Active v. passive surveillance for malaria in remote tribal belt of Central India: Implications for malaria elimination

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Balaghat district in Central India is characterized by perennial malaria transmission. In this study, we have estimated malaria parasite rates by microscopic examination of blood smears by conducting active (ACD) and passive surveillance (PCD) in the villages of Baihar community health center (CHC) during January 2012–December 2012. Comparison of the results of two methods revealed that ACD (active case detection) in villages provides relatively large numbers of malaria positive cases (1408/3601) as compared to PCD (passive case detection) at CHC (139/2743) (OR 12.03, 95% CI, 9.97–14.57, $p < 0.0001$). Similarly, large numbers of *Plasmodium falciparum* cases (1194) were found (SFR, 33.2%) in villages, while only 98 *P. falciparum* cases (SFR, 3.6%) were found at CHC (OR 13.39, 95% CI, 10.80–16.73, $p < 0.0001$). Likewise, *Plasmodium vivax* were 211 (SVR, 5.9%) in villages by ACD (OR 4.1, 95% CI, 2.91–5.9, $p < 0.0001$), while only 41 *P. vivax* (SVR, 1.5%) were found at CHC. In this cross-sectional study, we discussed the potential role of ACD in strengthening of surveillance for high coverage. For malaria elimination initiative, a surveillance system must be more sensitive than PCD along with effective tools for vector control to target high-risk population who are not visiting the health facility and seed transmission to the surrounding population. The study highlights the substantial difference in the malaria positivity rate by two methods in difficult and hard-to-reach areas and recommendations are made to understand how best to deploy ACD methods in the pursuit of malaria elimination.

Graphical abstract showing the month wise active and passive malaria prevalence.

Keywords: Active surveillance, Passive surveillance, Malaria, *Plasmodium falciparum*, *Plasmodium vivax*, Central India, Tribal, Microscopic examination

Introduction

Malaria is a major health problem in tribal areas of the India. A recent study indicated that 8% of India's population residing in tribal areas contributes to 46% of total malaria, 70% of *Plasmodium falciparum* and 47% of malarial deaths in the country.¹ Another study revealed that tribal households had 1.4 times more chances of malaria

when compared to other social groups and backward class households living in the same area and exposed to similar malarious conditions.² Parasite rates are important indicators of disease burden³ and malaria risk is not equally distributed within a population, and variation in the risk of malaria within a population is poorly understood particularly in tribal areas of India.^{4,5}

Balaghat district (longitude 80°15'E, latitude 21°84'N) in Central India is highly malarious with perennial

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Figure 1 Map of India showing state of Madhya Pradesh; district Balaghat and study villages in Baihar community health center.

transmission of malaria in a forested region where both *P. falciparum* and *Plasmodium vivax* are prevalent, and *P. malariae* also found^{6,7} (Fig. 1). An epidemiological study on the dynamics of forest malaria in Balaghat revealed that there are two highly efficient vectors i.e. *Anopheles culicifacies* and *Anopheles fluviatilis* and both are involved in perennial transmission of malaria,⁷ though the area is under two rounds of indoor residual spray (IRS) with synthetic pyrethroids. Understanding the multifaceted determinants of malaria transmission is important in areas of perennial malaria transmission. Most malaria control programs have passive surveillance systems to identify, treat, and report individuals who present themselves to health facilities.⁸ It is known that passive surveillance grossly underestimated the malaria prevalence as only those patients receive treatment when they seek medical care, thus it would have a limited impact on malaria transmission. On the contrary, active surveillance which involves screening of population by visiting door to door, targeting of all subjects with fever or history of fever is suitable for difficult and hard-to-reach areas in an attempt to increase access to care in underserved areas.^{8,9} This study was undertaken to understand the epidemiology and pattern of malaria in an endemic area by PCD in comparison with ACD carried out in the same area.

Material and methods

This cross-sectional study was undertaken in forest villages of Baihar community health center (CHC), Balaghat district, for one year (January 2012–December 2012). These villages are located at a distance of 5–35 km from the CHC and public transport facility is not available. The inhabitants of the Baihar CHC are mainly Baiga, particularly vulnerable tribes, who are less educated and less wealthy compared to the general population and have immense faith in sorcery and witchcraft. People are reluctant to go to a health facility and prefer to approach their spiritual leader for treatment. The details of the study area have been published elsewhere.⁷ Their houses are poorly constructed, scattered in fields and the forest on undulating terrain. The local economy is forest based. Most of the inhabitants of the villages work as laborers in forest nurseries, road construction, and other casual jobs. *P. falciparum* was a dominant parasite species throughout the year. Spleen rate was 43.8% in young children (2–9 years). Two efficient vector species, i.e. *A. culicifacies* and *A. fluviatilis*, were involved in malaria transmission during most part of the year i.e. 10 months.⁷ The study area is under two rounds of IRS with synthetic pyrethroid (First round in May–June and second round in August–September). Seasons

are defined as a spring (February–March), summer (April–June), monsoon (July–September), post-monsoon (October–November) and winter (December–January).

A malaria clinic was established at Baihar CHC by National Institute for Research in Tribal Health (NIRTH). All the symptomatic patients from 30 study villages (Population 20,000) who visited CHC with fever, body ache and other symptoms were screened for malaria parasites (PCD). A finger-prick blood sample was obtained from all symptomatic individuals under sterile conditions using disposable equipment. Thick and thin blood smears were prepared, stained with JSB stain,¹⁰ and examined under the microscope on the spot at CHC. A report of the result and treatment was given to all individuals prior to their departure from the clinic. In the same 30 villages, ACD was undertaken by a trained field team of NIRTH comprising a medical officer, one technician and two field assistants and a driver. The community was informed of active surveillance through community leaders. The active surveillance was carried out once a month by visiting door to door, and started at 8 AM after taking written informed consent.

A finger-prick blood sample was obtained from all individuals who participated in the ACD program. The field assistants assist in the preparation of blood smears and staining the slides which were also brought to CHC for processing. The results of the blood smears were made available the next day along with treatment.

The technician examined 100 fields in thick smears before declaring it negative. For quality control, 100% of positive smears and 10% of negative smears were re-examined by a second expert who was unaware of previous results. All *P. falciparum* cases were given ACT (artesunate + SP) and primaquine (PQ) and all *P. vivax* cases were given CQ and PQ as per national guidelines.¹¹ Pregnant women and infants were not given primaquine.

The data were double-key entered in MS Access 2003 (Microsoft Corporation, Redmond, Washington, USA) based data entry screen. Data analysis was done using SPSS 17 for Windows (SPSS Inc. Chicago, IL). Age was recoded as a categorical variable (<1, >1–4, >4–8, >8–14 and >14 and above) before analysis. Gametocyte carriers were recorded only for *P. falciparum*.

The slide positivity rate (SPR) is the proportion of examined thick films was found positive for malaria parasite and the related slide falciparum rate (SFR) and slide vivax rate (SVR) were calculated. The *P. falciparum* percentage was defined as the number of blood smears found positive for *P. falciparum* in all blood smears positive for malaria. The study is approved by the Institutional Ethics Committee.

Results

Comparison of the results by two methods revealed that ACD in villages provides relatively large numbers of positive cases (1408/3601) as compared to PCD at CHC (139/2743) (OR 12.03, 95% CI, 9.97–14.57, $p < 0.0001$). Similarly, large numbers of *P. falciparum* cases (1194) were found (SFR, 33.2%) in villages, while only 98 *P. falciparum* cases (SFR, 3.6%) were found at CHC (OR 13.39, 95% CI, 10.80–16.73, $p < 0.0001$). Gametocytes were recorded in 12% patients in ACD as against 4% in PCD. Similarly, *P. vivax* were 211 (SVR, 5.9%) in villages by ACD (OR 4.1, 95% CI, 2.91–5.9, $p < 0.0001$), while only 41 *P. vivax* (SVR, 1.5%) were found at CHC.

Age-group wise stratification revealed (Table 1) that highest SPR was found in young children of 1–4 years when compared to adults by both ACD (OR 3.6, 95% CI, 2.7–4.7, $p < 0.0001$) and PCD (OR 2.2, 95% CI, 1.3–3.9, $p < 0.005$). ACD revealed that gametocytes were highest in young children aged 1–4 years (OR 1.9, 95% CI, 1.0–3.7) followed by relatively older children aged 4–8 years (OR 1.9, 95% CI, 1.1–3.3) and infants less than 1 year (OR

Table 1 Age-group wise malaria prevalence in Baihar clinic and villages of Baihar CHC, district Balaghat

Survey type	Age group	BSE	Pos	Pf	Pv	Pfg	SPR	SFR	SVR	Pf (%)	Pv (%)	Pfg (%)	OR malaria (95% CI)
Passive	≤1 year	17	1	1	0	0	5.9	5.9	0.0	100.0	0.0	0.0	1.4 (0.2–10.4)
	>1–4 years	174	16	8	8	1	9.2	4.6	4.6	50.0	50.0	12.5	2.2 (1.3–3.9)*
	>4–8 years	250	16	14	2	1	6.4	5.6	0.8	87.5	12.5	7.1	1.5 (0.9–2.6)
	>8–14 years	344	20	15	5	0	5.8	4.4	1.5	75.0	25.0	0.0	1.3 (0.8–2.2)
	>14 years	1958	86	60	26	2	4.4	3.1	1.3	69.8	30.2	3.3	Ref. [1]
Total		2743	139	98	41	4	5.1	3.6	1.5	70.5	29.5	4.1	
Active	≤1 year	148	70	52	18	7	47.3	35.1	12.2	74.3	25.7	13.5	2.7 (1.9–3.9)**
	>1–4 years	310	168	128	39	20	54.2	41.3	12.6	76.2	23.2	15.6	3.6 (2.7–4.7)**
	>4–8 years	648	307	262	44	40	47.4	40.4	6.8	85.3	14.3	15.3	2.7 (2.2–3.4)**
	>8–14 years	1484	611	514	97	58	41.2	34.6	6.5	84.1	15.9	11.3	2.1 (1.8–2.5)**
	>14 years	1011	252	238	13	21	24.9	23.5	1.3	94.4	5.2	8.8	Ref. [1]
Total		3601	1408*	1194	211	146	39.1	33.2	5.9	84.8	15.0	12.2	

Notes: Passive collection: patients visited the hospital clinic; active fever surveillance: door-to-door visits for surveillance of fever cases in villages.

BSE: blood slide examination; Pos: positive for malaria; Pf: *Plasmodium falciparum*; Pv: *Plasmodium vivax*; Pfg: *Plasmodium falciparum* gametocyte; SPR: slide positivity rate; SFR: slide falciparum rate; SVR: slide vivax rate.

* $p < 0.005$.

** $p < 0.0001$.

*Three cases were *P. malariae*.

Table 2 Season wise malaria prevalence in Baihar clinic and villages of Baihar CHC, district Balaghat

Survey Type	Season	BSE	Pos	Pf	Pv	Pfg	SPR	SFR	SVR	Pf (%)	Pv (%)	Pfg (%)	OR Malaria (95% CI)
Passive	Spring (February–March)	170	5	5	0	1	2.9	2.9	0.0	100.0	0.0	20.0	Ref. [1]
	Summer (April–June)	515	16	6	10	1	3.1	1.2	1.9	37.5	62.5	16.7	1.1 (0.4–2.9)
	Monsoon (July–September)	1212	46	28	18	1	3.8	2.3	1.5	60.9	39.1	3.6	1.3 (0.5–3.3)
	Post Monsoon (October–November)	624	48	37	11	1	7.7	5.9	1.8	77.1	22.9	2.7	2.8 (1.1–7.0)
	Winter (December–January)	222	24	22	2	0	10.8	9.9	0.9	91.7	8.3	0.0	4.0 (1.5–10.8)*
	Total	2743	139	98	41	4	5.1	3.6	1.5	70.5	29.5	4.1	Ref. [1]
Active	Spring (February–March)	406	120	107	13	0	29.6	26.4	3.2	89.2	10.8	0.0	Ref. [1]
	Summer (April–June)	1003	313	254	56	30	31.2	25.3	5.6	81.2	17.9	11.8	1.1 (0.8–1.4)
	Monsoon (July–September)	752	289	226	63	20	38.4	30.1	8.4	78.2	21.8	8.8	1.4 (1.2–1.9)**
	Post Monsoon (October–November)	799	386	348	38	65	48.3	43.6	4.8	90.2	9.8	18.7	2.2 (1.8–2.9)*
	Winter (December–January)	641	300	259	41	31	46.8	40.4	6.4	86.3	13.7	12.0	2.1 (1.6–2.7)*
	Total	3601	1408#	1194	211	146	39.1	33.2	5.9	84.8	15.0	12.2	

Notes: Passive collection: patients visited the hospital clinic; active Fever Surveillance: door-to-door visits for surveillance of fever cases in villages.

BSE: blood slide examination; Pos: positive for malaria; Pf: *Plasmodium falciparum*; Pv: *Plasmodium vivax*; Pfg: *Plasmodium falciparum* gametocyte; SFR: slide positivity rate; SVR: slide falciparum rate; SFR: slide positivity rate; SFR: slide falciparum rate; SVR: slide falciparum rate.

* $p < 0.005$.

** $p < 0.0001$.

#Three cases were *P. malariae*.

Table 3 Village wise (active case detection) showing malaria positive *P. falciparum* and *P. vivax*

Village Code	BSE	Pos	Pf	Pv	SPR	SFR	SVR	Pf (%)	Pv (%)
AA	95	17	13	4	17.9	13.7	4.2	76.5	23.5
AB	115	55	53	2	47.8	46.1	1.7	96.4	3.6
AC	117	46	38	8	39.3	32.5	6.8	82.6	17.4
AD	80	28	22	6	35.0	27.5	7.5	78.6	21.4
AE	91	21	19	2	23.1	20.9	2.2	90.5	9.5
AF	84	40	22	17	47.6	26.2	20.2	55.0	42.5
AG	166	65	54	11	39.2	32.5	6.6	83.1	16.9
AH	175	80	69	11	45.7	39.4	6.3	86.3	13.8
AI	118	51	45	6	43.2	38.1	5.1	88.2	11.8
AJ	74	26	25	1	35.1	33.8	1.4	96.2	3.8
AK	114	44	37	7	38.6	32.5	6.1	84.1	15.9
AL	149	85	71	14	57.0	47.7	9.4	83.5	16.5
AM	181	64	49	15	35.4	27.1	8.3	76.6	23.4
AN	121	38	32	6	31.4	26.4	5.0	84.2	15.8
AO	128	47	41	6	36.7	32.0	4.7	87.2	12.8
AP	196	87	74	13	44.4	37.8	6.6	85.1	14.9
AQ	204	59	52	7	28.9	25.5	3.4	88.1	11.9
AR	116	40	29	11	34.5	25.0	9.5	72.5	27.5
AS	118	54	41	12	45.8	34.7	10.2	75.9	22.2
AT	75	28	27	1	37.3	36.0	1.3	96.4	3.6
AU	91	35	30	5	38.5	33.0	5.5	85.7	14.3
AV	128	66	53	13	51.6	41.4	10.2	80.3	19.7
AW	127	79	73	6	62.2	57.5	4.7	92.4	7.6
AX	80	26	21	4	32.5	26.3	5.0	80.8	15.4
AY	93	42	39	3	45.2	41.9	3.2	92.9	7.1
AZ	92	34	29	5	37.0	31.5	5.4	85.3	14.7
BA	140	41	35	6	29.3	25.0	4.3	85.4	14.6
BB	114	44	39	5	38.6	34.2	4.4	88.6	11.4
BC	137	30	27	3	21.9	19.7	2.2	90.0	10.0
BD	82	36	35	1	43.9	42.7	1.2	97.2	2.8

Notes: BSE: blood slide examination; Pos: positive for malaria; Pf: *Plasmodium falciparum*; Pv: *Plasmodium vivax*; Pfg: *Plasmodium falciparum* gametocyte; SPR: slide positivity rate; SFR: slide falciparum rate; SVR: slide vivax rate.

1.6, 95% CI, 0.6–4.1) when compared to adults. By PCD, very few gametocytes were found; hence, no trend was observed.

Season wise analysis revealed that the SPR was highest in winter and lowest in spring (OR 4.0, 95% CI, 1.5–10.8, $p < 0.005$) by PCD (Table 2), while highest SPR was observed in the post-monsoon and lowest in spring season by ACD (OR 2.2, 95% CI, 1.8–2.9, $p < 0.0001$). Gametocytes were significantly more in post-monsoon season as compared to other seasons. ($\chi^2 = 39.18$, $p < 0.0001$).

Table 3 showed village wise malaria positivity by ACD. Though all the villages are highly malarious but village-to-village variations are common. Average SPR of 30 villages was 38.8 (95%CI 35.2–42.4) and ranged from 17.9 to 62.2%; similarly, average SFR was 32.95 (95%CI 29.5–36.4) and ranged from 13.7 to 57.5%. The average proportion of *P. vivax* was 14.8 (95%CI 11.8–17.9) and *P. falciparum* was 84.8 (95% CI 81.6–88.0).

Discussion

Malaria is a major challenge in the forested tribal belt where no public transport system is available and health infrastructure is poor.^{7,12} With a year-round presence in some parts of the country, it exacts an unacceptable toll on the health of the people of all ages.¹³ Moreover, population movement in and out of the forest was common and there was no mechanism in place to check these movements.¹⁴ Extending effective and appropriate care in such sparsely

populated areas is difficult due to lack of resources.¹⁵ Recently, India launched the national malaria elimination program to eliminate malaria from India in a phase wise manner by 2030.

The PCD only detects symptomatic patients and overlook individuals who are not seeking treatment. Identifying hyperendemic communities within endemic areas constitutes an important challenge for malaria control and elimination as this population contributes disproportionately to malaria transmission. By treating these individuals, not only the community would be protected, but has also resulted in substantial reduction in transmission intensity. Targeting these high-risk populations prevents the spread of malaria more widely as was done in Brazil.¹⁶ Otherwise, the population who is not visiting health facilities, seed transmission in the surrounding population in receptive areas, thus creating new foci. The greatest risk of malaria among children of 1–4 years of age observed in this study was comparable to an earlier finding from this area⁷ and nearby tribal areas.¹⁷ Gametocytes were present in 12% of the subjects by ACD and highest during post-monsoon months which is the main transmission season. The prevalence of gametocytes is commonly used as a parameter of malaria transmission.¹⁸

Strengthening of surveillance to achieve high coverage is a priority and an alternative to ACD which would overcome the shortcomings of missed cases, who cannot seek treatment, is a mass screening of the population in high-risk areas which can be best performed through

screen and treat campaign. However, in inaccessible forested areas, screen and treat campaign can be practically possible using rapid diagnostic tests (RDTs) by visiting house to house and testing consenting people and dispensing anti-malarials for malaria parasites.^{19,20} However, low parasite density could be a major limitation for wide-scale testing by RDTs.^{21–23} Moreover, the operational feasibility and acceptability of malaria workers administering RDTs and ACTs within the community in remote areas needs careful evaluation. Furthermore, these communities should be screened at times when people are at home i.e. early morning or late evening. All missed cases should be covered by another visit in the same area to enhance the coverage. Demographic characteristics of these missed people will provide important information of people at high risk and they would not be missed. Many of them might be infected who can amplify transmission by transmitting the malaria parasites to a large number of mosquitoes.²⁴ Studies conducted earlier showed that in hard-to-reach areas, community-wide coverage with the IRS or insecticide-treated bed nets (ITNs) is difficult to achieve in a field situation.⁷ Moreover, a high coverage with ITNs may not be a guarantee for a sustained decline of malaria as it is linked with lack of proper use and mosquito biting behavior.²⁵ These intervention tools bring a substantial reduction in malaria transmission but have limitation for malaria elimination.^{26,27}

This cross-sectional study for the first time in our knowledge has estimated the malaria positivity by ACD v. PCD methods in the same area and has shed light on the substantial difference in the malaria positivity rate by two methods. A reliance on PCD will miss many infections thereby preventing access to diagnosis and treatment among populations at higher risk of malaria. More research on the operational feasibility of ACD and mass screening need to be explored to enable the development of evidence-based strategies for malaria prevention and elimination in inaccessible areas. Such an approach warrants investigation in the context of impact on malaria control and financial implication.

This study has some limitations. The two methods (ACD v. PCD) are actually not comparable as people visiting CHC are screened for malaria irrespective of fever or history of fever. On the contrary, in villages, only fever or cases with history of fever were screened for malaria once in a month. Moreover, our surveillance was confined to a small rural population. This probably explains why we found 39% malaria positivity in villages as against 5% at the CHC. Even though ACT is in the place as a first-line treatment, it is in short supply and there is no drug resistance against ACT.⁷ Access to treatment is also an important indicator of the success of the malaria control in that interventions need to reach remote communities at increased risk of malaria. The minimum distance of a village from CHC is 5 km in this study while traditional healers hail from the same

community, live among them, and are always available, which is another reason for their preference of the community.^{28–30}

How active surveillance will be deployed to pursue malaria elimination is a challenge. A malaria eradication research agenda consultative group suggested that any parasitaemia, whether high or low density, has the potential for malaria transmission and therefore is a threat to malaria elimination efforts.³¹ Active surveillance played a major role in interrupting malaria transmission in Sri Lanka.³² This study suggests that ACD tailored to the local epidemiological setting should be considered as a potential tool complementary to other antimalarial measures to achieve and maintain malaria control and thereby its elimination. This is further supported by the fact that malaria surveillance systems are estimated to detect only 14% of all malaria cases worldwide.³³ Strong malaria surveillance system is fundamental to both program design and implementation.

Ethical approval

The study protocol was approved by the institutional review board of the National Institute for research in Tribal Health (NIRTH), Jabalpur, Madhya Pradesh.

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