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GEOSPATIAL DISTRIBUTION OF MALARIA PARASITE AND ITS ASSOCIATED VECTORS IN DISTRICT NOWSHERA

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Abstract
Mosquitoes achieved top ranking among the lethal creatures in the world, as it causes deaths of millions of people annually by acting as vectors of different diseases globally. It creates chaos in the world by spreading Malaria, Chikungunya, Arbovirus, Encephalitis, Filiarisis, Zika virus, Yellow fever and Dengue. A research study was performed to check the relative abundance of adult mosquito and spatial distribution of malaria parasites in district Nowshera.Adult mosquitos were collected from animal rooms and human dwelling areas by using **Flit method**; protocol. The duration of collection of mosquitos was of 1 year. Collected mosquitos were identified by using taxonomic key by Christopher and Barraud up to species level. A total of 9913 adult mosquitos were collected which includes 4825 males and 5088 female mosquitos belongs to 5 genras Culex, Anopheles, Armigeres, Monsonia & Aedes. A total of 16 species were identified.Culex pipiens quinquifasciaituswere found outnumbered.. For comparing and check the current condition of malaria data of last 5 years were examined i.e. Aug 2016 to Jul 2021.The input data were based on the geospatial factors including climatic, NDVI and Topographical aspects. The data was analyzed using spreadsheet excel and SPSS. For vectors of malaria and its temporal distribution likewise accurate positioning and map making; data was collected from GIS and Remote sensing tools. The integrated malarial data was analyzed and relation with vectors abundance was examined. The data shows a gradual fall from 2016 to 2020 and formerly a slight inclination in the current year. Plasmodium vivax was found prevalent as compare to P.falciparum followed by mixed cases. Months of July, August, September & October were found to have high abundance of Anopheline mosquitos as well as the prevalence of malarial parasites. Age group of 15 and above were founded to be highly affected as compare to lower age groups.

INTRODUCTION

Mosquitoes are a nuisance species that may be found all over the world, in a variety of biotopes, and can transmit diseases to humans and animals[1] Protozoan parasites of the plasmodium genus

cause malaria there are four species of Plasmodium which are the source malaria in man, which vary in intensity depending upon the species. Mosquitoes exhibit spatial and temporal distribution based on species, climatic conditions and environment [2] } Latest WHO Malaria Report presents the current situation of malaria, stating that the number of malarias affected people across the globe has reached to about 219 million in 2020. Pakistan is the most vulnerable country in the world to malaria. There are 109 countries where Malaria persists in epidemic form and Pakistan is included in the list [3]There are 465 species of Anopheles in the globe, 70 of which are Malaria vectors. In Pakistan, there are 134 mosquito species belonging to the Anophelinae and Culicinae subfamilies. The incidence of mosquito-borne illnesses tends to increase when the climate of South Asian nations changes [4].

Malaria spatial and spatiotemporal research, including incidence, prevalence, mortality, risk assessment, and many other characteristics, have aided in the effective design and execution of malaria control and preventive programs in a variety of ways.

Geographically separated into two zones, each having a low, unstable transmission rate; yet, these zones cover a large geographic and demographic region. Understanding the disease's spatiotemporal distribution among these strata is still required for a successful control approach.

A three-year study on the mosquito fauna of the Chokara area of District Karak from January 2013 to January 2016. A total of 3479 mosquitoes were found, divided into eight species and three genera. Culex, Anopheles, and Aedes are among their findings. Culex quinquefasciatus, Culex mimeticus, Culex theileri, Anopheles maculates, Anopheles stephensi, Anopheles annularis, Aedes albopictus, and Aedes shortii were among the species detected [5] A survey was conducted examined 1684 mosquitoes from 491 sites in Punjab and Khyber Pakhtunkhwa, Pakistan, from 2010 to 2013. It found 32 species, with Culex quinque fasciatus dominating the assemblage (61 percent of the collection). The genus Aedes was represented by six taxa, with the two dengue vector species, Aedes albopictus and Aedes aegypti, being the most common and widely distributed. Anopheles was responsible for another 6% of the capture, with An. subpictus dominating. The geographical distribution of Aedes aegypti and Aedes albopictus showed that the latter was more common and could be found in both rural and urban areas A detai[6]led survey was conducted in Lahore to identify the mosquito species makeup. Mosquito larvae, pupae, and adults were collected in Lahore at various places. Anopheles, Culex, Aedes, and Mansonia were among the 8656 mosquito species detected. Among the fifteen species gathered, Cx. quinque fasciatus was the most numerous, while An. culicifacies was the least abundant. In August, the most mosquito variety was recorded, whereas in June, the least diversity was observed [7]. Another study looked at the geographical distribution of asymptomatic malaria infection among children under the age of five in 24 Burkina Faso health districts and found the factors that influenced it. A total of 38.2 percent of children under the age of five years were found to have asymptomatic malaria infection [8]

To evaluate the role of very-high-resolution data in predicting the geographical distribution of urban malaria incidence over broad spatial extents in two Sub-Saharan African cities, Kampala and Dar us Salaam, in this study. The findings indicate that PfPR2–10 spatial distribution in both cities is diversified and highly variable across the urban fabric. PfPR2–10 has a positive connection with dense informal settlements, and malaria hotspots have been discovered near ideal vector breeding areas such as wetlands, marshes, and riparian vegetation. The findings of this study reveal that people living in informal settlements had a greater malaria incidence than people living in planned residential districts

varied proportions and seasonal abundance, following baseline research [9]

Scientists used remote sensing technologies to produce a map to elucidate the causal variables and with the probable habitats of malaria vectors (An. arabiensis and An. fenestus) in the Vhembe District Municipality of South Africa. In the research area, both Landsat TM and Sentinel-2 datasets were employed. The spread of P. falciparum is strongly connected with vegetation wetness and greenness, according to the findings of this study. Remote sensing data, such as that from Sentinel-2, has, on the other hand, demonstrated a strong association with the distribution of cow hoof prints, which are recognized malaria vector habitats. The importance of remote sensing spectral indices,

such as those based on broadband reflectance, in describing the resting locations of An. complex has also been demonstrated in this work [10] A detailed survey in the Bagh district and some surrounding areas of Azad Jammu and Kashmir from May to October 2017 to determine the biodiversity of mosquitoes. Anopheles barianensis, Culex barraudi, Culex epidesmus, Culex fuscocephala, Cx. pipirms fatigans, Cx. pipiens pipiens, Cx. pseudovishnui, Cx. vishnui, Aedes aegypti, Aedes micropterus, and Armigeres subalbatus were among the eleven mosquito species collected from the study region. Armigeres subalbatus was the most common specie [11]
Another survey was done in tropical Australia. A total of 15,000 mosquitos were collected for the study, with 26 species and eight genera identified. The most prevalent species across all habitat types was Culex annulirostris, whereas Verrallina lineata and Culex pullus were more common in forest interiors. Their findings suggest that man-made grasslands near rainforests may increase the susceptibility of species in both habitats to disease transmission by causing noticeable changes in the vector population on rainforest borders [12] the spatial and temporal patterns of malaria parasites distribution in District Nowshera.mosquito diversity and identify malarial vectors in the region.And prepared malaria hazard & Vulnerability element at risk map by using remote sensing tools to provide sufficient data regarding prevalence pattern of vector and parasite. Malaria spatial and spatiotemporal research, including incidence, prevalence, mortality, risk assessment, and many other characteristics, have aided in the effective design and execution of malaria control and preventive programs in a variety of ways.

MATERIAL AND METHODS

Study Area

The proposed study was conducted in 3 tehsil of District Nowshera Khyber Pakhtunkhwa. The selected district includes tehsils of Nowshera, Pabbi and Jahangira with a total of 47 union councils. Study was performed in selected area of Distt Nowshera. Nowshera is situated on southern side of Mardan along with bordered by Charsada on north-west Peshawar district on west and Attock on east side.

Data collection

The summarized information regarding malaria is obtained for the intended study with the help of locals, BHU, DHQ and others well known. Public healthcare facilities are responsible for the diagnosis of malaria in every single tehsil. All the cases are diagnosed using methods and tests advised by WHO such as microscopy and rapid diagnostic test. All this information is combined in the form a summary sheet and forwarded to the Health secretariat. This summarized information is used in the current study.

Mosquito collection

Collections of mosquitoes are performed in three selected tehsil which include Pabbi, Nowshera and Jahangira. Flit method is used for the collection of mosquitoes. White fabrics are used for easier spotting of mosquitoes. Binocular Microscope is used for identification on the basis of morphological features. to identify the specimens up to species level using taxonomic identification keys based on morphological characters given in “The Fauna of British India including Ceylon and Burma” by Christopher and Barraud [1].

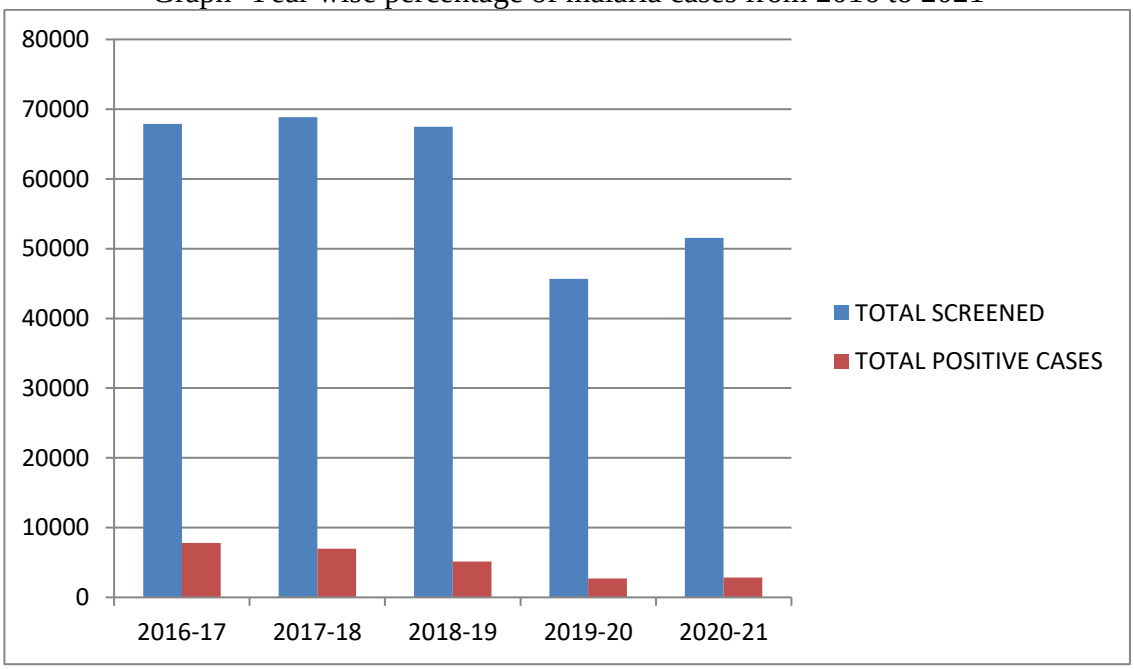
Data Analysis

The malaria prevalence data for the selected districts are obtained from DHQ and BHU were analyzed in a series of steps. Statistical analyses are performed using SPSS. The spatial distributions of malaria disease in the selected districts are analyzed by different software’s including MS Excel and GIS. Microsoft excel were used for the compilation of data on malaria cases keeping in view the needs of the Geographic Information System software. The malaria hazard analyses were computed using multi criteria evaluation using environmental factors such as topographic factors

(elevation) land use/ land cover, NDVI, then weighted overlay technique were computed in software to generate malaria prevalence map using different satellite approaches

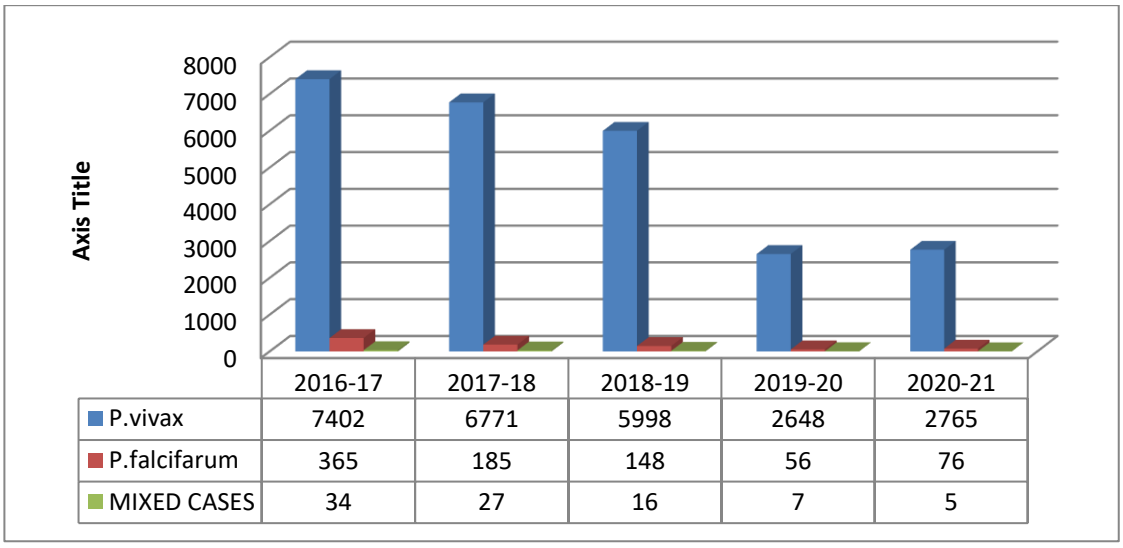
RESULTS

Graph Year wise percentage of malaria cases from 2016 to 2021



Graph shows indicates a gradual fall in total malarial cases from 2016 to 2021 this is due to the administrative facilities due to which the remote areas are being accessed under malarial control program. In 2016- 17 the number of screened cases were 67893 and total positive cases were 7801(11.49%) and later on falls to 5.52% gradually. Lowest cases reported in 2020 and 2021 this is due to corona pandemic major areas were sealed under lockdown due to which not many cases were reported. Beside this due to availability of medical labs facility locally majority of population prefers public labs of screening.

Year wise malaria incidence in District Nowshera 2016-2021

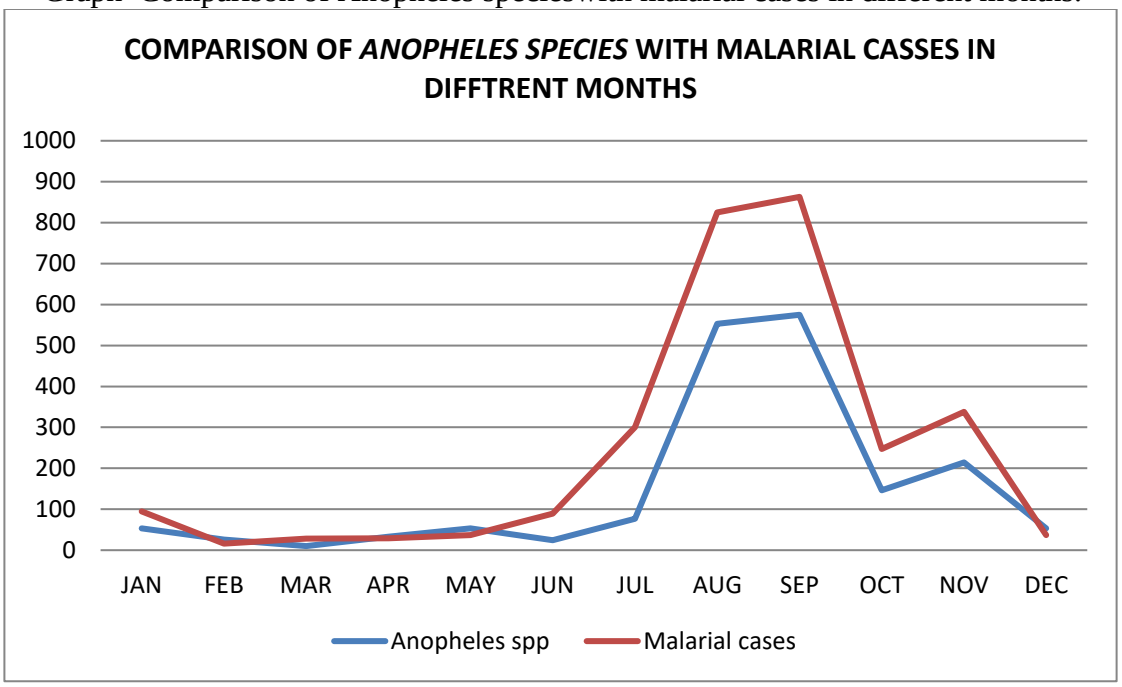


	2016-17	2017-18	2018-19	2019-20	2020-21
P.vivax	7402	6771	5998	2648	2765
P.falcifarum	365	185	148	56	76
MIXED CASES	34	27	16	7	5

Plasmodiumfalciparum and Plasmodiumvivax are the most common causes of malaria in humans, and they are transmitted by the same Anopheles species. In District Nowshera as the table indicates majority of the malarial cases were caused by P.vivax followed by P. falciparum and low cases are

of mixed type. A gradual fall in cases caused by P.falciparum can be seen from 2017 to 2019 and then a slight increase in the year 2020-21. Same is observed in case of P.vivax. A gradual fall in screened cases is also seen due to which the positive cases reported is also falling.

Graph Comparison of Anopheles specieswith malarial cases in different months.



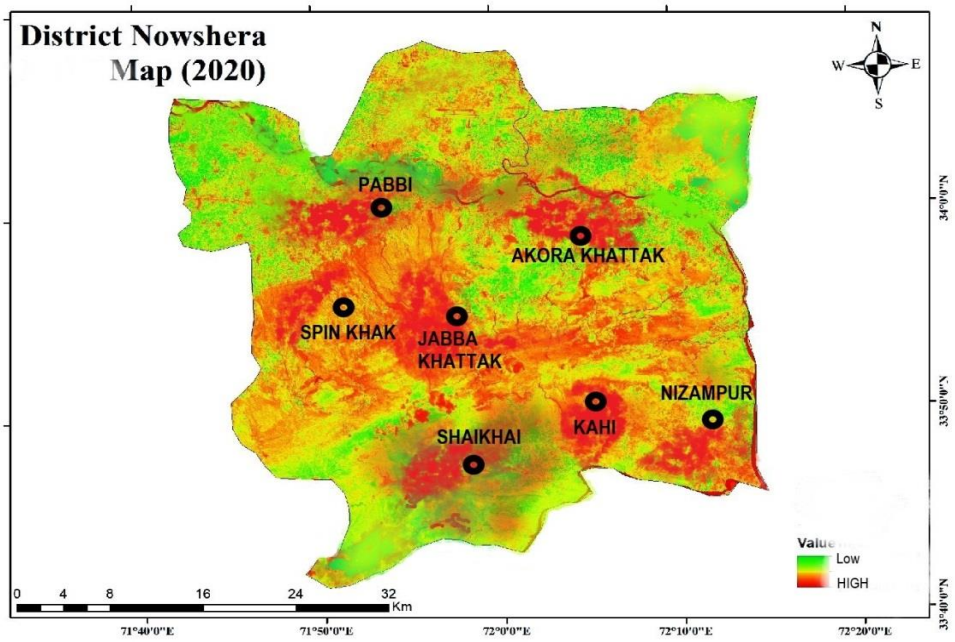
The relative abundance of Anopheles in different months is depicted in graph 4.12. The blue line depicts the distribution over time in different months. The figure above shows that Anopheles population increases during the months of March and April as the conditions become more suitable for them. During the months of May and June, there is a slight drop in mosquito populations due to high temperatures in the area, which can reach 46°C. Once the monsoon begins in the month of July, the conditions become more suitable for flourishing, so Anopheles populations peak in August and September. A gradual decline is expected in the next months.Because malarial cases are linked to the presence of its vector; similar findings have been recorded, such as a steady decrease in positive malarial cases from July to September, which corresponds to the prevalence of distinct Anopheline species.

Year	Cases	Name of Facility						
		Ch-akora khattak	Mrhsm hospital pabbi	Bhu spin khak	Cd jabba khattak	Rhc nizampur	Bhu shaikhai	Bhu kahi
2016-17	Screened	3731	4063	3711	2901	3784	1353	2968
	Positive	425	375	814	1163	721	197	139
2017-18	Screened	3628	4571	3843	2749	3518	1945	2537
	Positive	394	388	889	1214	669	239	121
2018-19	Screened	3863	2885	3354	2263	3204	2278	1749
	Positive	467	463	794	1317	522	227	79
2019-20	Screened	3319	2352	2660	937	2203	546	1260
	Positive	174	271	530	179	482	53	62
2020-21	Screened	2627	3260	2320	1149	2489	739	1365
	Positive	269	163	525	319	758	74	55

Table above shows that the prevalence of malaria in hotspot areas are varying accordingly.since 2016 the climatic chnges and mostly local weather changes affects the flourishing of relative vectors of malaria . Main reason behind this is the over exploitation of natural habitats by

interventions of human activities due to which the forest and wild areas promotes the destruction of natural vegetation. This leads to formation of the swampy and water logged areas which provide suitable breeding zones to mosquitos.

Figure4.16 Hotspots Map of District Nowshera



The maps represent the hotspots areas of the district Nowshera which are very prone to the prevalence of malaria. 1st map represents the situation of year 2016-17. The map indicates that the Jabba kahattak area is having more burden of malaria as compare to other spots; the main reason is that these areas have very diverse factors. On one side it is well settled while on other side good vegetation cover is present which contain standing waters followed by marshy and swampy areas. Due to these factors this area is well suited for flourishing of anopheline mosquitos. Other areas are also under malarial burden like well settled zone of Akora khattak and Pabbi reason behind this is because these are well settled and urbanized due to access and main route Peshawar to Islamabad these areas received outsiders which are also included in the screened cases.

DISCUSSION

Malaria is still a severe health issue in Pakistan. Malaria cases differ noticeably in diverse locations and cannot be evaluated precisely due to non-availability of information. Consequently, it has been tough to estimate the accurate rates of malaria in Pakistan. The analysis of data and consequent results in this study showed that there is a constant increase in malaria cases from June 2016 to June 2021. In Pakistan around 3.5 million supposed and confirmed malaria cases are documented annually. The history of the disease shows our inefficiency to fight and control this disease, as it is still the primary hazard to public health, financial development in numerous countries.

Entomological survey revealed the presence of mosquitoes from five genera which included Culex, Anopheles,Mansonia, Armigeres, and Aedes being represented by Cx. pipiens Cx. Quinquefasciatus,Cx.triataeniorhynchus, and Cx.vishnui. Anophles genera isbeing represented by 9 species An. stephensi, An. cuilicifascies, An. subpictus, An.fluviatalis, An.anularis, An.Splendidus, An. Pulcherimus , An.nigerimus and An.maculatus. Armigeres genra is being represented by Ar.subalbatous while Mansonia has been represented by Mn.crissipes. A total of 2 species has been reported and identifies as Ae.albopictus and Ae.aegyptii. A study by Ashfaqet al,. according to his

finding eleven species were identifies. The finding includes Cx. Pipiens, Cx.vishnui, Ae.aegyptii and Ar.subalbatous. 11]

The same species has been found in the Bagh district and several surrounding areas of Azad Jammu and Kashmir, according to the present study. Khalidet al. did yet another investigation. Their studies revealed three genera: Culex, Anopheles, and Aedes, with a total of six species. Culex quinquefasciatus, Anopheles maculates, Anopheles stephensi, and Anopheles annularis were all found in the Babel Khel District of Karak, Khyber Pakhtunkhwa, Pakistan[12]. As compare to the current study these all species were to be reported. Another study conducted by Basit et al,. in District Peshawar according to his findings the reported species were An.nigerimis, Ar. Subalbatus, Cx, pipens, An, cuilicifascies and An. Stephensi respectively[13]. These all species were reported in the current study conducted in District Nowshera.

Malaria endemicity varies greatly between provinces and even between towns with distinct climates. According to a province-by-province breakdown, the highest number of cases were recorded in Khyber Pakhtunkhwa (29.7%), Sindh (27%), Federally Administered Tribal Areas (FATA) (22.5%), Baluchistan (22.4%), and Punjab (1.1%) during 2017. (Annual Malaria Report, 2020).

During the previous 10 years, the NMCP has seen a six-fold increase in P. falciparum infection. The increase of P. falciparum infection across the country has been connected to treatment resistance to chloroquine. In addition, the temperature is warmer in the autumn, which increases the odds of transmission. Control measures are similarly ineffective and ineffective. The malaria epidemiology is impacted by a variety of environmental and socioeconomic factors that support vector proliferation and, as a result, enhance the parasite-host connection [14]

All the reported cases of malaria from 2016-2021, belonging to the 47 Union councils of the selected District for the study is included in research work. The total number of malaria cases were 25503 during the period 2016-2021.The results of data showed that majority 50.8 percent of the cases were Females.

Data and information from various parts of Pakistan report that males are affected in higher numbers by malaria than the females but in current study a slight uplifting can be scene. A study by Muhammad et al stated that the number of malaria cases among males was 53% in the Punjab province of Pakistan[15]. During the current study the numbers of malaria cases among males were 49% while females showed a prevalence rate of 50.8% in the District Nowshera.

All the stated patients of malaria were separated into three age groups. An assessment was carried out, incidence rates were found to be highest (77.42%) in adults, which consisted of age group of 14 years and above, followed by age group 5-14 years reported (8.02 %) of all malaria cases, the age group consisting of patients less than five years showed lowest incidence rates (14.56%). Similar outcomes were attained from a study by Malik et al., 2012, done in Quetta, where the younger patients from age 1-10 showed 15% prevalence, the age groups above 10 years showed higher prevalence[16] A study by 37 et al,. 71.78% of total malaria cases were observed in adults aged above 15 years old and 8.5% were children's under 15 years old in northwest Ethiopia[17]

Malaria rates changed based on seasonal fluctuations as well. Higher frequency of cases was documented in the months of July, August, September, October, and November. In the present data analysis, higher incidence was found in summer season. In month of January slight increase in cases can be seen this is due to availability of breeding grounds for malarial vectors as the winter prevail the temperature falls up to 7-10 C which makes mosquito unable to survive in outside environment. A study by Mazaharet al., Overall, 25%, 68%, 18% and 16% of the total area of Rawalpindi region was categorized as danger zone for Jun 2009, Oct 2009, Jan 2010 and Jun 2010, respectively[18]. The malaria risk reached at its peak during the monsoon season whereas air temperature and relative humidity were the main contributing factors in seasonal variation in the District Rawalpindi.[19]

The species-wise distribution of malaria in this study showed 96.4% P. vivax, 3.2% P. falciparum and 0.4% mixed infections out of 23942 total cases. A similar study by Khattak et al., 2019 from

Punjab reported species wise prevalence of malaria as: 66.7 % vivax malaria, 23.7% falciparum malaria and 9.6% were mixed infections[82]. A study by Humera Qureshi et al,The prevalence of P. vivax, P. falciparum and mixed infection was 92.4%, 4.7% and 2.9%, respectively in three districts of Khyber Pakhtunkhwa (Bannu, Dera Ismail Khan and Lakki Marwat).[20]

CONCLUSION

Maps has been constructed to represents the prevalence of malaria in hot spot areas. Tables and maps indicate that the areas which are near to the water bodies either natural or artificial are very much suitable for the nurturing of mosquitos specially anopheline. The areas which have good fluctuations of environment are suitable for prevalence and well adopted for malrail parasites. Majority of the malarial parasite

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