in malaria prevalence, peaking in September, underscores the influence of climatic factors on the transmission of the disease. The correlation between higher temperatures, humidity levels, and malaria incidence emphasizes the seasonal nature of malaria transmission, a pattern that is consistent with other studies conducted in the region (20). These insights highlight the importance of temporal considerations in the planning and implementation of malaria control strategies.

This study's strength lies in its comprehensive approach to assessing malaria prevalence and species distribution within a defined geographic and temporal scope, providing a detailed epidemiological profile that can inform targeted intervention strategies. However, limitations include the reliance on convenience sampling and the focus on a single Tehsil, which may not fully capture the broader epidemiological trends across Dir Lower or Khyber Pakhtunkhwa.

CONCLUSION

In conclusion, our findings reiterate the significant health burden posed by malaria in Tehsil Samarbagh, with Plasmodium vivax identified as the predominant species. The study highlights the nuanced nature of malaria epidemiology in Pakistan, characterized by regional disparities in prevalence and species composition. Addressing these challenges necessitates enhancements in diagnostic capabilities, targeted public health interventions, and continued research to refine understanding of malaria dynamics.

Recommendations include the adoption of species-specific diagnostic tests and the implementation of localized control measures, tailored to the unique environmental, demographic, and seasonal patterns observed in high-prevalence areas.

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