Original Research Article

Prevalence and associated factors of malaria in Pushparajgarh block of district Anuppur, Madhya Pradesh, India

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ABSTRACT

Background: The current study aimed to determine the prevalence of malaria and its association with seasonality of malaria and socio-demographic variables in a tribal dominated district Anuppur (Madhya Pradesh).
Methods: This cross-sectional study was based on blood films for malaria parasites (BFMP) data obtained from primary health centers, sub-health centers, community health centers and district hospital. This study was also based on household survey for information on malaria awareness and type of treatment preferred for malaria. From 2014-2016, a household survey was conducted regarding the type of treatment available, assessment of the influence of demographic factors, knowledge, awareness and education on malaria occurrence. Odds ratio were used to analyse the association between the gender, age group, season and types of malaria infection.
Results: Annual blood examination rate (11.81%) and slide vivax rate (0.66%) was highest in 2016. There was decrease in slide falciparum rate in 2016 (1.52%). Slide positivity rate was 3.78%, 3.73% and 2.74% in the years 2014-16. Annual parasite incidence rate was 3.20%, 3.82% and 3.07% in the years 2014-16. *Plasmodium falciparum* positivity rate was 78.13%, 78.17% and 54.49% in the study years and was highest among the females and in the age group of 26 years and above. Distinct seasonality was observed correlating with population dynamics of the vector and climatic and socio-demographic conditions.
Conclusions: The prevalence of malaria in tribal dominated Pushparajgarh area showed seasonality that was governed by mosquitogenic factors, their transmission and socio-demographic status of the population.

Keywords: Malaria, Malaria indicator survey, *Plasmodium falciparum*, Prevalence rate, Socio-economic status

INTRODUCTION

Malaria, a vector borne disease caused by the protozoan *Plasmodium* spp. spreads through bites of haematogenous female adults of *Anopheles* mosquitoes.[1] Five species of *Plasmodium* namely, *Plasmodium falciparum* (PF), *P. vivax* (PV), *P. malariae* (PM), *P. ovale* (PO) *and P. knowlesi* (PK) are responsible for causing human malaria. Among these the species namely, PF and PV are most common and are prevalent in the tropical and the sub-tropical areas.[2] Malaria affects about 300-500 million people each year leading to around 1.5 million deaths.[3]

India ranks next to Africa in the number of malarial cases with around 980 million people at risk, with the PF accounting for about 50 percent of the clinical cases.[4] The northeastern states account for around 91 percent cases of incidence in India while Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka and Madhya Pradesh are other risk regions.

The incidence of malaria is influenced by climate, seasonality, temperature and socio-demographic status of the communities.[5] Temperature and rainfall have a pronounced influence on the life cycle of female

Anopheles mosquito, thereby on the viability of the *Plasmodium* parasite within. Mosquito population increases after prolonged periods of rainfall followed by stagnating water. In semi-arid and/or highland regions malaria transmission shows strong seasonality that varies with the changing environment.[6-9] Climatic and socioeconomic conditions in India are conducive to the transmission of malaria. Nearly ninety percent of PF cases occur among people who are below the poverty line with sixty percent of malaria cases confined to the tribal areas.[10] The tribal communities mostly reside in areas covered with dense forests and/or in areas with difficult terrain and limited transportation facilities.[11] The state of Madhya Pradesh (MP) has around 30 percent tribal population residing in rural areas. The forest-clad regions of MP report very high prevalence of the PV and PFmalaria.[12] MP ranks third in malaria prevalence after Odisha and Chhattisgarh in India and contributed to nine percent of total malaria cases in India in 2015 with an annual blood examination rate (ABER) value more than 10.[13] The annual parasite incidence (API) was 1.22 in 2009 and 1.02 in 2014 while PF and PV were equally prevalent in the MP in 2015.[14]

For the upliftment of the healthcare facilities the state government has established primary and sub health centers in the remote villages while health programs have been initiated in rural areas such as accredited social health activist (ASHAS), auxiliary nurse midwives (ANMs) and multipurpose workers (MPWs).[15] Despite the efforts from government some of the patients are also visiting the traditional tribal healers available in the rural areas.

The studies pertaining to prevalence and treatment of malaria in this particular region are lacking and there is a need to undertake empirical investigations. Further, clinical investigations are also required to identify the type of malaria parasite prevalent in the region. The seasonal variation in the incidence of malaria need exposition as it has not been investigated in the past. Further, the approach of the population towards treatment of malaria needs in-depth investigation as it will provide an estimate of the healthcare needs in the tribal region. The current study was carried to determine the prevalence of malaria, the seasonal patterns of different Plasmodium species infection and its association with seasonality of malaria and socio-demographic variables in a tribal dominated district Anuppur (MP), India.

METHODS

Study area and population

District Anuppur spanning across an area of 3724 sq. km, lies between 22º7' and 23º25'N latitude and 81º10' and 82º10'E longitude, is one of the tribal districts of MP with 47.9% of scheduled tribe (ST) population.[16] The district has been divided into four administrative divisions namely Pushparajgarh, Anuppur, Jaithari and Kotma

(Figure 1). The study region selected is Pushparajgarh, a predominantly rural block with population of 194574 (97917 males and 96657 females), nearly 96% of which resides in 269 villages.[16] The population comprises 16% (36539) children with an age group of 0-6 years. Literacy rate of Pushparajgarh is 60.3% (male 80% and female 65.4%/).[16] Nearly 77% of the total population is ST who prefers to live in and around forested area. This division has two primary health centers (PHC), 15 sub-health centers (SHC) and one community health center (CHC).
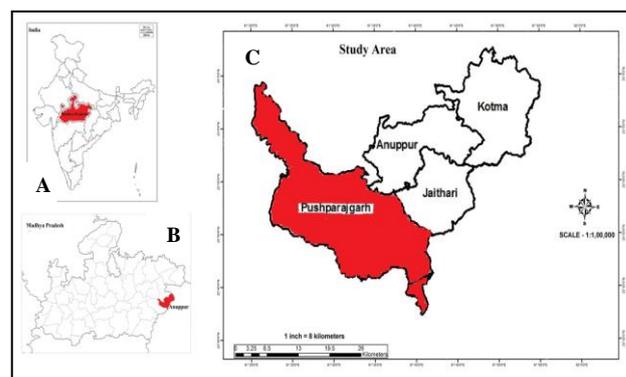
Figure 1: The study site located in Madhya Pradesh, India. (A)The figure represents the map of India and location of Madhya Pradesh. (B) Representative map of Madhya Pradesh and location of Anuppur (C) Representative map of Anuppur and location of Pushparajgarh.

Habit and habitat

Scattered amidst agriculture fields and forest areas, houses are mainly built of mud, thatch and bamboo and are often shared with domestic animals. The average family size is of five members and both men and women work as laborers in fields, forest nurseries, road construction and other casual jobs away from their homes.

Climate

Climate of the region is characterized by a hot summer (March-June), monsoon/rainy seasons (July-October) and a cool/autumn seasons (November-February). The area receives annual rainfall of 120 cm. Maximal precipitation occurs during July to October, little precipitation during the rest of the year. November is the driest month with 5mm rainfall.[17] Summer temperature ranges from 28-46ºC, while average winter temperature remains around 15ºC. May is the warmest month of the year, averaging around 40ºC. December is the coldest month of the year average 19.2ºC.

Data collection and laboratory analysis

The study area comprised Pushparajgarh block of district Anuppur, MP, India which is the most populous block occupied by mostly tribal and rural people. The present

study was carried out in two phases, in first phase the household survey was carried out and in second phase blood slide examination data was collected from the PHC, SHC and CHC to identify the active Plasmodium species prevalent in the study region.

Household survey

The minimum sample size required for the study is obtained using the "pwr" package of R. An effect size of 0.25 at 5 per cent level of significance with power 0.75 requires a sample size of 222 or more.[18] The random sample was obtained in two stages. In the stage-I 11 villages were selected out of 267 villages using the PPS sampling design. The weights for PPS sampling are the populations of villages as per the 2011 census. In the second stage 10 households were randomly selected from each of the villages selected in stage-I. All the members of the selected households were surveyed. The individuals who suffered with malaria even once during their lifetime were selected for interview. This resulted in a sample size of 231 and these were called eligible participants. Prior to the study data collection, information about the study was given the informants and informed consent forms were filled. The eligible participants were interviewed using a questionnaire which was divided into three major sections namely general information, malaria awareness and information about diagnosis and treatment. In general section information was collected about the household characteristics, details of family members, education and area of residence. The malaria awareness section gathered information about the knowledge of disease, its symptoms, causes, the mosquito vector and the preventive measures. The last section collected information on the diagnosis and type of treatment available, their preference for malaria treatment and the malaria incidences to the household members in the reference years. The survey gathered data for 36 months (2014 to 2016). The survey was based on the *de facto* population, that is, person who stayed in their houses the night before interview.

Blood film for malaria parasites data

We have collected the primary data of the blood slides from the primary health centers, sub-health centers and district hospital after due permission from the concerned authorities. The blood film for malaria parasites (BFMP) data was collected from the district hospital, SHC, PHC and CHC of the region. The slides were examined for the presence of malaria and cases are recorded as negative, positive for PF, positive for PV or positive for PF-PV (mixed types) of malaria. The data was used for the calculation of ABER, API, blood slide positive rate (SPR), blood slide falciparum rate (SFR), percent of positive slides that are positive for PF (%PF) or PV (%PV) and the mixed types of malaria (%PV-PF) infections. The percentage of PF positives was calculated using the formula %PF= [(no. of PF positives/total number of malaria positives) $\times$ 100]; the same formula

was used to calculate the percentage of PV and PV-PF mixed infections. Data of 2483 positive patients was selected and divided in different variables like gender, age groups and types of malaria. To ascertain the impact of seasonality the dataset has been divided into four quarters viz. Q1 (January-March), Q2 (April-June), Q3 (July-September) and Q4 (October-December). The malaria prevalence rates (MPR) for particular gender were calculated using the formula MPR (gender) = [(Total positives in particular gender during reference period/total population of particular gender during reference period) $\times$ 1000]. The MPR in different age groups was calculated using the formula MPR (age group) = [(Total positives in particular age group during reference period/total population of particular age group during reference period) $\times$ 1000] while the MPR for PV, PF or PV-PF mixed infections was calculated quarterly using the formula MPR (type of infection) = [(Total positives of a particular infection during reference period/ total population of study area during reference period) $\times$ 1000].

Statistical analysis

For the data analysis, descriptive and statistical analysis was carried out using the SPSS software. The level of statistical significance was set at a p-value of <0.05 with 95% confidence intervals (CI). Categorical data were presented as the number (n) and percentage (%). Chi-square test has been utilized for testing the signification of associations of malaria types (PV, PF, and PV-PF) with the gender, the age group and the season. The signification of the associations is depicted by the p value of the statistic in Table 3. However, the use of odds ratios is for descriptive purposes only.

Gender and incidence of PV malaria can be represented as a 2$\times$2 contingency table. The odd ratio obtained from this table gives the odds of having PV malaria in males as compared to the odds of having PV malaria in females. The odd ratio, so obtained, is utilized as a measure of association between gender and incidence of PV malaria. An odd ration if different from one indicates association between the two variables. Similar analyses were performed to determine the association of gender with PF and PV-PF types of malaria for all the tree reference periods. The odds ratios are utilized as descriptive measures of association. Similar analyses were performed for inferring about the association of age group with the malaria types and the association of season with malaria types.

RESULTS

Characteristics of the study participants

In this survey, total 231 participants were included for the study and the information on demographic characteristics has been summarized in Table 1.

Table 1: Demographic characteristics of malaria positive patients that participated in house hold survey.

Participants information		Frequency (%)
Total number	231	231 (100)
Gender	Female	136 (58.88)
	Male	95 (41.12)
	Sex ratio	0.95
Age group (years)	0-5	40 (17.31)
	6-25	103 (44.60)
	26 above	88 (38.09)
Educational background	Illiterate	87 (37.66)
	Primary school	61 (26.40)
	Secondary school	44 (19.04)
	Higher level study	39 (16.90)
Occupation	Farmer	112 (48.49)
	Daily worker	63 (27.27)
	Others	56 (24.24)
Malaria awareness	Yes	117 (50.64)
	No	114 (49.36)
Mosquito net user	Yes	132 (57.14)
	No	99 (42.86)
Malaria incidence	One time	64 (27.70)
	Two time	96 (41.56)
	Three time	47 (20.34)
	Fourth time	24 (10.40)

Random sampling was conducted in Pushparajgarh block (MP, India) between 2014 to 2016 selecting 231 eligible participants (de facto population) using a questionnaire to collect data about the household characteristics and details of family members, type of treatment available, type of treatment they preferred for malaria treatment and the malaria incidences to the household members in the reference years.

Most of the study participants were illiterate (37.66%) or had attended primary school (26.40%), secondary school (19.04%) and higher studies (16.90%). The age groups have been categorized in three groups 0-5 years (17.31%), 6-25 years (44.60%) and 26- above (38.09%). Most of the participants were farmers (48.49%) or daily workers (27.27%) and the rest (24.24%). The awareness about malaria was about 50.64% while the rate of mosquito net users was 57.14% among the study population. The percentage of people who got infected with malaria was 27.70% (once), 41.56% (twice), 20.34% (thrice) and 10.40 (four times) during the study period.

Malaria prevalence analysis

As displayed in Table 2, the observed ABER was 8.47%, 10.24% and 11.18% in the years 2014-16 respectively. According to NVBDCP guidelines, about 10% population should be screened annually for the ABER. SPR was found to be 3.78%, 3.73%, and 2.74% in 2014-16 respectively. The SVR was 0.4%, 0.49% and 0.66% in the study years 2014-16. SVR and SFR indicate the percentage of positive slides in total examined slides for *P. vivax* and *P. falciparum* respectively. In 2014 SFR was 2.84%, in 2015 2.91% and in 2016 it was 1.52% respectively. Out of the total malaria positive cases, the PF malaria cases were 75.13%, 78.17% and 54.49% in the years 2014-16 respectively. The PV malaria cases consistently increased from 10.66% in 2014 to 13.31% and 24.2% in 2015-16 that displays an increasing trend of PV infection among the study population. The mixed type (PF-PV) of malaria was higher in 2014 (14.21%) and 2016 (21.31%) but decreased in 2015 (8.52%). The API is malariometric index which expresses malaria cases per thousand individuals in a given population. The values of API were 3.20, 3.82 and 3.07 in the years 2014-16 respectively (Table 2).

Table 2: Blood slide examination data of Pushparajgarh Block. *Plasmodium falciparum* (PF), *P. vivax* (PV) and mixed infection cases from 2014-2016.

Blood Examination Data: Pushparajgarh Block, District Anuppur (MP) India														
Year	Total Population*	Total blood slides examined**	Total malaria positive cases	Total PF cases	Total PV cases	Total PF+ PV cases	#PF%	PV%	PF+PV%	ABER	API	SPR	SFR	SVR
2014		20849	788	592	84	112	75.13	10.66	14.21	8.47	3.2	3.78	2.84	0.4
2015	246082	25204	939	734	125	80	78.17	13.31	8.52	10.24	3.82	3.73	2.91	0.49
2016		27520	756	412	183	161	54.49	24.2	21.31	11.18	3.07	2.74	1.52	0.66

ABER (Annual Blood Examination Rate): Number of blood smears examined in a year x100 / Total population. API (Annual Parasite Incidence): Total no. of positive slides for malaria parasite in a year x 1000 / Total population. SPR (Slide Positive Rate) :(Total positive slides/ Total slides examined) x100. SFR (Slide Falciparum Rate): (Total positive PF/ Slides examined) x100. SVR (Slide Vivax Rate) :(Total positive PV/ Slides examined) x 100. #PF%: The percentage of PF positives was calculated using the formula PF%= (no. of PF positive/ total number of malaria positives) *100; the same formula was used to calculate the percentage of PV and PV-PF mixed infections. *Total population, Pushparajgarh as per Census 2011, **Total blood slides examined referred as sample size.

Pattern of seasonal incidence of malaria types

Prevalence rate and gender

The results suggest that correlation exists between prevalence of malaria in the area and gender type (Figure

2). For the year 2014, more females contracted malaria in first three quarters (January-March, April-June, July-September), however there was little decline in this trend in the last quarter (October-December). In 2015, the malaria prevalence rate in males was lower initially (January-March) but it was higher in all the next three

quarters (April-June, July-September, October-December). Contrary to this, higher prevalence rates were observed in females in 2016 (January-March, April-June, October-December) except in the months of July-September. Chi-square attributes further confirms that gender and the malarial prevalence are associated (p value <0.05, Table 3).
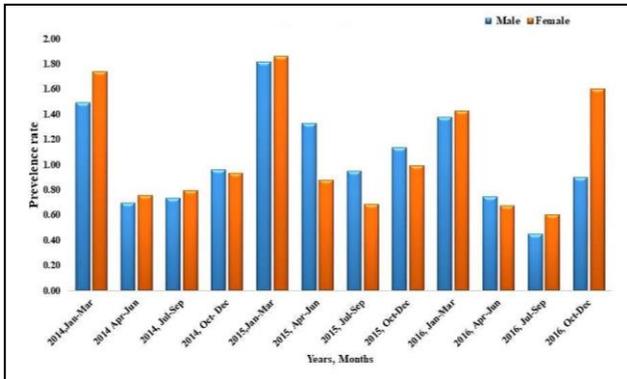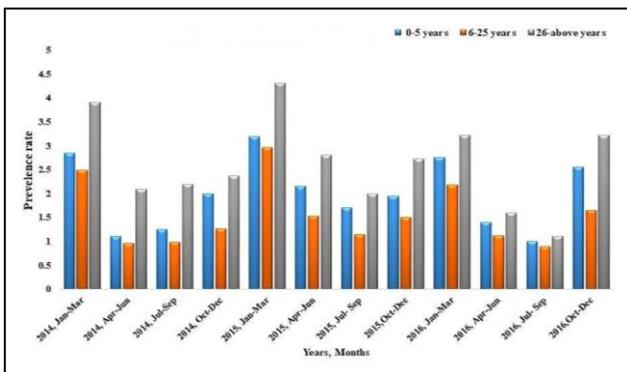

Figure 2: Gender-wise prevalence rate of malaria in Pushparajgarh block during 2014-2016.
The graph represents data of 1232 positive cases (male) and 1251 positive cases (females) out of the 2483 individuals who visited different health centers during 2014-2016.

Prevalence rate and age group

As per the observed statistics people of age group 26-above years were most prone to malaria, followed by 0-5 and 6-25 age groups (Figure 3). Age group and prevalence rate of malaria were found to be correlated significantly (p value<0.05, Table 3).


Figure 3: Age-wise prevalence rate of malaria in Pushparajgarh during 2014-2016.
The graph represents data of 478 positive cases among 0-5 years, 916 positive cases among 6-25 years, and 1089 positive cases among 26-above age groups among the 2483 individuals who visited different health centers during 2014-2016.

Season vis-a-vis types of malaria

The prevalence rate of *P. falciparum* induced malaria was highest during January to December while, *P. vivax* infection also remained high during January to march and

declined after that. For obvious reasons the mixed PF-PV infections are highest in the January to march season (Figure 4). The results strongly suggest that seasonality has significant effect on the incidence of PV, PF and PV-PF types of malaria (p value<0.05, Table 3).
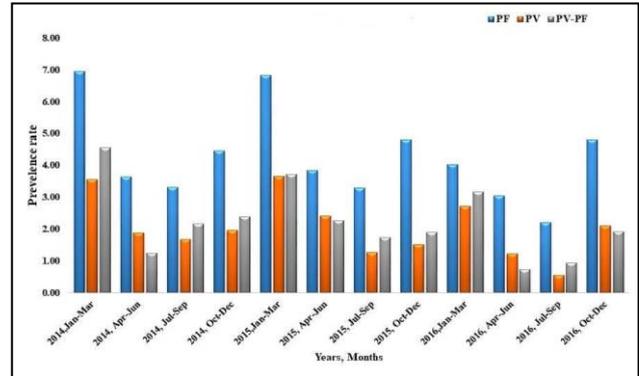
Figure 4: Monthly reported study of malaria types PF, PV and PF-PV in Pushparajgarh from 2014-2016.
The graph represents data of total 1244 positive cases of PF, 594 positive cases of PV, and 645 positive cases of PV-PF (mixed type) out of the 19657individuals who visited different health centers during 2014-2016.

Association between types of malaria infections with gender, age and season

For this study the females were taken as reference group. As per the prevalence odd ratio it was observed that the chances of mixed PV-PF infections were higher in males in 2014. In 2015, the prevalence odd ratios for all the three type of infections were higher in males. However, in 2016 prevalence odd ratios were displayed slightly higher chances of all type of infections in females (Table 3). The PF was found higher in each year but less than mixed type. The mixed infections were found to be more prevalent in the males except in 2016 as compared to the reference group.

Prevalence of *P. falciparum* was more common in the study region. The 26-above age groups were found to be much more prone to either malarial species as compared to the 0-5 age or 6-25 age groups. The rate of prevalence of PV, PF and PV-PF mixed types of malaria varied across the age groups. Considering the age group 26-above year as reference group, the likelihood of observing PV, PF and PV-PF mixed infections was always higher in this age group as compared to the age group 6-25 or 0-5 years (Table 3). The PV was higher in both age groups 6-25 years and 0-5 years in 2014 but in 2016 less than in both age groups 6-25 years and 0-5 years, compared to PF and mixed type malaria. The PF is highest in both age groups 0-5 years and 6-25 years.

The prevalence rate of the three types of malaria infections showed seasonal variation likelihood that varied from one quarter to another. The Q4 was taken as reference group, the likelihood of observing PF and PV-

PF mixed infections was higher in Q1 (Jan-Mar) in all the three reference years. The PV infections were mostly prevalent in the Q2 (April-June) in the study years (Table 3).

Table 3: Frequency distribution and odds ratio among *Plasmodium falciparum* (PF), *P. vivax* (PV) and mixed PF-PV malaria infections and selected variables.

Variables		Year (total positive patients)	Number of patients			Chi square p value	Odd ratio		
			PF	PV	PF-PV		PF	PV	PF-PV
Gender	Male	2014 (788)	84	160	125	<0.05	0.57	1.00	1.36
	Female		154	168	97		®	®	®
	Male	2015 (939)	125	198	189	<0.05	1.55	1.37	1.76
	Female		90	193	144		®	®	®
	Male	2016 (756)	71	156	113	<0.05	0.90	0.81	0.92
	Female		124	174	118		®	®	®
Age groups (year)	0-5	2014 (788)	48	64	32	<0.05	0.34	0.61	0.31
	6-25		65	135	79		0.73	0.83	0.77
	26 -above		78	185	102		®	®	®
	0-5	2015 (939)	50	75	55	<0.05	0.42	0.51	0.41
	6-25		84	165	101		0.92	0.86	0.76
	26 -above		98	178	133		®	®	®
	0-5	2016 (756)	38	99	43	<0.05	0.76	0.42	0.45
	6-25		72	136	79		2.05	0.81	0.82
	26 -above		89	130	96		®	®	®
Season	Jan-Mar (Q1)	2014 (788)	74	145	95	<0.05	1.57	0.55	1.91
	Apr-Jun (Q2)		39	76	26		0.82	0.95	0.52
	Jul-Sep (Q3)		35	69	45		0.74	0.85	0.90
	Oct-Dec (Q4)		41	93	50		®	®	®
	Jan-Mar (Q1)	2015 (939)	92	172	94	<0.05	1.43	0.41	1.97
	Apr-Jun (Q2)		61	97	57		0.81	1.61	1.19
	Jul-Sep (Q3)		32	83	44		0.68	0.84	0.91
	Oct-Dec (Q4)		38	121	48		®	®	®
	Jan-Mar (Q1)	2016 (756)	75	111	87	<0.05	0.84	0.77	1.64
	Apr-Jun (Q2)		34	84	20		0.63	0.58	0.38
	Jul-Sep (Q3)		15	61	26		0.46	0.46	0.49
	Oct-Dec (Q4)		58	132	53		®	®	®

® denotes the reference category.
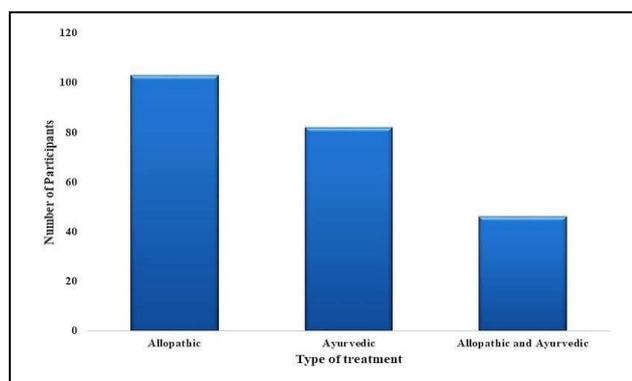
Figure 5: Type of treatment preferred by the malaria patients during 2014-2016.

The graph represents data from 231 individuals during household survey. 103 participants preferred allopathic treatment, 82 participants preferred ayurvedic treatment and 46 participants preferred both allopathic and ayurvedic treatment for malaria.

Primary health care facilities

The communities are mostly rural and reside in villages and deep forest areas. The government has set up primary and secondary health care centers in the region visited by several patients; however, a large number of individuals also depends on Ayurvedic system being practiced by traditional healers in nearby vicinity of the villages. Nearly one-third of the population uses both Allopathic and Ayurvedic medicines (Figure 5).

DISCUSSION

Pushparajgarh block is one of the four administrative units of the district Anuppur, (MP) India. Majority of its geographical area (60%) is covered with dense forest and is occupied by different tribal communities. Nearly 96% of its population lives in rural areas, with poor socio-economic conditions (education, occupation and income).

Prevailing climatic (high rainfall, humidity and water logging) and geographical conditions (villages intersected by numerous hill streams and their tributaries) coupled with unhygienic living practices of the residents often support mosquito breeding throughout the year. At the same time incomplete treatment and poor adoption of mosquito prevention measures by the communities results in malaria outbreaks.

In the current study, the incidence levels of malaria were measured in terms of ABER, API, SPR, SER, and SVR along with calculation of prevalence rates of PF, PV and PF-PV mixed infections. ABER is indicative of the success of malaria surveillance programs, if ABER is less than 10%, than the healthcare coverage is poor enough for estimation of malaria prevalence. ABER above 10% is indicative of good surveillance system. The national average ABER at national level (India) was 9.29%in 2015 and in 14 states it ranged from 1-8% while in other 15 states it ranged from 10-40%.[19] The ABER values from the current study indicates that the of malaria surveillance system is gradually becoming effective. API gives approximate disease burden and is measured from data of those patients who visit PHCs or health center for the treatment; however, it lacks information on the potentially large number of asymptomatic patients that may be present in the population. The national API rates as per the NVBDCP incidence records were <2 and around 2-5 in scattered regions. The API rates were above 3 in the study region comparable to that of Rajasthan, Gujarat, Karnataka, Goa, South MP, Chhattisgarh, Jharkhand and Orissa.[20] SPR and SFR are measures of diseases burden in only that population that visits the health centers and are thus not representative of the actual disease burden. The observed national SPR in 2014 was 0.89 which is very low as compared to the 3.78, 3.73 and 2.74 which was observed in the study region from 2014-16 indicating the high disease burden in the study region *P. falciparum*, a more lethal species is highly prevalent in this region as observed by the blood slide examination tests.[21] Apart from the chemotherapeutic treatment for the diagnosed cases, additional steps should be taken to break the infection cycle by limiting the growth of *P. falciparum* larvae, use of bed nets malaria awareness campaigns and other preventive measures.

Malaria in this region is mainly transmitted by *Anopheles culicifacies,* which breeds profusely in puddles, mining pits, river-bed pools, river edges, tanks, and artificial containers.[22] *An. culicifacies* population generally spikes in monsoon and post-monsoon months, resulting in focal to regional epidemics.[23] Although showing distinct seasonality, *P. falciparum* malaria was prevalent throughout the year with distinct peaks coinciding with months of rainfall, however transmission intensity and duration varied between months. High incidence of malaria coincides with the mosquitogenic period as they are the vectors for the disease. Understanding of the relationship between climatic factors and mosquito population is important for determining the parasite activity levels, hence, the disease risk.[24] Further, this could also help in formulating the region-specific effective vector control programs.

Limited information is available on impact of age, gender and poverty on prevalence of malaria in the country.[25] In our study, there was direct correlation between prevalence rate of malaria and gender with higher prevalence rates in females as compared to the males. This could be due to the low literacy and their lackluster attitude towards the health. During our interaction, we observed that majority of female respondent either had no education or maximally up to secondary level education. Children and pregnant women are more susceptible to malaria, due to social, economic and cultural factors, particularly, in poor and rural pockets. In rural areas, females are more active as agriculture workforce. During rainy seasons, they work in water submerged agricultural fields. Further, in evening times, they use to cook outdoors. These factors put them at great risk of malaria infection.[26] Availability of mosquito nets and their use often suffers from gender biases. If household have only one net, priority is given to male head of household.

While analyzing the age group observed adults were more likely to develop uncomplicated or asymptomatic malaria. In malaria-endemic areas adults usually have acquired some degree of immunity against severe, life-threatening malaria that supports the view that protective immunity exists and the immunological characterization could help in developing of prophylactic agents. However, infection among non-immune individuals invariably results in clinical manifestations and often leading to death, particularly in young children, if left untreated, as they have not yet acquired immunity. Children have a lower prevalence of infection and a lower incidence of clinical symptoms. The incidence rate was highest in individual aged between 26-above years as compared to the other groups. Dunyo et al reported that high prevalence of asexual parasitaemia (61%) among the individuals aged between 5 to 15 years.[27] The immune mechanisms of malaria infection are dependent on age, as suggested by the age dependency of malariometric indices, the pyrogenic threshold of parasitemia, speed of infection control, incidence of clinical episodesand parasitological complexity of individual infection.[28,29] Protective immunity effectively prevents severe clinical manifestations of malaria, hence, reduces parasite loads, but does not prevent infection.[30] Prevalence of parasitaemia in adults is crucial as they from a community reservoir for further infection in children.

In many parts of the country, malaria is a seasonal disease, with maximal prevalence from July to October. Malaria transmission is affected by temperature and land slope as they increase the survival rate of mosquito larvae and reduce the duration of sporogony (i.e., the time it takes for a mosquito that has ingested infected blood to be able to transmit the disease). The prevalence of symptomatic malaria during the dry season is relatively

low due to high temperature that inhibits vector population. Further, *P. falciparum* can persist in semi-immune individuals up to 18 months, with possibility of re-infection excluded.[31] The maximal prevalence was recorded from July to March owing to good rainfall, relative humidity of 60% and temperature between 20-30°C that favours the life cycle of malarial parasites and thus the spread of malaria.

Our study reports that government has established primary and secondary healthcare centers in the region and a substantial number of people depends on allopathic medicines for the treatment of malaria. This could be due to the purported slow relief of Ayurvedic medicines compared to that of allopathic drugs.

However, due to difficulty in transportation facilities, low socioeconomic profile and out of their belief many people visit traditional medicinal healers for Ayurvedic treatment for malaria resulting either, likewise, nearly one-third of respondents have taken combination of Ayurveda and Allopathy with positive result.

CONCLUSION

The study clearly demonstrates that malaria is highly prevalent among the population in block Pushparajgarh of Anuppur district. Here despite being substantial awareness about malaria, the high prevalence rates might due to faith on traditional medicinal system and difficulty in transportation system to the government health centers. *P. falciparum* is the main species responsible for malaria incidence as demonstrated by blood slide examination data. The disease is associated with gender and age and is mostly prevalent in female and in the age group 26 years and above. The *P. falciparum* was active during the quarters January-March and July-December while *P. vivax* rates are high during April-June.

We thus conclude that there is urgent need to strengthen the malaria surveillance programs, upgrade diagnostic and treatment facilities at rural health centers, create awareness about the strategies to reduce malaria infection and design species specific mosquito control programs in this region.

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