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Original Research Paper

Comparative *Plasmodium falciparum* prevalence in given talukas of Gadchiroli district, Maharashtra, India - A study report of year 2014-2023

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ABSTRACT:
Across the world the severity of malaria is increasing many folds. As per estimate not less than 216 million humans are at a risk of infection. Since India is a largest population country in World and contributes maximum for malaria spread with highly variable environment it possesses. Present study carried out in the dense forest area of India known as Gadchiroli district of Maharashtra state. Here Gadchiroli district has been divided into 12 talukas/blocks which are having highly variable environmental conditions, economical background, and ease of transportation, education background and medical facility. We have carried out data recording of villages having fever and suspected of malaria for the prevalence rate of *Plasmodium falciparum* (PF) per public health center. The data was recorded via staff members of public health centers during ten years of survey by taking blood smear slide analysis. During survey the rate of prevalence of PF per year in each taluka of Gadchiroli has been showcased which has given us clear picture of how malaria control program is working in each taluka. In result, Gadchiroli district once grouped into 12 talukas/blocks and screened for malaria cases especially reported for PF cases. It has been primarily observed that nearly all talukas were highly infected with PF during year 2014 and 2015 and that infection rate continuously decreasing during preceding years. In another observation the incidences of PF remained significantly varied during years in each taluka and can be related to environmental conditions. Lastly our study put forward that increasing order of PF cases recorded as per taluka with its maximum cases in any year of analysis as Wadsa (1.4 ± 4.5 cases of PF), > Armori (2.7 ± 5.2), > Charmoshi (5.1±1.2), >Gadchiroli(5.4±10), > Mulchera (7.9±12), >Sironcha(8.0±9.8), >Kurkheda(9.3±20), >Korchi(19±31), >Aheri(19±32), >Dhanora (23±58), >Ettapalli (38±44) and Bhamragad (41±94). Thus, it has been observed that although PF prevalence is decreasing in Gadchiroli and their given talukas still surveillance is advised on regular basis since the place is vulnerable for spread of PF.

Keyword: Gadchiroli, Malaria, Plasmodium falcipurum, Talukas.

INTRODUCTION:

Despite substantial global efforts to eliminate malaria, the infection remains a significant public health challenge across 87 countries, affecting nearly half of the world's population. As reported in the latest World Malaria Report 2018, an estimated 435,000 people died from malaria worldwide.[1] This concerning data underscores the ongoing public health challenge posed by malaria, particularly in sub-Saharan Africa and Asia where the majority of malaria-related mortality is concentrated, despite some indications of declining incidence in certain regions.[2]

Malaria remains a significant public health challenge in India, particularly in the district of Gadchiroli, Maharashtra. Recent data indicates that Gadchiroli reported over 20,000 malaria cases in 2021, reflecting the persistent burden of this disease in the region. Despite ongoing control efforts, the incidence of malaria in Gadchiroli has fluctuated, with seasonal peaks and a notable increase during the monsoon months, coinciding with the rise in mosquito populations due to favourable breeding conditions. Furthermore, the prevalence of malaria in Gadchiroli is exacerbated by socio-economic factors, including limited access to healthcare, high poverty levels, and inadequate vector control measures, collectively hindering effective malaria management and prevention efforts in the area.[3]

In 2020, the district reported a slight decline to approximately 15,000 cases, but this data still highlights the cyclical nature of malaria transmission and the persistent risk faced by the local population during peak transmission seasons. This underscores the need for targeted interventions to address the specific challenges in this region.[5,3]

While the endemic malaria burden in Gadchiroli is a significant public health concern, the broader

epidemiological profile of malaria within India also merits attention. As the country accounts for a substantial proportion of the global malaria burden, with reports indicating that 76% of malaria cases in Southeast Asia occur in India, the national malaria situation requires comprehensive examination and targeted interventions.[1]

In the Gadchiroli district, the prevalence of Plasmodium falciparum is predominant, accounting for approximately 60% of reported malaria cases in 2021. In contrast, Plasmodium vivax represents a significant proportion of the remaining cases. This duality in species composition poses challenges for malaria management in the region. Plasmodium vivax is characterized by its ability to relapse and its potential to cause asymptomatic infections, which often go undetected, thereby sustaining transmission within the local communities. The coexistence of these two malaria parasite species with their distinct epidemiological features complicates the implementation of effective control and elimination strategies in the Gadchiroli district.[3,5]

The coexistence of Plasmodium falciparum and Plasmodium vivax, the two predominant malaria parasite species in the region, requires a multifaceted approach to malaria control. This is particularly crucial given the increasing antimalarial resistance observed in both species, as evidenced by recent studies on drug resistance markers within India. Addressing the distinct epidemiological features of these two species, such as the acute symptoms associated with P. falciparum and the potential for relapses and asymptomatic infections caused by P. vivax, is essential for developing effective control and elimination strategies in this context.[5]

The development of chloroquine resistance in Plasmodium vivax presents additional challenges for implementing effective treatment strategies. This underscores the necessity for ongoing surveillance and the adaptation of therapeutic interventions to address the evolving patterns of drug efficacy in the region.[4]

Comprehending the prevalence and characteristics of both Plasmodium falciparum and Plasmodium vivax is critical for designing effective interventions. Consequently, continued research investigating the genetic markers of drug resistance and their impact on treatment protocols is essential for enhancing outcomes in malaria-endemic regions such as Gadchiroli.[5]

The Gadchiroli district in Maharashtra, India, exhibits a heterogeneous distribution of malaria incidence across its constituent talukas. This spatial variability underscores the need for tailored public health interventions that account for the distinct epidemiological profiles and vulnerabilities of each taluka to malaria transmission.[5]

The malaria burden within the Gadchiroli district exhibits heterogeneity across the various talukas. Differing environmental and socio-economic factors contribute to varied transmission dynamics and case numbers. Some talukas, like Armori and Wadsa, have reported higher malaria incidence rates with seasonal outbreaks, while others experience lower rates due to better vector control and healthcare access. This highlights the need for localized strategies to address the unique challenges in each region.[6, 7]

The heterogeneous distribution of malaria incidence across the talukas in Gadchiroli underscores the need for tailored public health interventions that account for the distinct epidemiological characteristics of each taluka. This would enable the optimal allocation of resources to the regions most affected by malaria, thereby enhancing the effectiveness of control and elimination efforts in the district.[6, 5]

Effective interventions must also take into account the seasonal and environmental factors that shape transmission dynamics, as demonstrated by research examining how ecological variables influence malaria risk across various districts in India, including the particularly vulnerable Gadchiroli region, which experiences pronounced seasonal variations in malaria transmission.[7]

In Gadchiroli, the accurate reporting and recording of *Plasmodium falciparum* cases are crucial for the region's malaria surveillance and control efforts. Local health centres play a vital role in this process by conducting diagnostic tests, reporting data, and implementing treatment protocols. However, disparities in healthcare infrastructure and resources across different talukas lead to significant variations in these practices. In some areas with limited healthcare access, the underreporting of Plasmodium falciparum cases is a major concern, resulting in an incomplete understanding of malaria incidence and hindering the development of effective interventions. Conversely, talukas with better healthcare and stronger public health strategies tend to have more accurate data recording, enabling health authorities to track outbreaks and allocate resources effectively. This disparity in data quality across talukas underscores the need for standardized reporting protocols and capacity-building initiatives for health workers. Ensuring that all cases are properly captured and that interventions are guided by reliable epidemiological data will ultimately enhance malaria control efforts in the region.[6, 8]

Additionally, the seasonal fluctuations in malaria transmission, with incidence often peaking during the monsoon period, further emphasize the necessity of reinforcing public health infrastructure and enhancing data collection mechanisms. This will enable timely and targeted interventions to address the dynamic nature of the malaria burden in Gadchiroli. Furthermore, fostering community engagement and awareness programs is crucial for improving case detection and reporting at the grassroots level, which can serve as a complementary strategy to augment the

effectiveness of public health initiatives and ultimately mitigate the malaria burden within the district.[6]

The Gadchiroli district in Maharashtra, India, faces significant hurdles in its fight against malaria, requiring a comprehensive approach to address the challenges. One of the key obstacles is the high prevalence of asymptomatic malaria cases, which often go undetected and contribute to ongoing transmission within the community, complicating eradication efforts. The limited availability of diagnostic resources and inadequate community awareness further exacerbate this issue, necessitating the implementation of enhanced screening programs to effectively identify and treat these asymptomatic cases. This, in turn, would disrupt the cycle of transmission and enhance overall malaria control measures in the region.[6]

The rugged geographical landscape of Gadchiroli, featuring dense forests and remote villages, poses significant challenges in accessing healthcare services and implementing routine vector control measures. To address these complexities, it is imperative to adapt interventions to the local context. This may involve leveraging mobile health technologies and engaging community health workers to extend the reach and accessibility of malaria-related services within the region.

The emergence of drug-resistant strains of *Plasmodium falciparum* and *Plasmodium vivax*, as reported in regional studies, underscores the critical need for sustained surveillance and research efforts to better comprehend the evolving malaria epidemiology. This is essential for developing tailored treatment and prevention strategies of container surveys, insecticide including IRS i.e. indoor residual insecticide spray, LLIN i. e .long lasting insecticidal net. To effectively address these challenges, it is imperative to implement integrated vector management approaches that incorporate chemical, biological, and environmental control measures. Furthermore, investment in community education programs is crucial to foster local support and collaborative, long-term efforts in combating the disease.[9, 10, 11, and 12]

The Government of India has implemented various initiatives to strengthen the surveillance and reporting of malaria data in the Gadchiroli district of Maharashtra. These efforts include the establishment of a comprehensive monitoring system that leverages mobile health technologies to enhance data collection and reporting in remote areas, thereby improving the accuracy and timeliness of malaria case recording. This system facilitates real-time data sharing between public health centres, enabling prompt responses to outbreaks and evidence-based decision-making. Moreover, the government has prioritized training programs to enhance the skills of local health workers in data collection, reporting, and analysis, ensuring that public health personnel are well-equipped to capture comprehensive malaria incidence data and address the challenges posed by the disease in the region. Additionally, ongoing collaborations with non-governmental organizations have facilitated community engagement and awareness programs, which are essential for fostering a culture of reporting and accountability among the local population, ultimately contributing to improved data integrity and more effective malaria control efforts in Gadchiroli.[12]

The government is also strengthening collaborations across different sectors, such as environment and agriculture, to address the complex nature of malaria control. This includes managing mosquito breeding sites and increasing community involvement in eradication efforts. These efforts aim to establish a more comprehensive approach to recording and using malaria data in the district. This demonstrates a commitment to improving public health infrastructure and ensuring data-driven decision-making supports ongoing malaria control initiatives, which is crucial for reducing the disease burden in Gadchiroli and similar regions facing similar challenges.[13]

During the past decade, the Gadchiroli district in Maharashtra, India, has experienced a fluctuating pattern in the incidence of Plasmodium falciparum and Plasmodium vivax malaria infections. Data indicate that while Plasmodium vivax remains the dominant strain, the proportion of cases attributed to Plasmodium falciparum has exhibited a concerning increase, suggesting shifts in transmission dynamics, and potentially reflecting the challenges posed by asymptomatic infections and the emergence of drug-resistant parasite strains.[3, 6].

Regional studies have reported a concerning increase in the proportion of Plasmodium falciparum cases, rising from 30% in 2010 to 45% by 2015 within the Gadchiroli district[14], underscoring the need for targeted interventions to address this trend.[6]

By the year 2020, the proportion of Plasmodium falciparum cases had risen to approximately 50%, indicating a significant shift in the malaria epidemiology of the Gadchiroli district. This change necessitates immediate attention and the implementation of targeted intervention strategies that address both Plasmodium falciparum and Plasmodium vivax infections concurrently, in order to effectively mitigate the overall malaria burden in the region.[6, 15]

The increasing prevalence of Plasmodium falciparum infections has significant implications for malaria control efforts in the region. This necessitates the implementation of an integrated approach that concurrently addresses both P. falciparum and P. vivax infections, while also considering the unique challenges posed by asymptomatic cases and the emergence of drug-resistant parasite strains.[16, 14, and 6]

In the present study the prevalence of malaria via P. falciparum and P. vivax has been studied for ten years across twelve talukas of the Gadchiroli district and resultant trend in P. falciparum incidences in each taluka by the year 2014 till 2023 has been statistically analysed which has showcased that how each taluka

dealt with malaria management and also given an idea about which taluka found to be more vulnerable to infection.

METHODOLOGY:

Prevalence of Malaria:

The present study carried out in the Gadchiroli district of Maharashtra where the twelve talukas namely Dhanora, Aheri, Korchi, Mulchera, Chamorshi, Bhamragad, Ettapalli, Gadchiroli, Kurkheda, Armori, Sironcha and Wadsa has been yearly sampled for prevalence of Malaria which is prominently recorded for the Malaria brought about by *Plasmodium falciparum* (PF) and *Plasmodium vivax* (PV).

Data collection of divisions (Taluka):

Here the data of population of each division is altogether analyzed as a subject. Here during data recording each taluka having its own public health center and their sub centers were permitted to collect the prevalence percent of malaria in local population. In a process the trained volunteers visited each taluka having more than 30 villages each to record the data. The study has initiated in the year 2014 till 2023.

Particulars of data collection:

During data recording trained staff visited villages and among total population only the population having symptoms like fever, headache, body ache and other were considered as suspected when we have screened then at home or as workplace. The suspected were asked to give samples of blood for peripheral smear with thick and thin preparation to record the presence of malaria parasites (P.F and P.V).

Data recording of positivity:

Among the sampled population showing symptoms like malaria, were blood smear based microscopically analyzed.

As per microscopy the patients were classified as negative, PV positive and PF positive from each village of the taluka patient. Here based on the data of total PV and PF positivity the village-based PF% has been put forward. This village specific PF% then average to record the real trend of PF% among the taluka for the given year.

Statistical analysis of PF prevalence variation within taluka as per year wise:

It is important to understand the trend of PF positivity for each taluka in terms of year wise variations and thus study systematically compared the positivity rate in given 12 talukas individually as per year wise statistical analysis using one way ANOVA using $P<0.05$ as significant variation. To do so data of each public health center were considered as mean and overall PHC were used to record the prevalence % for each year.

RESULTS:

PF prevalence in Dhanora :

As per Table 1 the PF prevalence rate was found to be on higher side till year 2014-15 as 58 ± 3.9 cases and 30 ± 2.1 cases, respectively. Thereafter the reduction in cases of PF recorded right after 2016 till 2023 with minimum cases reported as 3.0±0.20 in year 2018 and maximum was as 12± 0.79 and 12±0.50 in years 2021 and 2023 respectively as shown in Table 1. Here as per one way ANOVA it has been observed that the PF prevalence found to be constant from year 2017 till 2023 with no significance change in cases ($P>0.05$). In contrast year 2014 and 2015 Dhanora Taluka registered higher proportion of PF in cases and thus recorded significant ($P<0.05$) in difference as compared to other years.

PF prevalence in Aheri:

Taluka Aheri recorded with very high prevalence of PF as compared to PV in positive patients till year 2015 ranges from 2014 as 11±16 to 19± 32 cases per PHC based villages cases data, respectively. Here significant ($P<0.05$) increase recorded in year 2015 compared to 2014 and other also and noted with highest PF prevalence. Thereafter by year 2016 till 2023 continuous decline with as low as 0.37 ±0.73 cases to maximum of 3.4± 6.8cases was recorded. These reports are found to be non-significant ($P>0.05$) in many comparisons and few sets found to be significant ($P<0.05$) as shown in Table 2.

PF prevalence in Korchi:

As per the years of records (2014-2023) it has been observed that taluka Korchi has been very well controlled with the PF prevalence from year 2016 till 2023 since significant reduction in cases per public health centers been recorded ($P<0.05$) as compared to earlier two years. Here as recorded year 2015 noted with highest PF incidence with 14 ± 24 positive cases per PHC and second highest was in year 2014 as 4.4 ± 13 cases as shown in Table 3.

PF prevalence in Mulchera:

The taluka Mulchera also registered with the similar trend where prevalence of PF in PHC recorded to be on higher side till year 2015 by 2014 as 3.7 ± 7.0 and 5.1 ± 11 cases year, respectively across screened population. Further, the incidences recorded to be reduced significantly ($P<0.05$)from year 2016 till 2023 indicates the better controlling action taken to control PF prevalence as shown in Table 4.

PF prevalence in Bhamragad:

It has been recorded in a comparative manner that the prevalence of PF in Bhamragad is found to be very

high throughout the years (2014-23) once recorded with other taluka since cases are always on higher side indicates that Bhamragad is the hot spot for the PF prevalence and possible spread. The better controlling program can be implemented in such kind of taluka so that its prevalence can be controlled. As per data recorded the highest PF prevalence burst was recorded in year 2021 with 51±50 cases found to be positive per PHC which indicates very high count of prevalence. The higher count of PF also been recorded in year 2023 (38±54 cases) then in years 2015 (41 ± 94 cases) and in year 2014 (23 ±30) as shown in Table 5. Here it is interesting to find decline in the values in between years ($P<0.05$) and that also indicates the better PF controlling program will ensure proper management of the spread.

PF Prevalence in Ettapalli:
The taluka Ettapalli found to be higher in prevalence of PF in the year 2014 and 2015 with 27±33 and 38±44 cases per PHC of taluka. The prevalence then suddenly dropped down in a significant manner by years 2016 till 2023 with lowest prevalence of 2.2 ± 3.3 cases. The trend in declining manner indicates that Ettapalli taluka is improving in terms of PF control as low cases are getting reported as shown Table 6.

PF Prevalence in Gadchiroli:
As per the studies recorded of other taluka, the Gadchiroli taluka found to be very promising in controlling PF prevalence since 2014 till 2023. Here as per record the prevalence of PF positives cases was only higher by year 2014 (5.4 ± 10 cases) per PHC and then it has been reduced significantly ($P< 0.05$) by the year 2015 till 2023 with incidences not more than three cases per PHC which indicates its success in controlling PF significantly as shown in Table 7.

PF prevalence in Kurkheda:
The taluka Kurkheda once again found to be showing similar trend where year 2014 and 2015 recorded with highest PF prevalence as 9.3 ± 20 and 7.2 ± 12 cases per PHC which was then significantly reduced ($P<0.05$) by the years 2016 – 2023. Here in year 2016 only slight rise in PF cases (2.9 ±5.1) was recorded thereafter every year prevalence was not more than 3 cases per PHC indicated better control of PF in Kurkheda as shown in Table 8.

PF prevalence in Chamorshi:
The Chamorshi taluka also evident the highest PF prevalence in the year 2014 – 2015 with average prevalence as 5.1±12 and 5.0±11 cases, respectively by the year 2016 the incidences found to be lowered down significantly ($P<0.05$) with lowest cases recorded as 0.20 ± 0.71 cases in year 2019. This indicates that chamorshi taluka is better in controlling PF as recorded in Table 9.

PF prevalence in Armori:
Among Gadchiroli district the Armori taluka found to be lowest in PF prevalence right from year 2014 till 2023. The only higher prevalence recorded in year 2014 and 2015 (2.7 ± 5.2 and 2.2 ± 5.2), respectively and thereafter every year the prevalence found to be on lower side which indicates its better PF controlling program as shown in Table 10.

PF prevalence in Sironcha:
Taluka Sironcha found to be having marginally higher in PF prevalence from 2014 to 2016 with 6.2±9.9, 8.0±9.8 and 3.4±7.7 cases per PHC. The PF prevalence then significantly ($P<0.05$) reduced to normalcy with lowest prevalence as 0.41 ± 0.86 cases in year 2019. As per data Sironcha found to be lower in cases of PF as compared to others as shown in Table 11.

PF prevalence of Wadsa:
The Wadsa taluka found to be having the most stable rate of incidences of PF as by the year 2014 till 2023 with no rise recorded in any year. Thus, data found to be stable across all years studied with no significances change ($P>0.05$). Here the highest PF value recorded as 1.4± 4.5 in year 2015 and lowest i.e. nil in year 2023 which is showcased in Table 12.

DISCUSSION:
The Gadchiroli district is rich in greenery, forest, hills and well spread natural resources. The district is also varied in geographical make up, ecological factors such as agriculture, climate change, rainfall, humidity, and temperature with environmental degradation, socioeconomic structure with abundance of green zones, rivers, rich flora, marshy land, stream pools, drains and springs. The water bodies are closely associated with human habitat and remains the breeding places of mosquitoes. Here it has been observed that many mosquito varieties are uncharacterized and may be the carriers of deadly pathogens. These malaria vectors are the responsible sources to spread malaria in area like Gadchiroli.
As we know Gadchiroli district is rich in natural resources and in addition most of the villagers and the tribal are having less knowledge about malaria infection and villagers are mainly remains as asymptomatic carriers in the community. In addition, many malaria vectors like *An- culicifaciens*, *An. fluviatilis* and *An. annularis* able to feed on outdoor growing cattle which is prominently been reared by the farmers. According to Dhiman et al., (2005) A*n-culicifaciens*, *An-fluviatilis* and *An-annularis* are the major vectors of malaria of Dhanora taluka of Gadchiroli district[17]. Now it is important to interlink epidemiology of malaria with factors such as host, parasitic factor, location, vectors, and drug interaction as suggested earlier also.[18]According to one study *Anopheles culcifacies* persist all seasons and dominates in all villages and this species is reported to be

responsible for transmission for 60% of cases in India.[19]

In the present study since 12 talukas of Gadchiroli district studied for consecutive 10 years (2014-2023), it has been mainly observed that the Gadchiroli district and their talukas were registered with high incidences and prevalence of PF during years 2014, 15 and 16 but thereafter with proper managements, training and with awareness it has been brought down in a significant manner. This study does indicate that implementation of government vector control program especially in well maintained, easily approached talukas are registering low count of PF as compared to distant or hard to reach areas. For example, Gadchiroli taluka is very low in PF incidences but taluka like Bhamragad found to be high in prevalence rate this study does showcase that although local governance remains the same for all talukas for better vector control program but the ultimate output of the PF in every taluka remains varied. The possible reason behind this could be linked with seasons, geographical location, ecological factors including agriculture, climate change, rainfall, temperature with environmental degradation, humidity, rainy days, dense forests, water reservoirs in number, awareness , eradication program held, educational profile of villagers, farmland, and livestock in the villages. In this study it has also been observed that Gadchiroli taluka showed very steady rate of PF prevalence throughout the years while all other found to be higher during year 2014 and 2015 and reducing in incidences till 2023 due to better monitoring, data recording, sampling, automation and sensing in control, and awareness, preventive and curative measures.

In a similar manner researchers are reporting prevalence of PF percentage via public health department records mainly in Delhi and Gadchiroli district since they are regions of major outbreaks. Here in Gadchiroli district the decline in PF has been reported which agrees with our study also.[20]

CONCLUSION:

The study of Gadchiroli district with respect to malaria cases indicated that PF infection was highest in year 2014 and 2015 and thereafter reduced significantly ($P<0.05$) in every taluka of Gadchiroli. Study put forward the success of malaria elimination mission where it has been observed that with better resources, support of PHC, RH, SDH, WH, DH, government policies with preventive and curative strategies, the rate of PF infection has been found to be better controlled. The possible outcome has been evident in many talukas having limited access, high poverty, less education, lower medical facilities like in Ettapalli and Bhamragad talukas with high APIs are more prone to malaria cases as compared to other talukas and thus study suggests that more intense malaria control program should be implemented in these talukas as parasite load recorded to be high. In addition, root cause of vector transmission, spread and better control program should be implemented with very new technologies, automation, new insecticides and with better or early diagnosis and prompt rational treatment as per national malaria treatment drug policy and guidelines so that mortality rate could be reduced.

Table 1: Prevalence of PF in Dhanora taluka of district Gadchiroli

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	719	258	26	51	25	51	71	156	48	137
Mean	23	18	2.5	3.0	1.7	1.2	3.0	5.1	3.9	4.8
Std. Deviation	58	30	4.1	5.3	3.0	3.8	6.0	12	6.6	12
Significance indicator	a	a	bc	bc	bc	Bc	bc	Bc	bc	bc
Std. Error	3.9	2.1	0.28	0.36	0.20	0.25	0.40	0.79	0.44	0.80

Statistics: The row sharing the same alphabet found to be non-significant ($P>0.05$) and vice versa

Table 2: Prevalence of PF in Aheri taluka of district Gadchiroli

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	87	256	136	25	18	10	13	41	27	16
Mean	11	19	5.1	2.5	0.97	0.55	1.6	3.8	2.1	1.3
Std. Deviation	16	32	11	4.0	1.9	1.2	2.7	5.4	3.7	2.3
Significance indicator	a	b	C	dck	ek	Fk	gk	Hck	ick	jk
Std. Error	1.2	2.5	0.88	0.31	0.14	0.090	0.21	0.41	0.29	0.18

Statistics: The row sharing the same alphabet found to be non-significant ($P>0.05$) and vice versa

Table 3: Prevalence of PF in Korchi taluka of district Gadchiroli

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	293	261	105	22	18	9.0	41	15	17	26
Mean	8.6	19	6.0	1.7	0.99	0.81	3.0	2.1	1.3	1.4
Std. Deviation	25	31	10	3.5	2.3	1.8	5.7	3.5	2.3	3.6
Significance indicator	ac	B	ck	dk	ek	Fk	gk	hk	ik	jk
Std. Error	2.2	2.6	0.84	0.30	0.19	0.15	0.49	0.30	0.20	0.31

Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa

Table 4: Prevalence of PF in Mulchera of district Gadchiroli

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	56	34	20	9.0	3.0	3.0	20	8.0	10	8.0
Mean	7.9	5.3	1.2	0.88	0.24	0.098	0.65	0.87	0.63	0.33
Std. Deviation	12	6.9	2.7	1.6	0.62	0.40	2.3	1.9	1.6	1.0
Significance indicator	a	b	c	dck	ek	Fk	gk	Hk	ik	jk
Std. Error	1.4	0.81	0.31	0.19	0.068	0.045	0.26	0.21	0.18	0.12

Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa

Table 5: Prevalence of PF in Bhamragad of district Gadchiroli

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Maximum	188	910	227	80	97	90	142	356	475	180
Mean	23	41	14	11	5.8	8.1	21	51	38	18
Std. Deviation	30	94	23	11	11	13	23	50	54	22
Significance indicator	aco	bp	co	do	edko	Fdklo	gdklmop	Hnp	in	jklm
Std. Error	2.8	9.0	2.2	1.0	0.96	1.2	2.1	4.6	4.9	2.0

Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa

Table 6: Prevalence of PF in Ettapalli of district Gadchiroli

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	198	315	45	30	33	52	71	56	30	22
Mean	27	38	6.5	4.2	2.2	2.4	6.6	5.6	3.9	2.2
Significance indicator	a	b	cdefhij	defij	e	Fej	gdefhij	Hdefij	iefj	je
Std. Deviation	33	44	6.7	5.1	4.1	5.5	9.6	6.8	4.6	3.3
Std. Error	2.2	3.0	0.46	0.35	0.27	0.37	0.64	0.46	0.31	0.22

Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa

Table 7: Prevalence of PF in Gadchiroli of district Gadchiroli									
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	67	9.0	20	6.0	4.0	14	14	6.0	13
Mean	5.4	0.95	0.87	0.31	0.17	0.71	0.94	0.58	0.58
Std. Deviation	10	1.8	2.0	0.89	0.58	1.8	2.0	1.2	1.5
Significance indicator	a	bj	cj	Dj	ej	fj	gj	hj	ij
Std. Error	0.91	0.15	0.17	0.080	0.053	0.16	0.18	0.11	0.15
Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa									

Table 8: Prevalence of PF in Kurkheda of district Gadchiroli										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	132	65	40	36	11	6.0	8.0	22	23	17
Mean	9.3	7.2	1.7	2.9	0.59	0.26	0.77	1.6	1.4	0.96
Std. Deviation	20	12	4.4	5.1	1.4	0.77	1.3	3.3	3.2	2.7
Significance indicator	a	b	Ckl mnopqr	Dklm nopq	elmno	Fno	glmno	Hlmn Opqr	ilmnoqr	jlmnor
Std. Error	1.6	1.0	0.36	0.42	0.11	0.063	0.11	0.27	0.27	0.22
Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa										

Table 9: Prevalence of PF in Chamorshi of district Gadchiroli										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	120	99	17	9.0	10	5.0	17	25	40	16
Mean	5.1	5.0	0.87	0.78	0.40	0.20	0.50	0.99	0.98	0.76
Std. Deviation	12	11	2.2	1.6	1.3	0.71	1.8	3.1	4.0	2.1
Significance indicator	ak	bk	clm	dlm	em	Flm	glm	Hlm	im	jlm
Std. Error	0.84	0.81	0.15	0.12	0.089	0.050	0.13	0.22	0.29	0.15
Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa										

Table 10: Prevalence of PF in Armori of district Gadchiroli									
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	31	30	10	8.0	5.0	3.0	4.0	8.0	6.0
Mean	2.7	2.2	0.39	0.42	0.068	0.21	0.49	0.30	0.31
Std. Deviation	5.2	5.2	1.4	1.1	0.51	0.57	0.99	0.94	0.81
Significance indicator	a	b	cj	Dj	ej	fj	gj	hj	ij
Std. Error	0.52	0.52	0.14	0.11	0.050	0.056	0.097	0.093	0.081
Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa									

Table 11: Prevalence of PF in Sironcha of district Gadchiroli										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	61	64	62	23	8.0	5.0	7.0	9.0	5.0	17
Mean	6.2	8.0	3.4	2.1	0.54	0.41	0.66	1.5	0.51	0.78
Std. Deviation	9.9	9.8	7.7	3.6	1.4	0.86	1.3	2.1	1.0	2.0
Significance indicator	a	b	c	dk	ek	Fk	gk	Hk	ik	jk
Std. Error	0.88	0.88	0.68	0.32	0.12	0.076	0.12	0.19	0.090	0.18
Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa										

Table 12: Prevalence of PF in Wadsa of district Gadchiroli										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	19	25	4.0	11	1.0	1.0	3.0	2.0	3.0	0.0
Mean	1.3	1.4	0.21	0.42	0.067	0.067	0.17	0.17	0.23	0.0
Std. Deviation	4.3	4.5	0.78	2.0	0.25	0.25	0.59	0.53	0.63	0.0
Significance indicator	a	b	c	d	e	F	g	H	i	J
Std. Error	0.76	0.77	0.14	0.34	0.046	0.046	0.11	0.097	0.11	0.0
Statistics: The row sharing the same alphabet found to be non-significant (P>0.05) and vice versa										

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REFERENCES:

1. World Health Organization Fact sheet on the World Malaria Report 2018. Available at Website https://www.who.int/news room/factsheets/detail/malaria
2. I.N.Abdullahi, S.Yakubu, J.O.Mustapha, ``Epidemiology and Synergistic Hepatopathology of Malaria and Hepatitis C Virus Confection``, SAGE Publishing, 8, 1178122X1772441-1178122X1772441, 2017.
3. G.B. Modi, and H. Patel ``Prevalence and seasonal trends of malaria at general hospital, Palanpur Banaskantha, Western part of India`` IP International Journal of Medical Microbiology and Tropical Diseases, 4(3), pp.141-145, 2020
4. R. Suwanarusk, B. Russell, M. Chavchich, ``Chloroquine Resistant Plasmodium vivax: In Vitro Characterisation and Association with Molecular Polymorphisms``, Public Library of Science, 2(10), pp. e1089-e1089, 2007.
5. Anantabotla, V. M. Antony, H. A.Parija, et al, ``Polymorphisms in genes associated with drug

resistance of Plasmodium vivax in India` `Elsevier BV, 70, pp. 92-97, 2019.

6. M.K. Chourasia, K. Raghavendra, Bhatt, et al, `` Burden of asymptomatic malaria among a tribal population in a forested village of central India: a hidden challenge for malaria control in India' 'Elsevier BV, 147, pp.92-97, 2017.
7. R. Kumar, C. Dash, and K. U. Rani, `` Ecological covariates based predictive model of malaria risk in the state of Chhattisgarh, India``, Springer Nature, 41(3), pp.761-767, 2017
8. Krishna, A. Yadav, Bhandari, et al,`` Prevalence of malaria in two highly endemic Community Health Centres in the Bastar district, Chhattisgarh showing mixed infections with Plasmodium species``,NaturePortfolio,7(1), 2017.
9. M.Prato, A.Khadjavi, G. Mandili, et al, ``Insecticides as Strategic Weapons for Malaria Vector Control``, 2012
10. Malaria: ``An updated research agenda for diagnostics, drugs, vaccines, and vector control in malaria elimination and eradication.``, Public Library of Science, 14(11), pp. e1002455-e1002455, 2017
11. L.Kamareddine,``The Biological Control of the Malaria Vector``. Multidisciplinary Digital Publishing Institute,4(9), pp.748-767, 2012
12. M.bunge, E.Sibiya, M.N.Millham, et al,``m-health 6framework for improving malaria information dissemination in Buhera rural district amid COVID-19 and beyond``,2021.
13. S.Bhatt, Weiss, D.J.Cameron, et al, `` the effect of malaria control on Plasmodium falciparum in Africa between 2000 and 2015``, Nature Portfolio, 526(7572), pp.207-211, 2015.
14. D.J. Weiss, T. Lucas , M. Nguyen, `` Mapping the global prevalence, incidence, and mortality of Plasmodium falciparum 2000–17: a spatial and temporal modelling study` `Elsevier BV, 394(10195), pp.322-331, 2019
15. K.E.Battle, T.Lucas, M.Nguyen, etal, ``Mapping the global endemicity and clinical burden of Plasmodium vivax, 2000–17: a spatial and temporal modelling study``, Elsevier BV, 394(10195), pp. 332-343, 2019.
16. A.C.C Aguiar, E.Murce, Cortopassi, et al, ``Chloroquine analogues as antimalarial candidates with potent in vitro and in vivo activity, `` Elsevier BV, 8(3), pp.459-464, 2018.
17. R.C.Dhiman, B.Shahi, S.N.Sharma, V.N.Khargiwarkar, S.K.Subbarao, ``Persistence of malaria transmission in a tribal area in Maharashtra. Curr, Sci. ``, 88(3), pp.754-8, 2005
18. L.J.Bruce-Chwatt, ``Malaria and its control: present situation and future prospects``, Annu Rev Public Health, 8, pp.75–110, 1987
19. K.Raghavendra, S.K.Subbarao, `` Chemical insecticides in malaria vector control in India``, ICMR Bull 32, pp.94–99, 2002.
20. R.K.Singh, P.K. Mittal, M.P.Gourshettiwar et *al*. ``Susceptibility of malaria vectors to insecticides in Gadchiroli district (Maharashtra), India``, J Vector Borne Dis, 49(1), pp.42-44, 2012.
21. T.R.Rao,`` The Anophelines of India, Rev. edn. Malaria Research Centre (Indian Council of Medical Research, Delhi) ``, pp.154-8, 1984