



The Behavior of *Jhum* Cultivators Living in Chittagong Hill Tracts and Its Relation to Malaria in Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author MSIL designed the study, performed statistical analysis and wrote the first draft of manuscript. Author MK designed the methodology and edited the manuscript. Author SN wrote the protocol of study and involved in editing the manuscript. Author KC involved in data acquisition and management of literature review. Author MAS figure out the graph, involved in mapping and designed the references sheet. Author MAI reviewed and finalised the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Malaria is caused by invasion of hepatocytes and subsequent red blood cell infection by protozoan parasites of the genus Plasmodium. It is one of the focal disease where children under five years are most vulnerable and susceptible to malaria. Concurrently, malaria is still occupational

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disease in Bangladesh especially among *Jhum* cultivators who depends mostly on *the slash* and burn activities during the rainy season mostly at hill districts. This study unveils the behavior of *Jhum* cultivators and its relation to malaria infection in Bangladesh.

Study Design and Methodology: Both quantitative and qualitative methods were used for this study. A survey was done in 10 sub-districts of Chittagong Hill Tracts resulting 480 sample sizes considering high nonresponse rate in Chittagong Hill Tracts. A Focus Group Discussion was held in each sub-district to get in-depth view of *Jhum* cultivators related to malaria.

Results: In this study, total 386 (80.4%) people were *Jhum* cultivators followed by non-*Jhum* cultivators 94(19.6%). *Jhum* cultivators were 2.5 times of risk of malaria infection than other occupations (P -value = 0.046, CI =1.018-6.156). During their stay at *Jhum* sites, 54% of *Jhum* cultivators hang net in the evening and 44% of people did it during sleeping time. The most biting time at *Jhum* sites was 19.00-20.00 h (P -value = 0.011). The exposure of malaria was high when they came back home (70%) from *Jhum* sites than malaria being exposed at *Jhum* sites (27.4%). In logistic regression, distance (OR=1.20, P -value =0.000, CI=1.093-1.316) is most important factor while using of Long Lasing Insecticidal Nets at *Jhum* sites (OR=0.265, P -value =0.000, CI=0.162-0.431) the other notable factor behind infection of malaria in Bangladesh.

Conclusion: Malaria is still occupational disease especially among *Jhum* cultivators and needs to be taken a comprehensive awareness programme for using of LLIN at *Jhum* sites especially in 19.00-20.00 hours.

Keywords: Malaria; CHT; *Jhum* cultivators and LLIN.

1. INTRODUCTION

Malaria is caused by invasion of hepatocytes and subsequent red blood cell infection by protozoan parasites of the genus *Plasmodium*. It is one of major fatal diseases in Africa. In 2016, an estimated 216 million malaria occurred worldwide (95% Confidence Interval (CI) 196-263 million). About 90% of malaria deaths worldwide were occurred in African Region followed by South East-Asian Region (7%) and then the WHO Eastern Mediterranean Region (2%) [1]. Children under five years are most vulnerable group and susceptible to malaria infection. In Africa, about 285 000 children died before their fifth birthdays in 2016 [2].

Bangladesh, a country in South-East Region, is malaria endemic with 13 out of 64 districts which are endemic. The country's endemicity is stratified in three regions—High (API>5), medium (API =1-5 and low (API<1) [3]. High endemic districts--Rangmati, Bandarban and Khagrachari--the three districts of Chittagong Hill Tracts (CHT) bears 84% of malaria cases in Bangladesh [3]. The other endemic districts, mostly medium and low endemic districts which are covered with plain and hilly areas, experience a rapid malaria fall out since 2010 [3]. The CHT districts which has border with India and Myanmar is characteristic with high hill with difficult terrain, inaccessible foothill and deadly vector (*An. philippinensis*, *An. minimus*, *An. vagus*) which are available in densely and fringe forest and are

the major factors behind high prevalence of malaria in Bangladesh.

BRAC¹, a leading development organization in world, has been secured grant from the Global Fund Fights for AIDs, Tuberculosis and Malaria (GFATM) along with National Malaria Elimination Programme (NMEP) since 2007 and malaria has dramatically reduced since then. Malaria positivity decreased from 84,690 in 2008 to 29,247 in 2017 and Annual Parasite Incidence (API) also reduced from 7.77 in 2008 to 2.20 in 2017 with malaria mortality rate reduced to less than 1 (0.098) in 100,000 population in 2017 [3,4]. The prevalence of *Plasmodium falciparum* and *Plasmodium vivax* and mixed infection are observed 84%, 9% and 7% respectively [3]. Though malaria decreased rapidly in Bangladesh, still Chittagong Hill Tracts (CHT) are a major source of malaria morbidity and mortality in Bangladesh. The tribal people are predominately focused person in CHT districts along with Bengali people living in remote and forested areas dependent highly on *Jhum* cultivation, wood cutting (forest areas), daily labour and other agriculture practices. *Jhum* cultivation² is well correlated with malaria

¹ BRAC is a brand of organization which is previously known as Bangladesh Rural Advancement Committee

² *Jhum* cultivation is an age-old, rain-fed cultivation method, practiced by the Indigenous people on the hills and slopes of the Chittagong Hill Tracts. Under this system, seeds of different crops are mixed together and sewn in this 'field' after the first rain shower has fallen, usually during the months of

season. It starts with the early days of rainy season and ends with the harvesting period preferably, September to November. *Jhum* cultivators need to stay 5-7 or more days in *Jhum* site³ if the site is more than 3 Km away from their home. Most of the time, they do not have LLIN (Long Lasting Insecticidal Nets) according to the people living at *Jhum* site. All of them consider *Jhum* cultivator as a sheer contributing factor for malaria infection in Bangladesh.

Jhum cultivation is known as *slash* –and -burn agriculture, a kind of swidden or shifting cultivation in hilly areas of Chittagong Hill Tracts of Bangladesh has been recognized as subsistence food production system for tribal people. It is still being widely practiced in hilly areas of Bangladesh and considered as the major source of livelihood for tribal people [5,6]. This system involves cutting back and clearing large areas of the hillside through fire and then sowing a variety of seeds including the rice crop. During the harvesting period, *Jhum* cultivators like to go to the field with family member to harvest the crop as early as possible. This shifting cultivation, a substance firming system is also practiced globally, especially in Asia, Africa and Latin America.

As there is a very short study related to *Jhum* cultivation and malaria, BRAC conducted a large scale survey in 10 sub-districts of CHT districts using both quantitative and qualitative methods to get the behavioral practice of *Jhum* cultivators and to find whether there is any relationship between *Jhum* cultivation and malaria incidence in Bangladesh.

2. MATERIALS AND METHODS

Both quantitative and qualitative methods were applied in this study. A survey under quantitative study was carried out in 10 sub-districts of Chittagong Hill Tracts. Under this study, sample size was calculated with 5% margin of error with 95% confidence of interval and by assuming that 50% households of CHT districts have one *Jhum* cultivator resulting 384 sample size. To minimize high non- response rate in CHT, we added 25%

April to May. Typically, upland rice and vegetables are harvested within a few months after sowing, whereas cotton, turmeric and arum are harvested in December. In the past, land was left fallow for between 15 to 20 years, which allowed the soil time to regenerate its fertility, now the time frame to be reduced to a rotation cycle of between 3 to 5 years.

³ *Jhum* site means where *Jhum* cultivators cultivated the hilly area with slash and burn activity

to the sample size and then rounded up that finally the sample size was 480.

The survey was based on two-stage cluster sampling. First, we selected 10 sub-districts randomly from 17 sub-districts of two CHT districts--Bandarban and Rangamati--and then selected 3 villages/para⁴s (Small village: 10-50 Households named as para in CHT) randomly from each sub-district which resulted to 30 villages/para's selected under this study. Total 16 households were taken from each village/para under cluster sampling and enumerators had started their sampling from any corner of a village/para. If any para has less than required household then neighboring para was selected for completing the survey. Information from Bangladesh Bureau of Statistics (BBS) was utilized to obtain the sampling frame for selection of the village/para in each district. Khagrachari district of Chittagong Hill Tracts was excluded in the study considering very few *Jhum* cultivators living in this district.

A fixed questionnaire had been used by trained enumerators to collect data from household. If a tribal community was different from the tribe of enumerator then local educated tribal people was appointed for translating the questionnaire. At first, a *Jhum* cultivator was selected from household to required answer. If a household had no *Jhum* cultivator then other occupation such as forest goer, plain cultivator or daily labourer had been chosen. If any participant agreed to have malaria disease in last one year then it was cross checked with Rapid Diagnostic Test (RDT) or laboratory register. All population above the age of five years, irrespective of sex, religion, ethnicity in a cluster was eligible to participate in the study. The survey was conducted in November, 2016 and analysed by STATA 12.

2.1 Qualitative Study

Focus Group Discussion (FGD) was done to get in depth information from *Jhum* cultivators. Around 5-7 members of a para with 50% of *Jhum* cultivators participated in the discussion. Both male and female were included in FGD. If a para

⁴ Para is small village constitutes of 10-50 households of different tribal groups living in CHT areas which is different from plain land of Bangladesh. This is culture of living of tribal people in CHT. In each para, there is a Karbari who is leader of that para.

was inhabited with mixed tribe, then the tribal people with high population were taken for discussion. Two persons were working for one FGD, one as Moderator and other one as Reporter. A fixed questionnaire was shared with them which included whether and how long they need to stay on the field during *Jhum* cultivation, their willingness and practice to hang LLIN and ways to increase the use of LLIN at *Jhum* sites. At the end of FGD, a village map was designed by participants to delineate the household with *Jhum* cultivator and the malaria patient within the community. One para or village under one sub-district was selected for FGD that implies 10 FGD were done under this study.

to develop codes that identify important and common concepts related to the main theme of the study. Data analysis was done based on the thematic approach that involved organizing from the collected information into meaningful category.

3. RESULTS

Total 480 samples were studied in 10 sub-districts where 386 (80.4%) people were *Jhum* cultivators followed by other occupations⁵ 57 (11.9%) and then plain cultivators⁶ 37 (7.7%). Chakma (28.5%) were highest tribal people among the participants followed by Marma (18.4%) and then Tripura (15.7%). Half (52%) of the participants were illiterate and only (4.8%) were secondary and higher educated (P -value = 0.000) (Table 1). 70.6% participants were between 26-56 years group and 16.9% were under 26 years of age (P -value = 0.017) (Table 1).

Mean age of study people was 39.5 ± 14 years of age. Among the 10 sub-districts, we found that Alikadam sub-district of Bandarban district is the most malaria endemic areas with 52% patient with malaria followed by Belaichhari sub-district of Rangamati district (45.8%) while Rajasthali and Juraichhari sub-district of Rangamati are least endemic areas under Chittagong Hill Tracts. Among the sex, 71.8% were male and 28.2% were female. Of them, 32.5% male and 18.5% female were infected by malaria (OR = 2.11, P -value = 0.002) (Table 2). Among the tribal people, odds of the disease was high in Tripura people (1.2) followed by Boam (0.73) and then Thanchanga (0.51). (P -value =0.000) (Table 2).

Among the occupation of study people, *Jhum* cultivators were infected highly (32.7%) followed by P. cultivators (16.2%) and then other occupations (8.8%) (Table 2). The Odds Ratio of *Jhum* cultivator is 2.50 (P -value< 0.05, CI =1.018-6.156) which implies that *Jhum* cultivators is 2.5 times at risk of malaria than other people (Pseudo R^2 = .034, P -value= 0.0001) (Table 3).

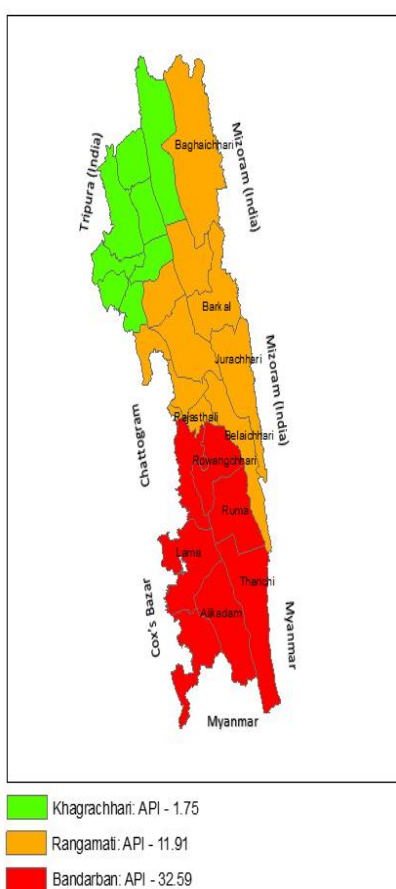


Fig. 1. Chittagong Hill Tracts and the survey areas

Data was transcribed in Bengali language and then it was finalized after completing the discussion. Both enumerators should agree on each point of discussion. When necessary the transcripts were supplemented by field noted to clarify the issues. English transcripts were made

⁵ Other occupation means wood cutter, forest goers, daily labour and other service holder

⁶ Plain cultivators means rice cultivators who are working in plain land of CHT

Table 1. Association between education and age group with occupation

	Occupation						Total	P-value
	Jhum cultivators	Frequency	Plain cultivator	Frequency	others	Frequency		
Education								
Not at all	209	54.15	20	54.05	21	36.84	250	0.000
Pre-primary	111	28.76	12	32.43	9	15.79	132	
Post -primary	57	14.77	5	13.51	13	22.81	75	
S.S.C	7	1.81	0	0.00	9	15.79	16	
H.S.C	2	0.52	0	0.00	4	7.02	6	
Degree	0	0.00	0	0.00	1	1.75	1	
Age Group								
>26	55	14.25	7	18.92	19	33.33	81	0.017
26-41	171	44.30	15	40.54	21	36.84	207	
41-56	113	29.27	8	21.62	11	19.30	132	
56-71	41	10.62	7	18.92	4	7.02	52	
71-81	6	1.55	0	0.00	2	3.51	8	
Total	386		37		57		480	

Table 2. Malaria infection irrespective of sex, ethnicity and occupation

	Malaria in last one year				Total	P-value
	0	Percent	1	Percent		
Sex						
Male	233	67.93	112	81.75	345	0.002
Female	110	32.07	25	18.25	135	
Tribal						
Chakma	112	32.65	25	18.25	137	0.000
Tripura	32	9.33	39	28.47	71	
Marma	65	18.95	18	13.14	83	
Mro	41	11.95	17	12.41	58	
Boam	15	4.37	11	8.03	26	
Tanchanga	39	11.37	20	14.60	59	
Bengali	39	11.37	7	5.11	46	
Occupation						
Jhum Cultivator	260	75.80	126	91.97	386	0.000
P.Cultivator	31	9.04	6	4.38	37	
others	52	15.16	5	3.65	57	
Total	343		137		480	

Table 3. Logistic regression with Malaria infection and occupation

Predicator	Odds ratio	Std. err.	z	P>z	[95% Conf. Interval]
2 (Jhum cultivators)	2.503846	1.149337	2.00	0.046	1.018314 6.156496
3 (others)	0.4967949	0.3212521	-1.08	0.279	0.1398776 1.764437
_cons	0.1935484	0.0863245	-3.68	0.000	0.0807505 0.46391

P. falciparum malaria was high (86 %) among *Jhum* cultivators followed by mixed cases (8%) and then *P. vivax* (6 %). Most of the treatment done by *Shasthya Kormi*⁷ / Health worker (69.3%) followed by *Shasthya Shebika*⁸ (12.4%)

and then Govt. hospital (11.7%). Non –formal health care provider (Village Doctor) was also provided (6.6%) (Table 4) treatment to *Jhum* cultivators, but 50% of them did not follow national treatment protocol and this is significant with education (*P*-value= 0.029).

⁷ *Shasthya Kormi* is the Community Health Worker of BRAC who supervise *Shasthya Shebika*

⁸ *Shasthya Shebika* is the Community Health Volunteer of BRAC

Table 4. Malaria treatment provider for *Jhum* cultivators

Treatment provider	Frequency	Percent	Cum.
Govt. Hospital	13	9.49	9.49
Shasthya Kormi/Health worker	95	69.34	78.83
Shasthya Sebika	17	12.41	91.24
Upazila Health Complex	3	2.19	93.43
Village Doctor	9	6.57	100
	137	100	

During their stay at *Jhum* sites, 54 % of *Jhum* cultivators hang net in the evening and 44% of people did it during the sleeping time. During their stay at *Jhum* sites,60% people infected by

malaria, those who hang net within two hours (19.00 h) of the evening followed by 45.5% who used nets within three hours (20.00 h) and then 32.3% within one hour(18.00 h) of the evening (P -value = 0.011) (Table 5).

Though the prevalence of malaria among *Jhum* cultivator is high, the exposure of malaria is different. It was high when they came back home (70%) from *Jhum* sites than malaria being exposed at *Jhum* sites (27.4%). However, this is not significant.

The regression line between distance and exposure of days of malaria revealed that most of the exposure happened within 10-15 days and few of them exposed after one month (P value = 0.0135, R^2 =0.055,CI = 0.0197-0.16747) (Fig. 2).

Table 5. Malaria infection at hour basis through the evening

Sleeping time starting from evening (0)	Malaria in last one year				Total
	0	Percent	1	Percent	
0	8	17.02	0	0.00	8
1	21	44.68	10	30.30	31
2	12	25.53	18	54.55	30
3	6	12.77	5	15.15	11
Total	47		33		80

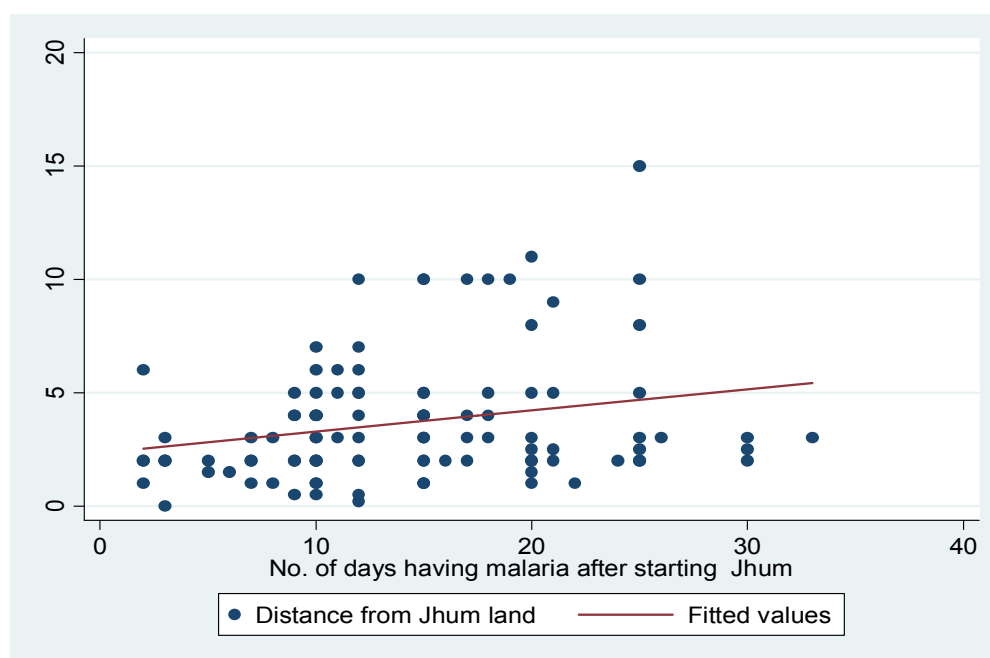


Fig. 2. Regression line between distance and exposure of days

Table 6. Logistic regression of multivariate variables

Predictor	Odds ratio	Std. err.	z	P>z	[95% Conf. Interval]
No. of LLIN					
1	0.2525105	0.1933396	-1.8	0.072	0.0563041 1.132449
2	0.1941317	0.1401586	-2.27	0.023	0.0471572 0.7991796
3	0.2528257	0.1928998	-1.8	0.072	0.0566729 1.127891
4	0.1248502	0.1222236	-2.13	0.034	0.0183272 0.8505176
Distance	1.200004	0.0567957	3.85	0.000	1.093694 1.316649
Hang LLIN at Jhum site (2)	0.2651453	0.0658626	-5.34	0.000	0.162946 0.4314437
_cons	8.458607	6.506874	2.78	0.006	1.87285 38.20276

Table 7. Summary of qualitative findings

Hypothesized mechanism	Results
1. Whether <i>Jhum</i> cultivator need to stay at <i>Jhum</i> sites	<i>Jhum</i> cultivators should stay at <i>Jhum</i> sites. If it is 2-3 km away from their home, they would like to comeback home in evening. “Many times we have to stay at <i>Jhum</i> sites and sometimes we haven't. It depends on distance.” “Many person like to stay at <i>Jhum</i> sites as it secure the crop.”
2. Whether LLIN hung during <i>Jhum</i> cultivation	Most of the people do not use LLIN during <i>Jhum</i> cultivation. If people are aware, they bring LLIN from their home. “We should take LLIN if it available. We could not sleep without net at <i>Jhum</i> site. But most of time it do not cover the whole family.” “Yes, we should hang net at <i>Jhum</i> site. But most of them do not use LLIN.” “Sometime we do not remember to bring LLIN. But we use net for sleeping at night at <i>Jhum</i> site.”
3. Ways and how to use LLIN during <i>Jhum</i> cultivation	Usually they hang the LLIN during sleeping time. They tied the LLIN along the pole of temporary house. “We hang LLIN with temporary bamboo sheet at sleeping time.” “If we bring LLIN, then tied with pole of four corner and sometimes hang it with rope.” “It is difficult to hang LLIN at <i>Jhum</i> site. But we should do it because there is mosquitoes singing all the night.”

The logistic regression with malaria and other variables-- LLIN, distance, and hanging of LLIN at *Jhum* sites--the model is fitted significantly (OR: distance =1.2; OR: hanging LLIN: 0.265 (Pseudo R² = 0.11, P-value = 0.000). The Odds Ratio of LLIN (No. 4) is 0.124 tells us that malaria decreases significantly by 12% if we change no. of LLIN from 3 to 4. The Odds Ratio of distance is 1.2 explain that one unit of change of distance increases risk of malaria by 1.2 times and the Odds Ratio of LLIN hanging at *Jhum* sites is 0.265 tells us that malaria decreases significantly by 26% for each unit of positive change of using of LLIN at *Jhum* sites (Table 6).

The qualitative results addressing the practice of using of LLIN at *Jhum* sites are summarized in the table. In a focus group discussion, most of the members stated that they had to stay at *Jhum* sites for several days but sometimes they could not bring the LLIN. If they carried it, they hung it along the pole of temporary shelter. The summarize of the findings are listed in Table 7.

4. DISCUSSION

Bangladesh has been experiencing rapid malaria cases fall out since 2008 with a sudden malaria upsurge in 2014 [3]. But this is not the case in Chittagong Hill Tracts (CHT) which is still contributing 93% of malaria cases in Bangladesh [4]. The deep forest, difficult terrain and inaccessible foothill along with diverse occupation of the tribal people render a causal effect for high incidence of malaria in CHT of Bangladesh. In this study, *Jhum* cultivation alone came as a greater risk of malaria infection (OR=2.5, P-value <0.05) in CHT where 80% people of tribal population cultivate this slash-burn activity in remote hilly areas in rainy session. The result shows that 54.6% people of *Jhum* cultivators do not access to school, which is a real concern for Chittagong Hill Parisad (P-value <0.001). Education holds the key to a sustainable response to malaria. The probability of dying from malaria is inversely related to income and education [7]. A clustering of risk

factors, including low education increases people's vulnerability to malaria and may be as important as the exposure itself [8,9]. The report shows that *P. falciparum* malaria was higher (86%) among *Jhum* cultivators [10] and they got most of the treatment from *Shasthya Kormi (SK)* and *Shasthya Shebika (SS)* of BRAC. Govt. Hospital and Upazila Health Complex provided lower case (11.7%) of treatment as the Govt. Health Complex doesn't stand in remote places and most of the time they treated the referral cases from SK and SS.

Jhum cultivation, a mix crop cultivation, which is dominated by male member has more exposure to malaria than female. In this study, male (32.5%) were more affected with malaria than female (18.5%) (OR = 2.11, *P*-value = 0.002) [3]. In tribal community, women are involved in *Jhum* cultivation, but they are significantly less at risk of malaria infection [11]. This is because women usually go to sleep earlier with children while men like to sit outside in a shop or around a fire for a while before retire to bed. Considering that *An. dirus* bites early and is a highly anthropophilic and exophagic vector, men are obviously more exposed than women.

The result shows that LLIN has been covered systemically in CHT areas. The country follows 100% LLIN coverage in CHT in line with 1.8 populations' @LLIN following National Malaria Strategic plan (2017-2021) [12]. Though this aggressive LLIN distribution, our study found 2.7% people did not have LLIN during the survey period. This may have happened as Chittagong Hill Tracts are always facing migrating people from plain land and also tribal people sometimes replace their households to secure their livelihood. But the more growing concern is that 44% people at *Jhum* sites like to hang the net during the sleeping time and 41.3% people were inflicted with malaria (*P*-value <0.01). The result also shows that the most biting periods of vector was 19.00-20.00 h with the peak of 19.00 h. The revelation is congruent with the finding of Ziway Central Ethiopia which observed that the Peak indoor and outdoor activities of *An. arabiensis* was the early period of the night, between 18:00–19:00 and 19:00–20:00h though the ecology of city of Ziway is different from CHT [13].

Jhum cultivators still come as a major factor for malaria infection in Chittagong Hill Tracts. In the logistic regression with multiple variables like distance, LLIN and hanging of LLIN at *Jhum* sites, we found distance is the critical factor in

Jhum cultivation, which implies that one unit of positive change of distance increases risk of malaria by 1.2 times. If the distance of *Jhum* sites from household is 2-3 km, they will be back to the household in the evening and there will be no point of risk of malaria. The other important factor is hanging of LLIN which refers risk of malaria will decrease by 26% for each unit of positive changes of using LLIN at *Jhum* sites. The result is complementary and consistent with qualitative findings. Most of the participants stated that people seldom use LLIN at *Jhum* sites, if they bring it to *Jhum* sites, most of the time they could not hang it. People like to go to *Jhum* sites with family and LLIN do not cover the whole family. Sometimes it is difficult to hang LLIN in a temporary household or shelter, which discourages them to use it. The result of Central Vietnam is also congruent to the findings where regular working and sleeping in the forest were a strong risk-factor with the odds almost three times higher than that of people not working in the forest. Even occasional forest work was a significant risk-factor for malaria (Adjusted OR = 1.48; 95%CI [1.01; 2.17] [11].

Jhum cultivators often work in large group, including the family member in several phases of cultivation period exposed by malaria during the cultivation at *Jhum* sites. The risk of malaria is high when it is exposed during the cultivation days and it will turn severe if they do not seek treatment within the day or two. *P. falciparum* malaria may be fatal if the treatment is delayed beyond 24 h after the onset of clinical symptoms. The result shows that the exposure of malaria was high among the people who came back home (70%) from *Jhum* sites than the people who had been in cultivation (27.4%) at *Jhum* sites. The fact is, *Jhum* cultivators like to stay at *Jhum* sites for 5-7 days or even months, it is difficult for them to seek treatment during their stay at *Jhum* sites and most of them come back immediately whenever they feel the fever. This implies the treatment of *Jhum* cultivators are always in delays as the health facility or service provider is not within his/her walking range. Household located more than 3 km from a health facility is more likely to delay seeking malaria treatment. The study in Myanmar and on the Thai–Cambodian border found that malaria treatment was often delayed in remote areas [14].

The results of this study are in agreement with several other studies that show that agricultural practices may affect an individual's risk of

malaria infection. Agricultural practices have been previously implicated as an occupational risk factor for malaria infection in other settings, including palm oil plantations in Papua New Guinea, irrigated rice paddies in Ethiopia and Cote d'Ivoire, and forest settings in Vietnam [15,16]. In one study, agricultural irrigation was associated with greater abundance of *Anopheles* vectors in rural Tanzania [17]. In contrast, one study in Peru found that agricultural practices were statistically associated with lower malaria incidence rates [18]. This study shows that a specific agricultural practice may impact malaria transmission, depending on the ecology of local *Anopheles* vectors and the nature of the agricultural practice. Furthermore, several studies in Asia had observed increases in malaria vectors after deforestation, conceivably because it allows surface water accumulation at clearing sites, although these studies looked at large-scale general deforestation, the same mechanism may apply at *Jhum* sites after the removal of the jungle [19].

It is a fact that the abundance of mosquitoes at *Jhum* sites leads to higher rates of infection among the *Jhum* cultivators. Topologically, the CHT districts vary from other regions of the country being typical of ranges of forested hills and associated valleys with rivers and small lakes [20] that provide abundant oviposition sites for potential vector species. The study of the International Centre for Diarrhoeal Diseases, Bangladesh (ICDDR'B) found the abundance of diversified *Anopheles* vector in remote areas of Matiranga sub-district of Khagrachari district. *An. philippinensis*, *An. nivipes*, *An. minimus*, *An. vagus* are found profoundly in Matiranga Sub-district, which is surrounded by plain and hilly areas that is adjacent to Bangladesh and India boarder [21]. Another study done by ICDDR'B found similar vectors--*An. philippinensis*, *An. minimus*, *An. vagus*, *An. jeyporiensis*, *An. kochi* in Khohalong union of Bandarban district. The highest diversity of species was found in July and lowest in September [22].

Though this study covers more than 50% sub-districts of Rangamati and Bandarban hill districts, it has left Khagrachari district where diversified cultivation is prevailing apart from *Jhum* cultivation, which we could not generalize the findings for Chittagong Hill Tracts. In this study, we defined malaria cases by only getting information from participants, not testing RDT or laboratory examination. In addition, an entomological study is also needed to conclude

whether *Jhum* cultivation contributes to develop a breeding site for mosquitoes that only intensify mosquito biting during *Jhum* cultivation.

With this study, we conclude that though *Jhum* cultivation is a major contributor for malaria infection in Bangladesh, we still could not reach them to mitigate this. The behavior of *Jhum* cultivator needs to change, to take early bed to interrupt malaria transmission at household as well as at community level. Using LLIN at *Jhum* sites need to be utmost priority in a bid to reduction of malaria and thus enable Bangladesh to achieve malaria elimination in the near future.

5. CONCLUSION

The study confirms that there is high malaria morbidity in CHT areas where a major portion of malaria is transmitted through *Jhum* cultivators. A comprehensive awareness programme is needed to change the behavior of *Jhum* cultivators in using LLIN both at home and *Jhum* sites. Early to bed and sleeping under LLIN at *Jhum* sites is the best way to reduce malaria in Chittagong Hill Tracts which will foster malaria elimination in Bangladesh.

CONSENT

All participants involved in survey provided written consent before the interview.

ETHICAL APPROVAL

As there was no risk of health hazard like testing of RDT or examination of microscopy, and we just recorded the malaria cases based on participants response, ethical approval was not deemed consider important for this study. Willingness and independence of participants were utmost important which we follow throughout the study and all papers are kept in safe custody as confidential. Anonymity of participants was strictly followed in qualitative study where the opinion of participants only recorded with their due consent.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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