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Seasonal variation in the occurrence of malaria parasite incidences in Srikakulam district, Andhra Pradesh, India

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Abstract
The objective of the current study was to determine the seasonal variation of malaria prevalence of the tribal and district areas among the selected people of Srikakulam, Andhra Pradesh. The seasonal variation of surveillance indices like Monthly Parasite Index (MPI), Slide Positivity Rate (SPR), Slide *vivax* Rate (S*v*R), Slide *falciparum* Rate (S*f*R) and *Plasmodium falciparum* proportion (*Pf*%) of Srikakulam was described. The current study investigation represents that the surveillance of malaria infection was found to be highest during the dry season when compared with wet season. The assessment of the climatic parameters represents the current malaria transmission in India which was based on the present endemic nature of malaria in India, and likely to be extent of malarial activity in the future due to climate change.

Keywords: Malarial parasites, prevalence, *Plasmodium*, seasonal variation

1. Introduction

India is one of the 11 countries in the WHO South-East Asia region and has nearly 980 million people at risk of acquiring malaria. According to the WHO's estimates, India has the largest number of malaria cases outside Africa. India's official statistics suggest that *Plasmodium falciparum* accounts for about 50% of the clinical cases in India. India has a long history of attacking malaria. Organized control programs, which started in the 1940s, used Dichloro-Diphenyl-Trichloroethane (DDT) to control mosquitoes. These programs were originally very successful in India and nearly eliminated malaria by 1961. In the subsequent years, however, the disease has reestablished itself in India. Malaria is a major cause of morbidity and mortality in the tropics. Disease is of global importance, results in 300-500 million cases yearly and 1.5-2.7 million deaths annually. Approximately 2.48 million malarial cases are reported annually from South Asia, of which 75% cases are from India alone (Mohapatra *et al*., 2012; Hussain *et al*., 2013) [21, 13].

Malaria, one of the most important parasitic diseases of man, is estimated to cause between 300 and 500 million cases of clinical malaria illness and about half a million deaths of children each year in Africa alone and an estimated 2.7 million deaths worldwide every year (WHO, 2003) [32]. World Health Organization (1997) [33] estimated that of all patients who die in hospitals in Africa, between 17% and 30% die from malaria. In Namibia, malaria is the major cause of outpatient consultations and admissions in health facilities in northern Regions where about one in four inpatient children are hospitalized (Obeid *et al*., 2001) [23]. In Namibia, malaria is the leading cause of illness and death amongst children under the age of five years and the third most important cause of death among adults, after HIV /AIDS and tuberculosis (MoHSS, 2002) [20]. Persistent malaria is the characteristic feature in most forest areas and both *Plasmodium vivax* and *Plasmodium falciparum* are prevalent in forest areas of Madhya Pradesh (Singh and Khare, 1999) [27]. Hema Joshi (2003) [12] reported the existence of genetic diversity among the field isolates of *P. falciparum* and *P. vivax* in India.

Malaria contributes to a significant burden in widespread populations with premature deaths, infirmity from sickness and it inhibits on economic and social development (WHO, 2013). World Malaria Report 2015 stipulated that, globally, malaria incidence was estimated to be at 214,000,000 infected cases and 438,000 deaths (WHO, 2015). Malaria was estimated to have contributed to about 82,685 disability-adjusted life years (DALYs), in the year 2010, which accounted to almost 19.6% of all causes of diseases (Murray *et al*., 2013) [22]. The disease has remained a major cause of morbidity and mortality in Malawi (Roca-Feltrer *et al*., 2012; Mathanga *et al*., 2012) [26, 19].

Malaria incidence was estimated as 34% among outpatient visitation to hospital in Malawi in 2011. Further in 2015, malaria incidence was estimated as 200 cases per 1000 population. The distribution of malaria is strongly related to rainfall and availability of vector breeding habitats near perennial rivers and stagnant water (Obeid *et al*., 2001) [23]. High prevalence of malaria during rainy season coincides with periods when most farmers are busy with important agricultural activities such as ploughing, planting and growing up of their crops (Malaney *et al*., 2004) [16, 18].

The primary vectors of malaria parasite, *Plasmodium falciparum*, in Africa are mosquitoes of the *Anopheles gambiae* complex (Toure *et al*., 1994) [28]. In southern Africa, these comprise of *Anopheles (Cellia) gambiae*, *Anopheles* (*Cellia) arabiensis*, *Anopheles funestus*, *Anopheles merus*, *Anopheles quadriannulatus, Anopheles bwambae*, *Anopheles moucheti* and man biting populations of *Anopheles nili* (Toure *et al*., 1994; Kiszewski *et al*., 2004) [28, 16]. Knowledge of species identity and seasonal variation in their abundance and behavior is very important in that it will facilitate determination of vectors involved in transmission of malaria, targeted control of malaria vectors and identification of vectors that are difficult to eradicate (Hay *et al*., 2010) [11]. In countries in which malaria is endemic, a significant proportion of Plasmodium species infections are asymptomatic or subclinical. Microscopy-detected levels of asymptomatic carriage are as high as 39% have been reported in other countries (Vafa *et al*., 2008; Mabunda *et al*., 2009; Baliraine *et al*., 2009) [31, 17, 3]. Similar data from India are not yet available. This study was carried out to determine variation in the vector species responsible for malaria transmission in Srikakulam, to investigate seasonal variation in the prevalence of malaria and to compare the number of patients that are diagnosed to have clinical malaria or not, on the basis of fever and microscopic examination of blood smears.

Materials and methods

Study area

The aim of the current study was to determine the seasonal variation of malarial prevalence of the tribal and district areas of Srikakulam and the study was conducted during January 2014 to December 2017 in Srikakulam district of Andhra Pradesh.

Sampling size

Keeping in view of the population size of 27,03,114, the total number of RDT performed in both tribal and district areas of Srikakulam was 3,45,001 and the average percent of RDT performed was 7.83% in the study area of Srikakulam.

Method of data collection

The eighty (80) PHC centers (2 Tribal PHCs; 25 Sub-Plan PHCs; 45 Non-Tribal PHCs; 5 newly formed PHCs) were taken into consideration to collect the information on perception of people or individuals, the causation of malaria and treatment practices and noted accordingly. Also the information regarding the indoor resting mosquitoes and the larvae from breeding sources was collected to assess the mosquito density and larval density.

Collection of blood samples

A sample of 5 cubic micron (μm^3) of blood was collected by finger prick method (left hand ring finger) from the person suffering with fever for preparation of thick and thin blood smears. For investigation of biochemical tests, 5 ml of blood collected from the vein of right hand with the help of disposable syringe.

Results

The current study revealed the epidemiological data of malaria (District and Tribal areas) month wise and year wise. The samples have been collected from selected PHCs located in villages of Srikakulam. The results obtained through Rapid Diagnostic Tests and Blood Smear examination from the selected area like District and Tribal area of Srikakulam, Andhra Pradesh, during the year 2014 to 2017 represents the number of positive cases of *Plasmodium vivax* and *Plasmodium falciparum* out of the total number of screened samples.

The seasonal variation of surveillance indices like Monthly Parasite Index (MPI), Slide Positivity Rate (SPR), Slide *vivax* Rate (S*v*R), Slide *falciparum* Rate (S*f*R) and *Plasmodium falciparum* proportion (*Pf*%) of study areas of Srikakulam district was described below.

The highest values of Monthly Parasite Index (MPI) were found in pre-monsoon season i.e., 8.17, 12.21 and 13.83in the year of 2014, 2016 and 2017 respectively; and in monsoon season with 18.74in the year 2015 in both District and Tribal areas of Srikakulam (Table 1).

The values of Slide Positivity Rate (SPR) were found to be more in monsoon season with 0.262 during 2014 to 2017, whereas in tribal area the highest values were found in monsoon season during 2014 to 2017 than district areas (Table 2).

The seasonal variation of Slide *vivax* Rate (S*v*R) accumulated more in monsoon season in the year 2015 and 2016. But it was found to be more during pre-monsoon season in the year 2016 and 2017 in NVBDCP-Srikakulam District area whereas in NVBDCP-Srikakulam Tribal area the highest values were found in monsoon season in the years 2014, 2015, 2017 and in the year 2016 it was found more in pre-monsoon season (Table 3).

The Slide *falciparum* Rate (S*f*R) of Srikakulam District area was accumulated more in monsoon season in all the four study years i.e., 2014, 2015, 2016 and 2017 whereas Slide *falciparum* Rate (S*f*R) values of Srikakulam Tribal area were more in monsoon season of 2014, 2015, 2016 and pre-monsoon season of the year 2017 (Table 4).

The seasonal variation of *Plasmodium falciparum* proportion (*Pf*%) values found to be more in post-monsoon season in the year 2014 and 2017, monsoon season in the year 2015 and 2016 of NVBDCP-Srikakulam District area, while *Plasmodium falciparum* proportion (*Pf*%) values of NVBDCP-Srikakulam Tribal area was found more in pre-monsoon season in the year 2014, monsoon season in the year 2015 and 2016, post-monsoon season in the year 2017 (Table 5). And all the surveillance indices seasonal variations were graphically represented in Figure 1 and Figure 2 respectively.

Discussion

The predominant species of *Plasmodium* was *Plasmodium vivax* and *Plasmodium falciparum* which made it a significant cause of severe malaria whereas the prevalence of malarial intensity in the endemic zones of Srikakulam (UNDP, 2004). The findings of the present study revealed that the occurrence of *Plasmodium* species infections in the both tribal and non-tribal (district) areas of Srikakulam, Andhra Pradesh which was not previously reported, whereas in the lower altitude areas the malaria has widely been reported (Brooker *et al*., 2004; John *et al*., 2005; Ernst *et al*., 2006; John *et al*., 2009) [5, 14, 7, 15].

Anjali Singh and Bhagyalaxmi (2010) [1] determined the high rate of malarial infection during the monsoon months from July to October. It is obviously trusted that the lack of proper sanitation and hygienic conditions might be the root cause along with their innocent and traditional life styles played the significant role for the widespread of the disease of malaria in the tribal areas of Srikakulam district. Pull and Gramiccia (1976) [24] and Gadzama (1983) [8] showed the seasonal variation of malarial infection, where they reported that the more fluctuation of malaria were seen during monsoon season and low level of fluctuations were observed during summer or dry season respectively.

The current study investigation represents that the surveillance of malaria infection was found to be the highest during the dry season when compared with wet season. This study was similar to other findings which shown the highest transmission of the disease malaria during the dry season due to the risk associated to peri-domestic crop production (Bigoga *et al*., 2012; Townes *et al*., 2013) [4, 29].

Enosolease and Awodu (2003) [6] described that the infection of malaria was very high in the rainy season and low level of malarial infection was observed in pre-monsoon season and monsoon seasons. In contrast to this, the detailed studies shown that the increase of rainfall interaction with malarial transmission from the zones of highland in the country of Africa where the temperature rather than rainfall has been the greater interest (Ayanlade *et al*., 2010) [2].

The prevalence of the seasonal malaria seems to act as more significant role in the disease malaria transmission than the temperature. The previous studies by peer researchers conducted in various places shown the same results (Gupta, 1996; Greenwood and Pickering 1993; Ramasamy, 1992) [10, 9, 25]. In addition, formerly it has been represented that a positive association occurred in between the species of Plasmodium incidences (Gupta, 1996) [10]. Each of these studies, as well as several others has indicated that there appears to be some level of predictability of malaria seasonality in endemic settings.

Conclusion

In the current study, the assessment of the climatic parameters represent the current malaria transmission in India which was based on the present endemic nature of malaria in India, and likely to be extent of malarial activity in the future due to climate change. The increase or decrease in vulnerability due to climate change in the 2050s will therefore not only depend on the changing climate scenario but also on the developmental path to be followed by India in the future

Table 1: Seasonal variation of Monthly Parasite Index (MPI) NVBDCP-Srikakulam (District & Tribal) from 2014 to 2017

	2014		**2015**		**2016**		**2017**	
	District	**Tribal**	**District**	**Tribal**	**District**	**Tribal**	**District**	**Tribal**
Pre-monsoon	8.17	10.11	6.87	9.88	12.21	11.36	13.83	18.21
Monsoon	6.45	7.68	18.74	22.88	6.61	7.20	6.25	7.21
Post-monsoon	4.37	5.21	8.41	10.33	7.40	8.09	5.10	6.28

Table 2: Seasonal variation of Slide Positivity Rate (SPR) NVBDCP-Srikakulam (District & Tribal) from 2014 to 2017

	2014		**2015**		**2016**		**2017**	
	District	**Tribal**	**District**	**Tribal**	**District**	**Tribal**	**District**	**Tribal**
Pre-monsoon	0.195	0.378	0.202	0.403	0.172	0.254	0.166	0.328
Monsoon	0.262	0.486	0.381	0.670	0.181	0.297	0.169	0.296
Post-monsoon	0.145	0.298	0.149	0.281	0.122	0.226	0.097	0.177

Table 3: Seasonal variation of Slide *vivax* Rate (S*v*R) NVBDCP-Srikakulam (District & Tribal) from 2014 to 2017

	2014		**2015**		**2016**		**2017**	
	District	**Tribal**	**District**	**Tribal**	**District**	**Tribal**	**District**	**Tribal**
Pre-monsoon	0.014	0.014	0.026	0.043	0.057	0.038	0.031	0.042
Monsoon	0.026	0.036	0.037	0.047	0.030	0.031	0.029	0.042
Post-monsoon	0.009	0.011	0.022	0.024	0.021	0.027	0.018	0.021

Table 4: Seasonal variation of Slide *falciparum* Rate (S*f*R) NVBDCP-Srikakulam (District & Tribal) from 2014 to 2017

	2014		**2015**		**2016**		**2017**	
	District	**Tribal**	**District**	**Tribal**	**District**	**Tribal**	**District**	**Tribal**
Pre-monsoon	0.18	0.36	0.18	0.36	0.11	0.22	0.14	0.29
Monsoon	0.24	0.45	0.34	0.62	0.15	0.27	0.14	0.25
Post-monsoon	0.14	0.29	0.13	0.26	0.10	0.20	0.11	0.22

Table 5: Seasonal variation of *Plasmodium falciparum* proportion (*Pf*%) NVBDCP-Srikakulam (District & Tribal) from 2014 to 2017

	2014		**2015**		**2016**		**2017**	
	District	**Tribal**	**District**	**Tribal**	**District**	**Tribal**	**District**	**Tribal**
Pre-monsoon	92.71	96.32	87.19	89.31	66.06	84.29	80.42	85.63
Monsoon	89.31	92.42	89.24	92.11	83.96	90.22	83.69	85.82
Post-monsoon	93.95	96.21	84.36	91.16	83.07	88.28	84.72	89.49

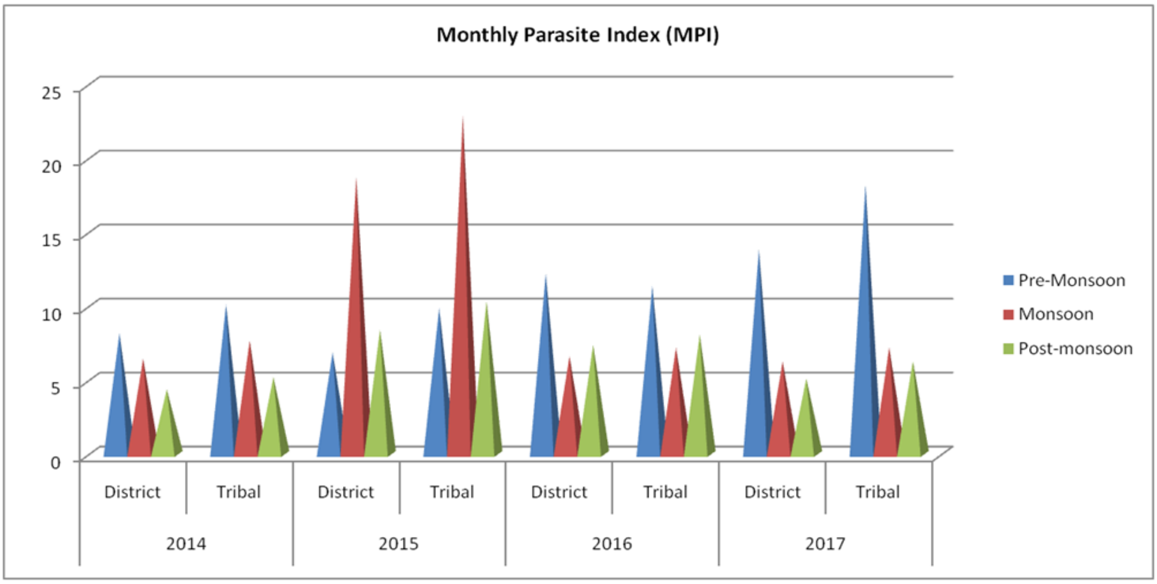
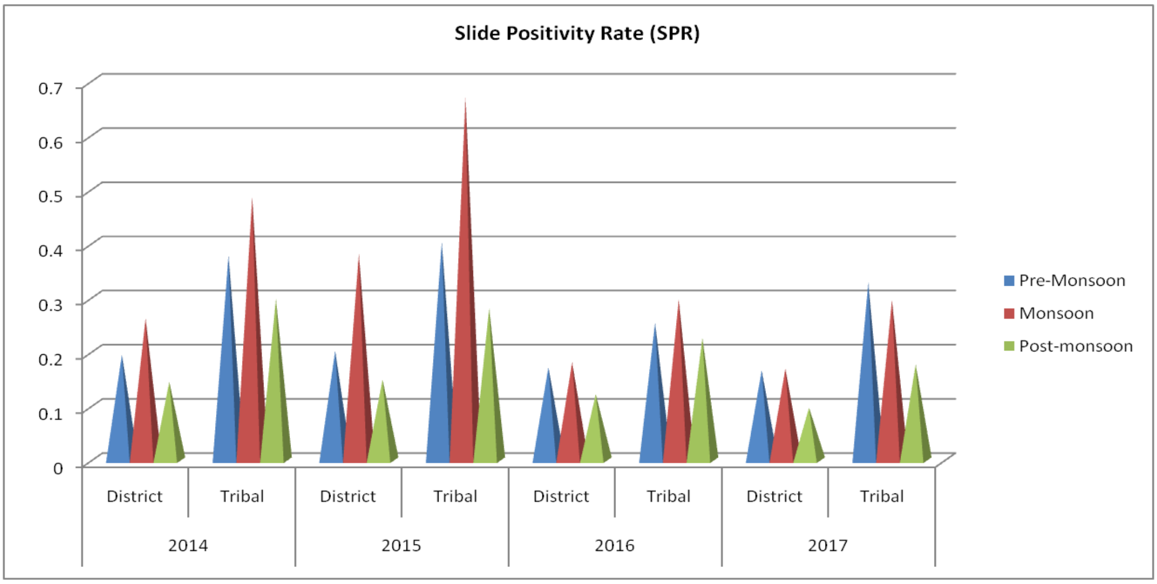
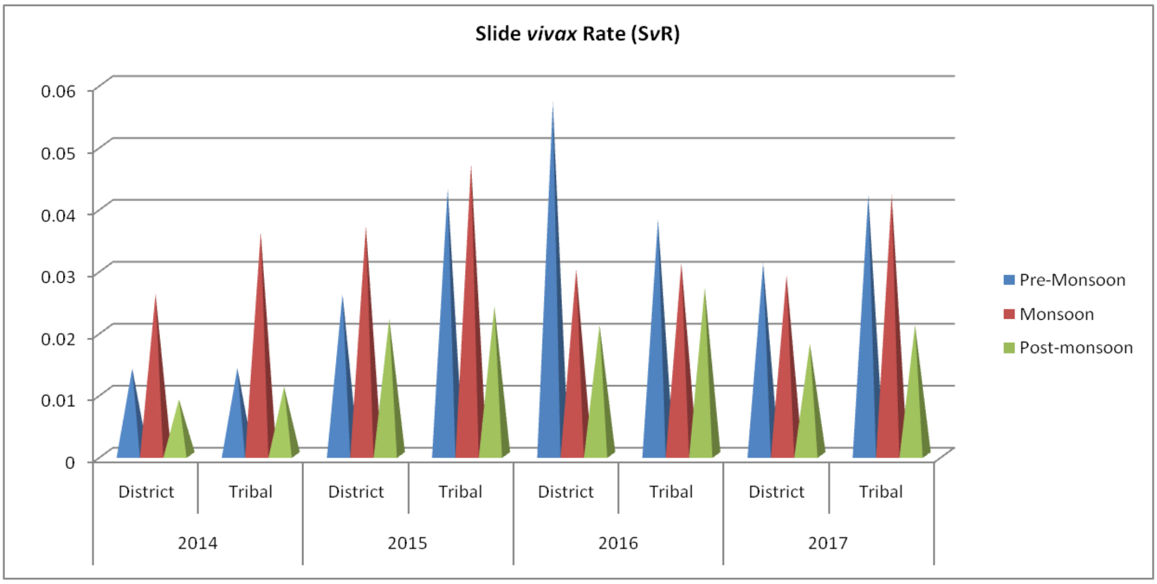


Fig 1: Seasonal variation of Monthly Parasite Index (MPI) (District & Tribal) from 2014 to 2017





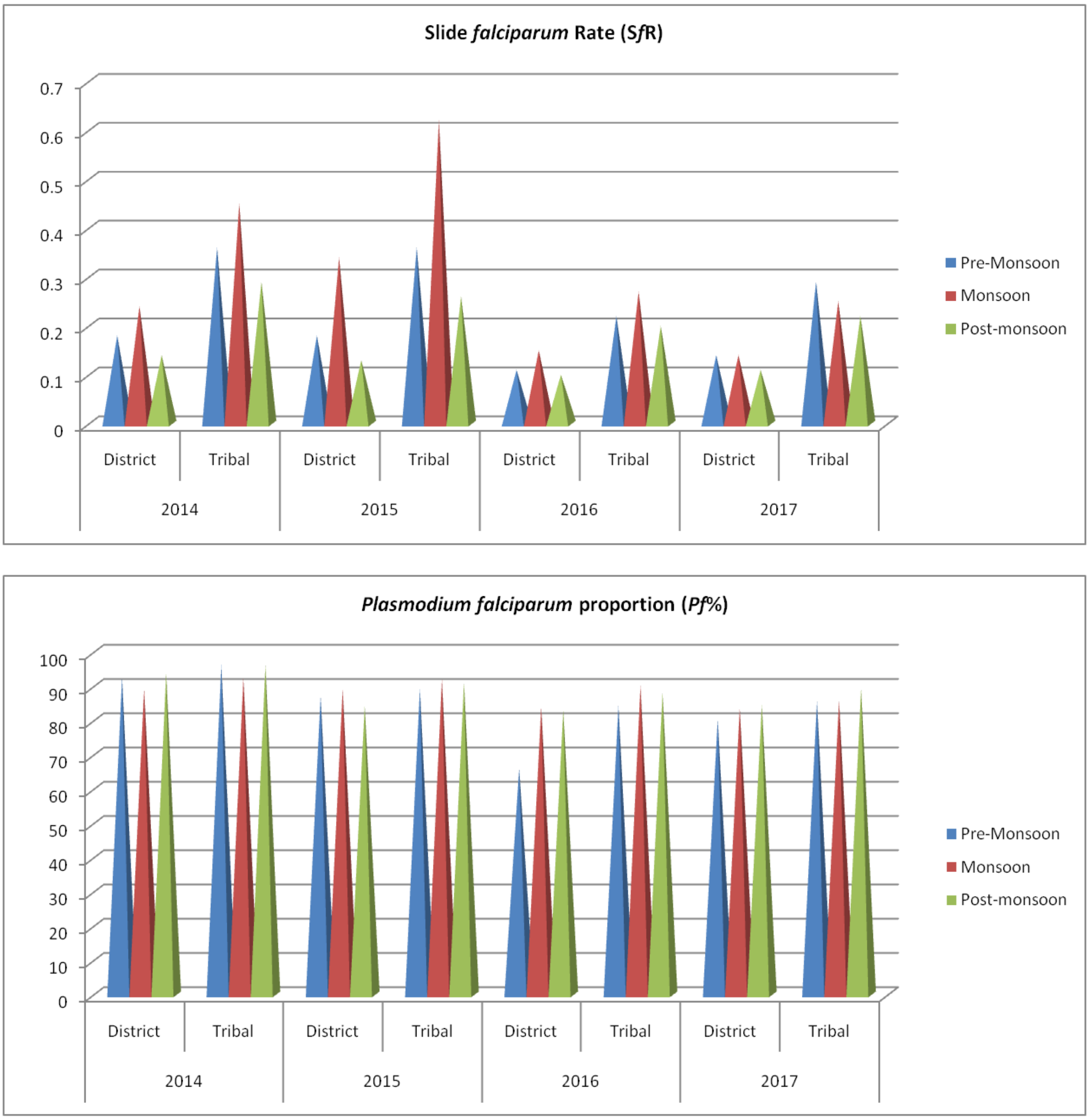


Fig 2: Seasonal variation of SPR, SvR, SfR, Pf % (District & Tribal) from 2014 to 2017

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