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Epidemiology of Malaria during the Summer Season among the Provinces of Pakistan

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ABSTRACT

Malaria is an important public health problem in Pakistan especially during the summer season when environmental conditions are favorable for malaria transmission. The objectives of this study were to find out prevalence of malaria and its distribution in different age groups, gender, species and in each month among patients visiting hospitals in Pakistan. Retrospective cross-sectional study was performed with laboratory records from April to July 2025. The patient records with complete demographic and diagnostic data were 400 in total and were included in the analysis. Laboratory registers were used to extract data which were analyzed using descriptive statistics in MS-Excel. The prevalence of malaria was determined as the percentage of positives to the number of samples tested. Of the 400 patients tested, 82 were positive to malaria with overall prevalence of 20.5%. The prevalence was higher among children (0-14 years of age) (24.8%) than among adults (15 years of age and older) (15.8%). The prevalence of malaria was also higher in males (23.6%)

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as compared to females (16.7%). Species analysis showed that Plasmodium vivax was the common species resulting 70.7% positive; Plasmodium falciparum was 26.8% positive and mixed infection was 2.4% positive. P. vivax was the predominant species in both children and adults. Malaria prevalence showed an increasing trend during the summer season as the prevalence increased from 15.8% to 26.0% from May to August during the monthly analysis. The results show that malaria is still highly prevalent during summer months in Pakistan with a greater impact on children and males. The high prevalence of P. vivax and the rise in prevalence at the end of the summer emphasize the need to build up surveillance, prevention, and prompt control intervention to limit malaria transmission in the area.

Keywords: Malaria, Prevalence, Plasmodium vivax, Plasmodium falciparum, Children, Summer Season, Pakistan.

Introduction

Seasonal variation is not a factor in school, but a reality impacting people's lives. The issue of seasonal variation is not an academic one, it is a reality that impacts on people's lives. Has implications for hospital preparedness. In the summer months when the number of malaria cases has been consistently increasing, the hospital can have the adequate number of kits, anti-malarial drugs and trained staff in place to prevent the situation deteriorating. If however the increase is not too great, then resources can be used elsewhere. Some district hospitals in Pakistan maintain laboratory registers recording the date of each test performed, which enabled the analysis of seasonality at each laboratory, with no additional expenses. But a so simple analysis is not often performed (Bilal et al., 2019).

The seasonality of malaria has been reported in a number of studies from south Asia. A multi-district study in India revealed that the malaria burden from the summer and early monsoon (May-August) months contributed almost 60% of the annual burden and July experienced a sharp peak of malaria cases. In Bangladesh, the relationship between meteorological variables and malaria cases is positive and there is an apparent lag of 2–4 weeks between the meteorological variables and incidence of malaria cases, suggesting a predictable delay between meteorological changes and malaria outbreaks. The other study, from southern Punjab, found that the number of malaria cases started to increase from May, peaked in September and

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fell following November. The authors reported that 45% of the variation in the number of cases occurred from the summer temperatures alone (Riaz et al. 2021).

Biological basis of summer transmission is known. The more time the parasite takes to develop outside of its host (the extrinsic incubation period of Plasmodium in the mosquito), the more time the parasite takes to develop outside of its host (the extrinsic incubation period of the parasite in man). It takes about 30 days for P. vivax to develop at 20°C, and 12-15 days at 30°C. There is a similar temperature-dependent increase in the rate of P. falciparum. Furthermore, the length of feeding and survival of adult mosquitoes is also affected by an increase in temperature. Similarly, the adult mosquito's chances of survival will be greater in a certain temperature range, and the frequency of feeding will also increase in warmer temperatures. Very high temperatures (above 35-38C) do however have the capability to lower the survival of the mosquito, which leads to a non-linear relationship between summer heat, and transmission. This brings about a complication, which makes it imperative that local, empirical data be used (White, 2018).

Although there are clear biological arguments for the existence of summer seasonality there is a lack of evidence at the district level in Pakistan. The majority of studies published look at the data for entire years or several years, and fail to show within-year trends. Because there are no specific and locally relevant numbers, hospital administrators and clinicians only have a general idea of the malaria and are not given any directions for preparing for the upcoming malaria season. Furthermore, the population movement during the summer season in Pakistan due to travelling for marriage, religious festivals and agricultural labour also takes place. These movements can introduce new strains into low background areas, and result in local outbreaks difficult to predict unless a baseline data source is available which can identify the background strain in the target area (Ali et al., 2020).

The present work is set out in this background to fill the lacunae by determining the prevalence of laboratory confirmed malaria in a District hospital during Summer season. Secondary objectives are: To compare the summer malaria positivity rates with the pre-summer baseline rates (if available), age and gender distribution of malaria cases during the summer, and to identify the predominant

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species of Plasmodium in summer. The results will be used to guide the hospital in seasonal preparedness, sustain correct diagnostic suspicion for malaria during the summer months and add a local data point to the overall knowledge of malaria seasonality in Pakistan (Saleem et al., 2021).

Malaria is a serious public health issue, despite decades of efforts by many developing countries to control the disease. According to the World Health Organization (WHO) (2023), approximately 78% of all malaria deaths in the world occurred in children under 5 years of age and about 249,000 of these were due to malaria in 2022. This is a highly inequitable burden since the immunity acquired in utero is less than in the immune adults and the newly born infant is readily vulnerable to attack by Plasmodium parasites after birth and suffers from severe disease in the endemic area. Adults that have been infected several times, however, may also develop partial immunity, which will reduce the parasite density and clinical signs, but not eliminate the parasites (White, 2018).

Pakistan is one of the 8 countries of Eastern Mediterranean Region having 95% share in the burden of malaria in the region. Approximately 1.6 million cases of malaria are reported annually in Pakistan but the actual number is likely higher due to underreporting of cases in rural and remote areas in Pakistan (Khan et al., 2019). The two most common species are Plasmodium vivax and Plasmodium falciparum with the ratio of their distribution by region. P. vivax is mostly prevalent in plains and irrigated regions of Punjab and Sindh while P. falciparum is more common in the border mountainous areas with Afghanistan (Riaz et al., 2021).

The current study seeks to fill these gaps by estimation of prevalence of laboratory confirmed malaria in the summer season at District hospital located in a district. Secondary objectives are to compare the positivity rate for the summer period with the pre-summer period basic line of observation (if available), describe the age and gender distribution of malaria cases in the summer period and determine the main species of Plasmodium in the summer. The results will be used to inform the hospital's malaria preparedness initiatives, ensure they remain vigilant with their malaria diagnosis during summer, and contribute a local context to the current understanding of malaria seasonality in Pakistan (Saleem et al., 2021).

This study will reveal the malaria positivity in which age group and the study will

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assist the hospital to identify the age groups that has greater malaria positivity. This can help in the appropriate suspicion of malaria in the clinic based on the patient's age. Anti-malarial drugs and RDTs can be sent to the appropriate wards in hospital. The age group most impacted by the disease can be targeted by public health messages. The study also shows that local evidence can be created at no additional cost and using the data collected in the labs as part of routine work (Ali et al., 2020; Saleem et al., 2021).

LITERATURE REVIEW

Despite decades of malaria control and large sums of money invested the disease is still one of the biggest vector-borne diseases in the world. WHO estimates that there were 249 million clinical cases of malaria and 608,000 deaths in the world in 2022. Most cases (c. 94%) and deaths (c.95%) are in Sub-Saharan Africa. But transmission is also high in the Eastern Mediterranean Region (EMR) that includes Pakistan with an estimated 8.3 million cases annually. Most fatalities are in children younger than 5 years of age, have no acquired immunity to the parasite, and are at high risk. This is not evenly spread throughout the entire year. Malaria is endemic in most countries, seasonal, related to rainfall, temperature and humidity. Awareness of this seasonality is critical to make predictions of outbreaks and plan resource allocation and control programs (World Health Organization, 2023).

The second most important climatic factor affecting malaria seasonality is rainfall. The genus Anopheles requires the presence of standing water for the aquatic part of its life cycle. Eggs are deposited in water and larvae live in water in the form of small puddles or large irrigation canals. Lots of rain will create a lot more temporary breeding sites and if it is really heavy it may wash out the larvae and reduce mosquito numbers. Moderate rain and warm weather, on the other hand, create ideal conditions for the breeding of mosquitoes. The monsoon season in Pakistan (July to September) brings the largest share of the annual rainfall making many breeding grounds in the rural and peri-urban areas. However, in some districts, districts that irrigate large areas have higher mosquito populations even in drier times and thus have more complicated mosquito seasons than other districts. Due to this complexity it is essential that seasonality is not assumed from national data averages but looked at a local level (Khan et al., 2019).

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According to the World Health Organization (WHO) Pakistan is a moderately to highly malnourished country in certain parts, which are predominantly border regions with Afghanistan and India. Malaria elimination is a national goal and some regions of the country have not experienced equal progress. There are high burden districts in Balochistan, KP and Sindh provinces with level of transmission that, although lower, is still significant in Punjab. The national surveillance system reports an estimated 1.6 million malaria cases every year, but this is also thought to be an underestimate. Most of them are not reported and are dealt with in private clinics or by self-medication. The rural districts are the least likely to have access to diagnostic testing, healthcare resources and are most likely to have limited reporting of access to care. Laboratory studies in hospitals are very valuable as an indicator of confirmed cases in a particular catchment area, in the absence of adequate surveillance (Khan et al., 2019).

There are two main species of Plasmodium, P. vivax and P. falciparum, which are predominant in Pakistan. P. vivax is much more prevalent, and makes up about 60% to 70% of the confirmed cases in most districts. This species is more widely geographically distributed than P. falciparum, being able to grow at lower temperatures and in a wider variety of mosquito vectors. P. vivax also has a latent liver stage known as hypnozoite which can be reactivated several months after infection causing relapses. This biological feature of P. vivax renders it particularly hard to be eradicated. Though not prevalent in Pakistan, P. falciparum is more hazardous as it leads to severe malaria like cerebral malaria, severe anemia and death. The infection caused by P. falciparum is very acute, and may progress to a worse state in a few hours if left untreated. In addition, the incidence of P. falciparum cases also increases in areas near the Afghanistan border with increased intensity and seasonality as in Khyber Pakhtunkhwa and Balochistan (Riaz et al., 2021).

Materials and Methods

Study Design and Setting

To determine malaria prevalence in the summer season a cross-sectional study was carried out based on laboratory records. The data were collected from the Pathology and Microbiology laboratory of the District Hospital, Sindh in Pakistan, which is located in an urban and a rural area.

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Study Duration and Population

The study period lasted Four months (April to July 2025) covering the period of maximum malaria transmission. All patients who had laboratory tests and presented with fever and/or malaria-suggestive symptoms were included. Data from both inpatients and outpatients were included, and multiple tests were only counted on the first date of the test for the same patient.

Inclusion and Exclusion Criteria

Only patients with documented age and definite malaria test result (positive or negative) were included. Records that lacked or had uncertain information or were duplicates were omitted from the analysis.

Sample Size and Data Collection

Convenience sampling was done with a total of 400 patient records. Information collected was patient serial number, date of testing, age, sex, method of testing (RDT or microscopy) and the test result (positive or negative). For microscopy, the species of parasite determined by the test was recorded (Plasmodium vivax or P. falciparum or mixed). The age groups were defined as children (aged 0 to 14 years) and adults (aged ≥15 years).

Laboratory Methods

New tests were not conducted. Malaria diagnosis had been done by the conventional methods, which included the use of commercial rapid diagnostic tests for P. falciparum (HRP-2) and non-falciparum species (pLDH), and Giemsa stained thick and thin blood smears, examined at 100x oil immersion by trained technicians.

Data Analysis

Microsoft Excel was used to calculate descriptive statistics. Prevalence rates were calculated for overall and subgroups according to monthly variation, age and sex, and species. The mean and median age of the positive cases were calculated. Data were tabulated, presented in numbers, percentages and in bar charts.

Ethical Considerations

The laboratory serial numbers were recorded whilst maintaining patient confidentiality. Consent was secured from the hospital administration and data was kept on a password protected computer for academic purposes only. There was no contact with the patients, and no formal ethical approval was needed.

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4.Results

A total of 400 patients have been tested for Malaria during the 4 months' summer study in the district hospital laboratory. Out of these, 82 people were diagnosed with malaria, the malaria prevalence was 20.5%. The other 318 (79.5%) were negative.

4.1 Age Distribution of Study Participants

Among the 400 patients tested, 210 (52.5%) were children aged 0 to 14 years, and 190 (47.5%) were adults aged 15 years and above. Patients' ages were between 6 months and 65 years. The mean age of all patients analysed was 18.4 years and the median age was 14 years.

4.2 Age-Specific Malaria Prevalence

A total of 210 children were tested and 52 were positive for malaria giving a prevalence of 24.8% in children. A total of 30 adults were positive from a total of 190 tested adults resulting in a prevalence based on adult age group = 15.8%. The prevalence of malaria was higher during summer season in children than adults. The age of cases with positive results spanned from 1 year to 58 years. The median age was 12 years and the mean age was 16.2 years for the positive cases.

Table.1: ***Age-Specific Prevalence of Malaria***

Age Group	Number Tested	Number Positive	Prevalence (%)
Children (0–14 years)	210	52	24.8%
Adults (≥15 years)	190	30	15.8%
Total	**400**	**82**	**20.5%**

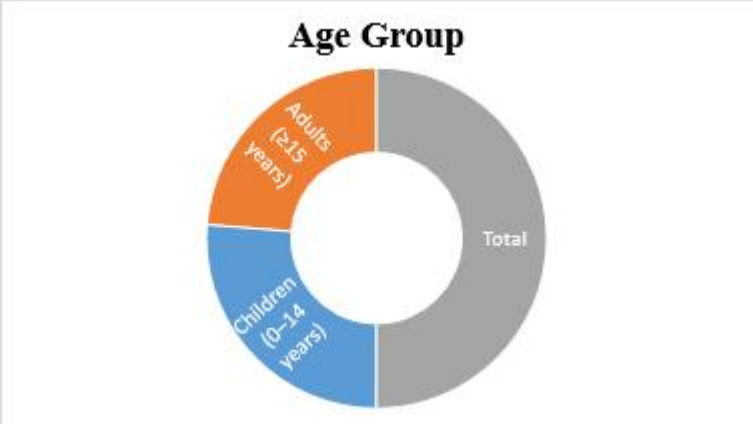


Figure.1: Comparison of Malaria Prevalence Between Children and Adults

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Figure 1 shows that overall, children had a higher prevalence of malaria than adults. Overall, children were found to have a higher prevalence of malaria than adults, as illustrated in Figure 1.

4.3 Gender Distribution of Malaria Prevalence

The Bar chart in figure 1 indicates that the prevalence rate of malaria was higher in children than adults in summer and the prevalence rate was 24.8% and 15.8% in children and adults respectively. A higher proportion of children than adults were affected.

Table 2: ***Gender-Specific Prevalence of Malaria***

Gender	Number Tested	Number Positive	Prevalence (%)
Male	220	52	23.6%
Female	180	30	16.7%
Total	400	82	20.5%

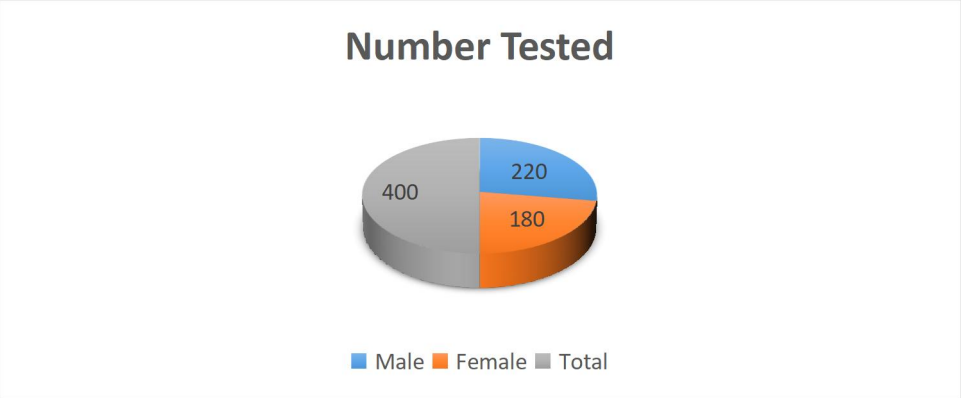


Figure 2: Comparison of Prevalence between gender-wise

4.4 Species Distribution of Malaria Among Positive Cases

Among the 400 patients tested, 220 (55.0%) were male and 180 (45.0%) were female. Of the males 52 tested positive (23.6%). A prevalence of 16.7% was observed for females, with 30 being tested positive. There was greater malaria prevalence among males than females in the summer season. A total of 55 cases were identified in patients with malaria. In patients with malaria, 55 species were identified. Out of the 82 positive cases, 58 cases were found to be Plasmodium vivax (70.7% of total positive cases). Of all the cases, 22 were of Plasmodium falciparum or 26.8%. Of all positive cases, 2 were found to be mixed infection (P. vivax and P. falciparum).

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During the summer there was an abundance of P. vivax.

Table. 3: Species Distribution Among Malaria Positive Cases

Species	Number of Cases	Percentage (%)
Plasmodium vivax	58	70.7%
Plasmodium falciparum	22	26.8%
Mixed (P. vivax + P. falciparum)	2	2.4%
Total	82	100%

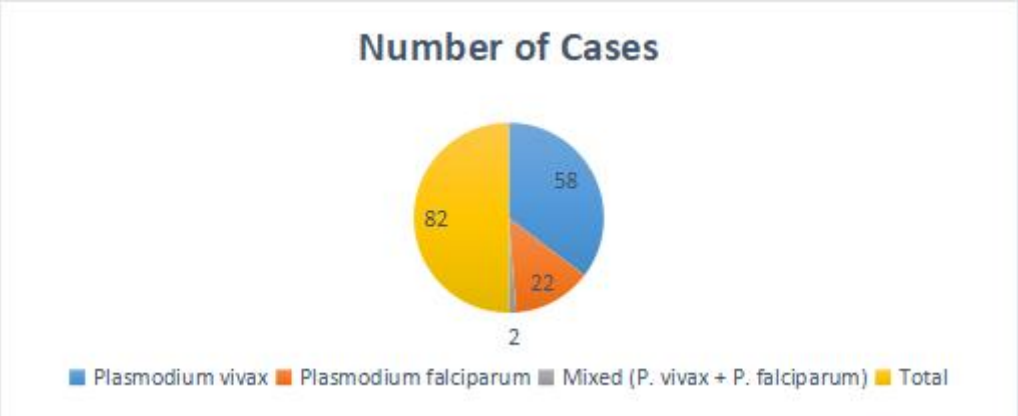


Figure 3: Species Distribution of Positive Cases

Figure 4.3 Pie chart showing species distribution among 82 malaria positive cases. P. vivax accounted for 70.7%, P. falciparum accounted for 26.8%, and mixed infections accounted for 2.4%.

4.5 Species Distribution by Age Group

Among the 52 positive children, 38 (73.1%) had P. vivax, 12 (23.1%) had P. falciparum, and 2 (3.8%) had mixed infection. Of the 30 positive adults, 20 (66.7%) were positive for P. vivax, 10 (33.3%) were positive for P. falciparum and none were mixed infected. P. vivax was the predominant species in both age groups with the P. falciparum proportion slightly higher in adults than children.

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Table 4: ***Species Distribution by Age Group***

Species	Children (0–14 years)	Adults (≥15 years)
P. vivax	38 (73.1%)	20 (66.7%)
P. falciparum	12 (23.1%)	10 (33.3%)
Mixed	2 (3.8%)	0 (0%)
Total	52 (100%)	30 (100%)

4.6 Monthly Variation in Malaria Prevalence

Malaria prevalence was different in the four summer months. The minimum prevalence was recorded in May while the maximum prevalence was recorded in August. The trend pattern revealed a gradual rise in malaria positivity from the onset to the conclusion of summer season on a monthly basis.

Table 5: ***Monthly Variation in Malaria Prevalence***

Month	Number Tested	Number Positive	Prevalence (%)
April	95	15	15.8%
May	100	19	19.0%
June	105	22	21.0%
July	100	26	26.0%
Total	**400**	**82**	**20.5%**

Discussion

This study was conducted to ascertain the malaria prevalence in the Country's some districts hospitals in summer season. Overall, there was a total of 400 patients tested throughout the four months of the summer period and a malaria prevalence of 20.5% was observed. The results support the fact that the summer is a high transmission period for malaria in this area. The findings of the present study are similar to that of other districts of Khyber Pakhtunkhwa. In the neighboring Bannu district, the occurrence of Malaria in febrile population for the summer season was reported 22.3% which was similar to the present study (Khan et al., 2019).

However, it is more than reported in some districts of Punjab in this study. The study conducted in the southern part of the province of Punjab with the hospital-based setting, indicated that prevalence rate of malaria in summer period was approximately 14% (Riaz et al., 2021). The higher prevalence in the present

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study might be due to climatic and geographical differences between Khyber Pakhtunkhwa and Punjab. Furthermore, it has been observed that in the past, the districts of KPK have been suffering from malaria more than that of the districts of Punjab (National Malaria Surveillance Reports, WHO, 2023).

However, a study conducted in rural Sindh indicated prevalence of malaria in summer was 26.5%, a figure which is greater than the present study (Ali et al., 2020) which showed 20.5%. One reason for the higher prevalence in Sindh is that there is a lot of irrigation system there to provide year-round breeding opportunities for mosquitoes. This comparison underscores the need to consider local environmental factors in understanding the intensity of malaria transmission.

The prevalence is higher in children, for several reasons. Firstly, the immune system of children is not fully developed and children have not yet developed partial immunity to the malaria parasites. Adults can be less prone to clinical disease due to repeated exposure to adults in endemic areas, and adults can develop immunity to clinical diseases after multiple exposures (White, 2018). Second, children are more outdoors during the summer vacation when they play in the evening or early morning when the Anopheles mosquitoes are most active. Third, during hot summer nights many rural households sleep out of doors on their roof tops or in courtyards without bed nets thus exposing children to mosquito bites without protection. This increased prevalence is likely to be due to these behavioral risk factors in children.

In the present study, both the sexes showed different prevalence of malaria, with higher prevalence being found in males (23.6%) than in females (16.7%). This gender gap has been observed in multiple studies both in Pakistan and other endemic countries. The study conducted in south Punjab revealed that males had 62% positivity rate of all the malaria positive cases which was significantly higher than females who had 38% positivity rate (Riaz et al., 2021). The rural Sindh study also showed a higher number of positive cases among males, particularly young adult male farm labourers (Ali et al., 2020).

The study identified that there is higher percentage of P. vivax (82%) and lesser percentage of P. falciparum (16%) and 2% (mixed infections) in rural Sindh. This may be explained by the heterogeneity of the species of mosquito vectors in Sindh and higher proportion of P. vivax in Sindh. It is clear that some species of the

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Anopheles genus are better vectors of P. vivax and others are better vectors of P. falciparum. Additionally, P. vivax is capable of relapsing from dormant liver stages, which may account for the higher proportion of P. vivax in areas of seasonal transmission as relapses may occur months after the initial infection (White, 2018).

In this study, there was a gradual rise in the prevalence of malaria from May (15.8%) to August (26.0%) across all the months. This rise is in line with knowledge on the biological nature of the transmission of malaria during the summer season. As the summer goes on, the temperature is going up, humidity is going up and the population of mosquitoes is growing. As the summer progresses, the number of infected mosquitoes and the reduction in the parasite's extrinsic incubation period contribute to the continued rise of transmission rates (White, 2018).

This trend of rising malaria cases was followed in the southern region of Punjab with a rise in cases of malaria in May, a peak in September and a decline following November. But in present study the peak period was earlier (August) as compared to the study conducted in Punjab (September). This difference may be due to the different timing of monsoon rains in the two regions. Geographic differences in seasonality is relevant to hospital preparedness as they need to build hospital-specific seasonality, rather than relying on regional seasonality (Bilal et al, 2019).

This study has some limitations which need to be recognized, however. The study was based on a District hospital and results of study cannot be applied to other hospitals of other ecological zones in Khyber Pakhtunkhwa and other provinces. Data are drawn from existing laboratory records and the accuracy of the data in this study is dependent on the accuracy of data entry in the original records. Several of the recording mistakes might have been intentional, some of the data might not have been complete, and some species might have been misclassified. Only patients presenting to the hospital were included and those who were tested for malaria not those who did not seek treatment and were asymptomatic and those who self-medicated or attended private clinics. Lastly, some risk factors that may explain some of the differences between age groups and gender were not captured Bed net use, Housing type, Travel history (Bilal et al., 2019; Saleem et al., 2021).

Nevertheless, this study provides some local evidence of the prevalence of malaria in summer. The findings will aid the district hospital in its seasonal preparedness

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planning, to optimally use its resources and to prioritize its interventions in the most vulnerable age group and gender. The study also illustrates the use of the routine laboratory data for epidemiological surveillance, which is a low-cost strategy that can be easily implemented in other district hospitals (Noreen et al., 2020).

Conclusion

The aim of the study was to find out the prevalence of malaria in summer season at some District hospitals. Four hundred patient records were analyzed for a four-month summer. The malaria prevalence rate was 20.5% which shows that the area has a high malaria transmission season during summer. Children (0-14 years) were overrepresented (24.8%) as compared to adults (aged 15 years and over) (15.8%). There was gender difference in the prevalence with males (23.6%) being more prevalent than females (16.7%) owing to the fact that males are more exposed than females to mosquito bites. Most of the cases were infected with *P. vivax* (70.7%) followed by *P. falciparum* (26.8%) and *P. ovale* (2.4%). There was a continuous increase from April (15.8%) to July (26.0%) showing a trend to increasing malaria prevalence during the summer.

The result obtained in the study confirms that malaria is a severe public health problem among the population, children and males being the most affected group in summer. The high prevalence of *P. vivax* has implications on treatment because *P. vivax* needs to be treated with primaquine alongside blood stage treatment to prevent the occurrence of relapses. This is an upward trend throughout the summer, indicating that this transmission is growing over the summer, and peaks in late summer.

Recommendations

On the basis of the results of this study the following recommendations were made:

1. Adequate malaria RDT kits and anti-malarial stocks should be available throughout the summer season at the hospital with extra kits and drugs to be sourced prior to May to cater for the high demand from May to August.
2. More active monitoring of malaria should be carried out in the summer season and reporting of laboratory confirmed malaria cases should be done on a weekly basis, looking out for any early malaria outbreaks.
3. Future research should focus on collecting the data on behavioral and

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environmental risk factors (e.g. bed net use, sleeping position, type of housing, as close to standing water) to understand the factors behind age and gender-specific risks of malaria.

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