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Adaptation to Malaria in Rainforest Valleys: The Case of Indigenous People of the Chittagong Hill Tracts, Bangladesh

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Abstract: This paper looks at the adaptation of the indigenous people to endemic malaria in the rainforest hilly valleys in the Southeastern part of Bangladesh. The prevailing thoughts and practices of malaria derived from a biomedical science paradigm deploy two interventions – attacking the vector (preventive) and treating the disease in humans (curative). Drawing on local and international data, a recent study in the Chittagong Hill Tracts (CHT) revealed that adaptations to malaria tend to be distinctive. Particular types of epidemiology, ecology, and indigenous people's traits constitute the adaptations. The epidemiology of malaria is rather complex and is characterized by seasonal epidemic cycle, diverse *anopheline* species, coexistence of *Plasmodium falciparum* and *Plasmodium vivax*. Tropical and multiethnic ecology appears with the manifestation of its adaptive value in determining the breeding sites for larvae and malaria transmission. Traits of indigenous people as individual, self and person demonstrate the various ways in which exposure to mosquitoes is reduced and thereby malaria rates are decreased. The paper concludes by anticipating more discussions on adaptation so as to make the malaria measure multipronged.

Keywords: Endemic malaria, CHT indigenous groups, epidemiology, ecology, adaptive strategy

1. Introduction

The praxis to control malaria, a major communicable disease in tropical and subtropical areas is expanding and the need to promote public health in endemic areas is increasing. There is a growing realization that a multi-pronged approach is more effective than a single intervention to halt this public health problem. In this regard, the validity of adaptations has been an explicit concern in the literature since the 1960s. Though five species of *Plasmodium* can infect human beings two of these – *Plasmodium falciparum* and *Plasmodium vivax* – pose the greatest threat (Amouzou *et al*., 2015) which is the main one responsible for malaria in the Chittagong Hill Tracts (CHT), Bangladesh. Towards the goal of 'zero case and zero death' by 2020 the national strategic plan of the Government of Bangladesh consists of both preventive and curative measures *e. g.*, vector control, awareness, bed nets, diagnosis, treatment, referral, surveillance, monitoring, and evaluation (Bangladesh Government, 2015). Many aspects of malaria have received scholarly attention: for instance, infection (Galagan *et al*., 2014), pathology

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(Mohon *et al*., 2014), epidemiology (Maude *et al*., 2008; Fuehrer *et al*., 2010; Starzengruber *et al*., 2014), climatic change (Haque *et al*., 2010) and effect of the measures (Haque *et al*., 2014). A trend in this field is to validate and justify existing approaches to malaria. This fatal public health problem today kills around 0.6-1.2 million people (Godfray, 2013; Amouzou *et al*., 2015). The majority of people who are at risk of being infected are natives of the tropical zone. In both hot and cold seasons of the year tropical and subtropical areas are ideal for malaria endemic. Summer temperatures are required for the malaria parasite *P. falciparum* to complete its growth cycle within the mosquitoes and to be transmitted, while winter temperatures below 20°C (68°F) are for *P. vivax*. However, as this paper is concerned, there has been no attempt to look at adaptation to malaria particularly in indigenous people inhabiting tropical rainforest valleys of the Chittagong Hill Tracts. It, indeed, remains a rather unexplored problem in the public health field.

The article aims to investigate adaptations to endemic malaria among the people of various indigenous groups of the CHT. To central of the research are the magnitudes of adaptations, indigenous people, and the CHT tropical rainforest maintain valleys for malaria elimination. There is a growing realization that a multipronged approach is more inclusive and effective than an exclusive and single intervention to halt this disease (Godfray, 2013). In this regard, the validity of adaptations has been an explicit concern in the literature since at least the 1960s (Alland, 1966, 1969; Brown, 1981, Hussain, 2001). Historically the CHT is considered hyper endemic for malaria in Bangladesh (Alam *et al*., 2012). The characteristic natural environment, ecological setting, and multiethnicity of inhabitants make the valleys different from other regions. On the other hand, in several recent works (for example, World Health Report, 2010; Meireles *et al*., 2020) a perspective is observed to view indigenous people as the most vulnerable group. The way of life, as well as the livelihood in the CHT, is distinctively characterized by privation and cure of the disease, cultural behaviors, and traits (Islam, 2016). In this area an individual as a host is the most vulnerable and susceptible to and the worst affected by malaria. In such a context, the key question is what shape adaptations to malaria take.

The paper begins by looking at concept of adaptation along with its role and importance for malaria. Adaptation is taken as a core phenomenon of ecology and put in an intrinsic relationship with ecology. Then the paper describes malaria epidemiology and the ecology of the CHT. These situations are necessary for taking the place of the mechanism of adaptations to malaria. In the ecological setting malaria and adaptations are situated simultaneously. In exploring the relationship between indigenous people and their malaria-prone environment the research looks at the relationship organized in several levels taking form with the complex set of interactions between indigenous people and pathogens in an ecological niche. Finally, the core of the paper involves an analysis of traits of indigenous people, which have adaptive significance in improving the chances of the CHT indigenous people being protected from malaria.

2. Methodology

In this article, primary data have been used from a study on malaria control in the CHT. Fieldwork was carried out in Bandarban Hill District applying methods of in-depth interview (II), direct observation (DO), and exploring secondary sources as well as literature review. Using an ‘open-ended’ agenda 70 IIs with patients, parents, caregivers, medical practitioners, family members, relatives, and NGO workers were conducted. 30 DOs, following a checklist, covered a variety of malaria cases, activities of diagnosis and

control, behaviors and daily works of local people, and local ecological situation. Information on infections and controlling measures were collected from secondary sources *i.e*., monthly malaria-specific report (MMSR) of pathology, and malaria surveillance activities report (MSAR) compiled by health service institutes including CSO, District Sadar Hospital, and Upzilla Health Complexes. MMSR includes (a) blood slide *+ve Pv, Pf* (*Plasmodium vivex,* and *falciparum*), and *Pv+Pf* ; (b) rapid diagnostic tests *+ve Pv, Pf,* and *Pv+Pf* ; (c) diagnosis and treatment of uncomplicated malaria, severe malaria and vivax malaria; (d) prevention by distributing long-lasting insecticidal nets (LLIN) and insecticide treated bed nets (ITN), behavioral change communication (BCC) and workshop-training. MSAR covers the surveillance activities for detecting and controlling malaria in all Upazillas under the National Malaria Program. Relevant libraries, governmental offices, research institutes, United Nations and international agencies, non-governmental organizations (NGOs), and websites – were explored for the literature review.

3. Adaptations from Molecular to Socio-cultural Level

The concept adaptation refers to humans' successful interaction with the natural or physical environment (Hussain 2001). 'Adaptation' translated by the Bengali term *ovijhojan* has many different rather than single homogenous meanings in English. In an etymological dictionary (Harper, 2001), its few meanings are: 'to fit', 'adjust', 'to join', 'fitted', and 'to undergo modification so as to fit new circumstances'. As an Oxford dictionary (Hornby, 2005: 924) defines, 'adapt' refers to 'to change something in order to make it suitable for a new use or situation' and 'to change your behavior in order to deal more successfully with a new situation', while adaptation is 'the process of changing your behavior to suit a new situation'.

The biological sense of adaptation was first recorded in 1859 in Darwin's writings. As a key biological concept adaptation is brought to study the roles of particular traits of an organism for its chances of survival in a particular situation (Kelly, 1975). Integral to most adaption studies is ecology – the relationship between a species and its total environment. Adaptation and ecology have kindred sense and they are depicted as operating in the same way. Brown (1981) referring to Alland (1966, 1970), Alland & McCay (1973) and Netting (1964) conceptualizes adaptation looking at the fundamental process of evolution in which particular traits are selected in a given environment so as to increase an organism's chances for survival and reproduction. The interactions between organisms and their environment are central concerns of ecology. Adaptation – selection of particular traits is situated in an ecological relationship while ecology takes place through the adaptive relationship. Indeed, the relationship what happens between organisms and their environments is nothing else except adaptation. Thus adaptation and ecology come to be studied as conditions and core principles of each other.

Adaptation implies that the environment sets certain 'problems' that organisms need to 'solve' and that natural selection is the mechanism by which such solutions are found. Diseases are primary environmental 'problems' and agents of natural selection. Adaptation means the traits are tolerable or have minimally sufficient positive consequences to improve an organism's chances for survival in a particular environment. Adaptive (symbiotic) and non-adaptive (asymbiotic) – two types of relationships between organisms with others, as the paper takes, happen in ecology. In the case of malaria, the relationship between human host (organisms) and infectious agent mosquitoes and *plasmodium* (environment) is non-adaptive as well as asymbiotic. As the Center for

Disease Control and Prevention (CDC) (2016) outlines, for instance, three components of such relationship situating malaria include vector (female Anopheles as invertebrate host), host (indigenous people as vertebrate host), and malaria agent (plasmodium parasites) – they all are inevitable parts of ecology. Other components of the environment include such natural factors as temperature, moisture, altitude, and indigenous plants and animals, as well as such artificial or cultural factors as housing, cultivation, domesticated animals, livelihood, ethno medicine, beliefs, and patient care practices, may serve to promote the malaria transmission. Besides, the present research interests whether ecological relationships and factors have an adaptive value that contributes to limiting or preventing malaria occurrence. Explored adaptations of indigenous people are viewed as different from those of mosquitoes and parasites. Their adaptations are both functional and volitional since they can think and can be stimulated to think about environmental problems (Alland & McCay, 1973; Islam, 2010).

3.1 Seasonal Peak Epidemiology

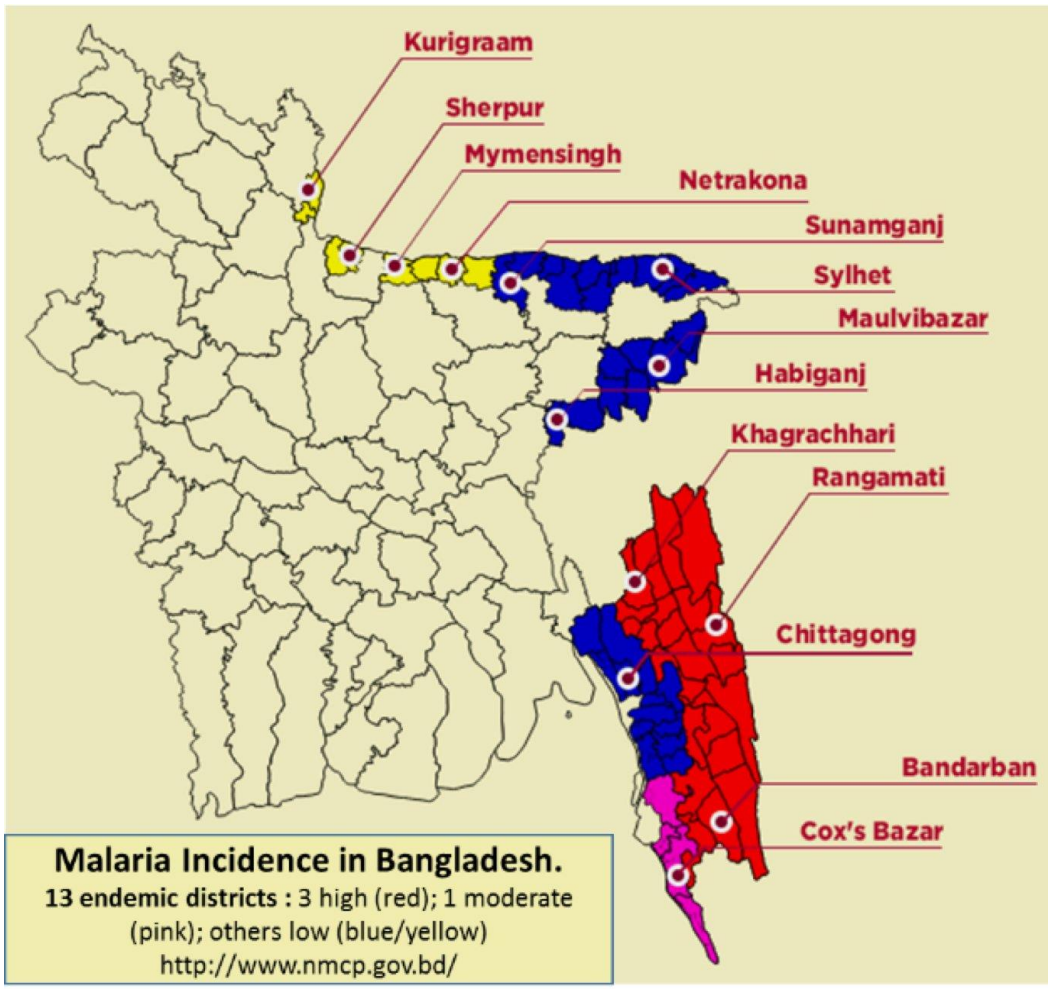
As the research revealed, the malaria epidemiology of the CHT is characterized by seasonal epidemics & multilevel consequences. Besides, more infection among children is another dimension of the epidemiology. As World Health Organization (WHO) and UNICEF estimate, globally 86% of malaria deaths occurred in children aged under 5 years by 2000 (Amouzou *et al*., 2015). Malaria accounted for 12% of all deaths in children aged 1–59 months. In Bangladesh, according to an estimate drawing on data from Islam *et al*. (2013) and UNICEF (2016) children at risk of malaria would constitute at least 34% which counts for more than 19 million children.

Table 1: Country Epidemiology of Malaria based on data from Bangladesh Government (2013)

Category of Districts	Name of Districts	No. of Cases	Percentage
CHT and Adjoining Districts	Khagrachari	5,997	20.32
	Rangamati	7,981	27.04
	Bandarban	8,461	28.67
	Cox's Bazar	3,888	13.17
	Chittagong	1,095	03.70
	Total	27,422	92.90
Other Districts	Sherpur	73	0.25
	Mymensingh	168	0.57
	Netrakona	285	0.98
	Kurigram	101	0.35
	Sylhet	436	1.47
	Hobigonj	72	0.24
	Sunamgonj	540	1.82
	Moulvibazar	421	1.42
	Total	2,096	7.10
	Grand Total	29,518	100

Source: Government of Bangladesh,

Figure 1: The Malaria Hotspots in Bangladesh



Source: Bing.com Image, Bing.com/images/search?view=detailV2&ccid=CgMTrj6J&id=DD1B13F500C1AF582E285B0137E56BDAA9CCDDB1&thid=OIP.CgMTrj6JQIN1AJilv)

The largest portion of people who are at risk of malaria lives in the Chittagong Hill Tracts (CHTs) and neighboring areas. A total of 29518 malaria cases in 2012 in figure #1 is categorized as 'the CHTs and adjacent districts' and 'other districts'. With 274228 cases (92.90%) the malaria prevalence in the CHT and adjacent districts was significantly higher compared to that of other districts (N = 2096, 7.10%). Infections have a more age-based nature and account for the annual epidemic during the time age from conception to 15+ years. The size of the annual epidemic primarily depends upon variable ecological conditions. However, figure 2 shows that last 5 years (2011- 2015) 83031 malaria cases of four age groups i. e., 1 yr, 1-4 yr, 5-14 yr, and 15 +yrs along with pregnant women were diagnosed and treated in the government hospitals of the research area. Besides

three levels of morbidity - uncomplicated malaria, severe malaria, and *vivax* malaria, the cases include mortality.

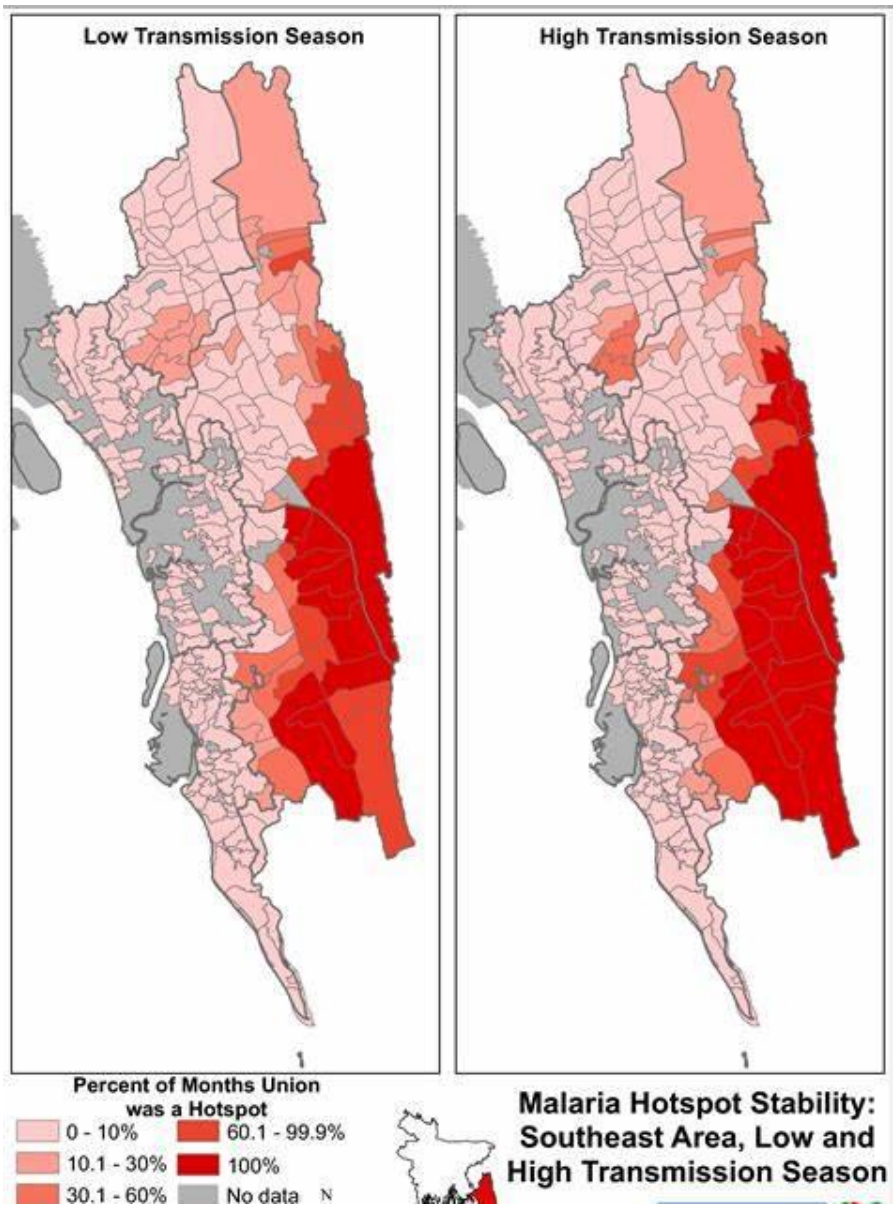
Table 2: A Snapshot of Epidemiology of Malaria in Bandarban 2011–2 015 based on data from documentation of Upazilla Health Complexes, Sadar Hospital and Civil Surgeon Office

Type of Cases	< 1 yr	1-4 yr	5-14 yr	15 +yrs	Pregnant Women	Total
Uncomplicated Malaria	243	6679	21549	43520	110	72101
Severe Malaria	110	730	1818	3502	45	6205
Vivax Malaria	59	914	1535	2164	11	4683
Death	-	9	20	13	-	42
Total	412	8332	24922	49199	166	83031

Source: Bandarban UH Complex

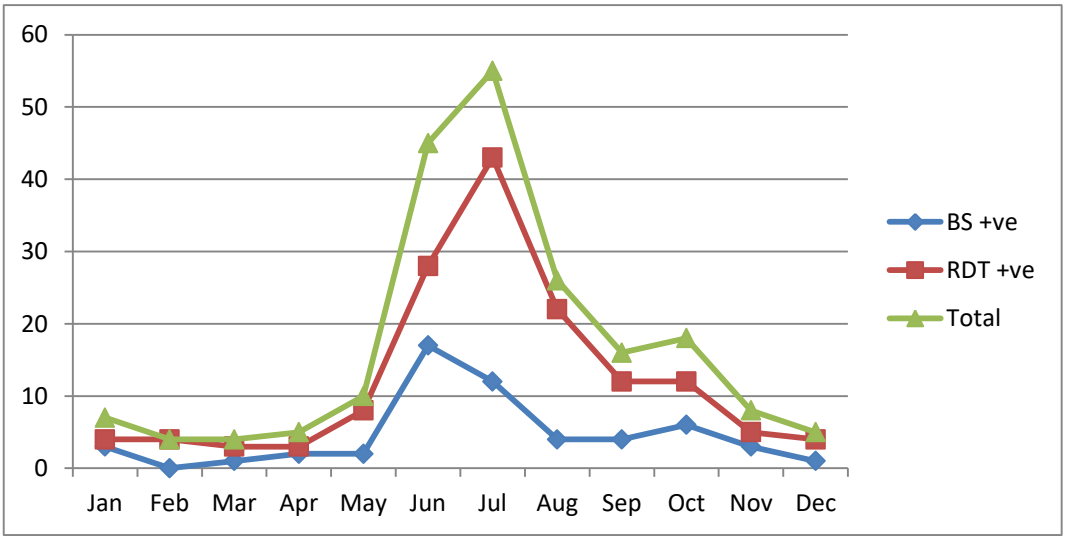
The epidemiology of malaria in the CHTs is distinctive because of a set of facts: seasonal epidemic cycle, diverse *anopheline* species, the coexistence of *P. vivax* and *P. falciparum*, ecologic setting, and indigenous people's traits. The seasonal cycle of malaria in an Upazilla which is graphically depicted in Figure 3 presents the fact of a 'malaria season' in the CHTs. It, referring to Brown (1981), is important for understanding adaptations. The months of June, July, and August are the time when the incidence of malaria transmission reaches an epidemic peak that contrasts with a hiatus of infections during the late autumn, winter, and early spring. The epidemic cycle of malaria causally related to the ecological parameters of temperature affects both the larval development of Anopheles species and the extrinsic reproductive cycle of the malaria protozoa, *Plasmodium* (Galagan *et al*., 2014). Two species of forest mosquitoes, *Anopheles baimaii* (*An. dirus D*) and *An. minimus*, are found in this region in recent entomology studies though these mosquitoes are relatively uncommon compared with other species (Alam *et al*., 2010, 2012). Among a total of 2,576 female *anopheline* mosquitoes, 15 (0.6%) *anophelines* belonging to eight species were positive for *Plasmodium* infection by *Circumsporozoite* proteins and Enzyme linked *immunosorbent* assay (CSP-ELISA). Of those, 11 (0.4%) mosquitoes were positive for *P. falciparum* and four (0.2%) for Pv-210. As studies show, other infected species were *An. nigerrimus, An. nivipes, An. jeyporiensis*, *An. kochi*, and *An. vag*us. Out of 11 *P. falciparum* CSP positive samples, seven turned out to be positive by polymerase chain reaction (PCR).

Figure 2 : Malaria Hotspots in Low and High Transmission Season



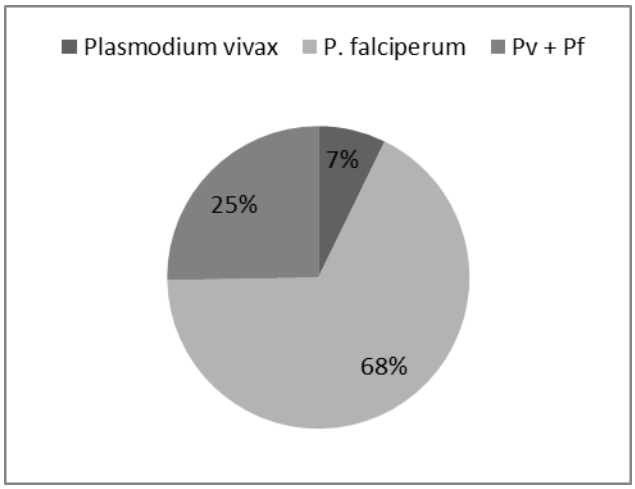
Source: Bing.com/Image (bing.com/images/search?view=detailV2&ccid=Zv0N9IdY&id=BC619764A66C6A7955247EA2992629C06A3A5071&thid)

Figure 3: The Seasonal Epidemiological Cycle of Malaria in Sadar Upazilla of Bandarban 2015 based on data from documentation of Sadar Hospital and Civil Surgeon Office.



Both *P. vivax* and *P. falciparum* affected the inhabitants of the CHT, and were characterized by high morbidity but low mortality (figure 2, 4). It is seen in the pie chart for total malaria (figure 4) that *P. vivax* and *P. falciparum* coexisted (25%) and neither strain was predominant for which the epidemiology of malaria in the CHT is rather complex. As local health workers and caregivers report, multiple infections are often observed. *P. falciparum* had the highest annual incidence (68%) which accounted for the stable. This incidence also is a signifier of the endemic nature of malaria on the terrain.

Figure 4: The Epidemiology of Malaria by *Plasmodium* Category in Bandarban 2015 based on data from documentation of Sadar Hospital and Civil Surgeon Office.



4. Tropical and Multiethnic Ecology

The CHT, where the ecology with tropical as well as rainforest mountain valleys and multiethnic habitation is situated, is a southeastern region with 13231 km^2 area of

Bangladesh comprising three hill districts Rangamati, Khagrachori, and Bandarban. The region is bounded on the north by the state of Tripura, India, on the south by the Province of Arakan, Myanmar, on the west by the districts of Chittagong and Cox's Bazar in Bangladesh, and on the east by the Lushei Hills (Mizoram) of India. Ecology of this region has a distinct position in South Asia due to their close proximity to the neighboring native groups practicing *jhum* (swidden) cultivation on the one hand and the Burmese and Indian civilizations based on wet-rice/plough cultivation on the other (Sopher, 1964; van Schendel *et al*., 2001). It occupies a peripheral position between two distinctive environments and subsistence patterns. Having the ties of various relationships, the CHT indigenous people, as the field data and relevant literature (cf. Islam, 2005; Haque *et al*., 2010; Khan *et al*., 2011; Reid *et al*., 2012; Galagan *et al*., 2014; Kirk *et al*., 2015) show, belong to ecology that is malaria prone and they undergo the process of 'becoming malaria host'. This does not only indicate that the infected person is a malaria patient, but also signifies that the infected person contains the possibility to become the cause of infecting others. Thus, the malaria ecology lets the relationship of indigenous people take place and operate with various components of their environment. This relationship is illustrated by putting it in three levels: tropical climate, evergreen mountain topography, and multiethnic setting.

Figure 5: Levels of Ecology in the CHT

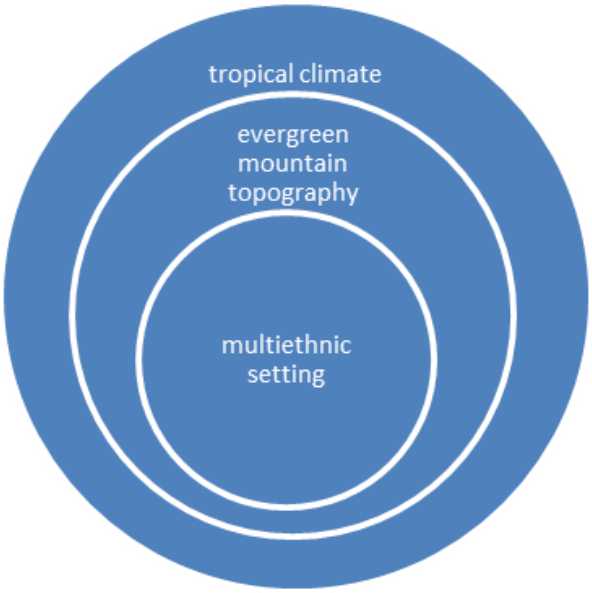
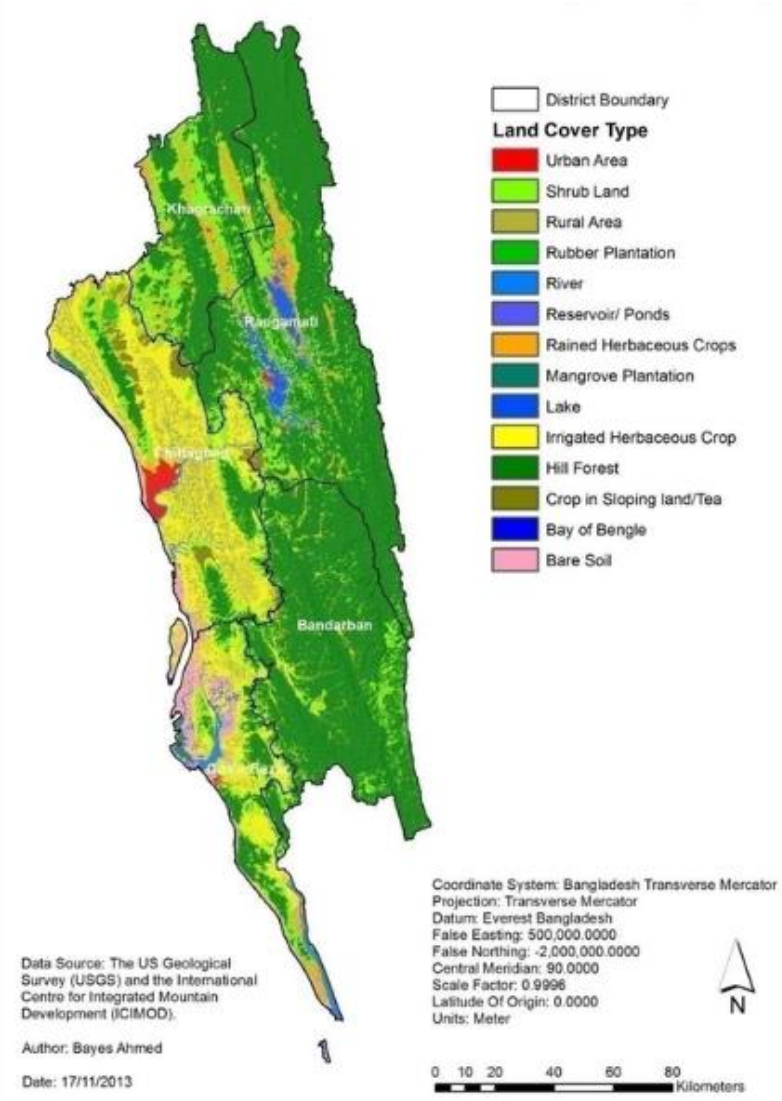


Figure 6: Topography of Chittagong Hill Tracts



Topography of Chittagong Hill Tracts, Bangladesh
Source: Bing Map, 2023,
(//qph.fs.quoracdn.net/main-qimg-71c816486372d38bb2761169882cef26)

4.1 Climate and Topography:

Lying between Lat 21.25° and 23.45° north, and Long 91.45° and 92.50° east the CHT is characterized by a tropical monsoon climate. A topographic depiction is found in this research that the region tends to be a mass of hills, mountains, and rivers and deep and narrow valleys covered with dense forests, jungles, and sungrass (Lewin, 1870; Dewan

1991). Tropical rainforests covering 81% of the total CHT area are overgrown with vines and interspersed with swamps of all sizes, many of which have now been drained and converted into fertile agricultural lands. The vegetation is tropical evergreen, dominated by tall trees. Being formed by the rivers Karnafuli, Sangu, Feni, and Matamuhuri and their tributaries the major valleys are bounded by chains of hills and mountain ridges running from southeast to northeast. The altitude of the ridges ranges from 100-2000 feet in the north and 1500-2900 feet in the south where Keokradang (4,034 feet), the heist mountain is located. Three main seasons characterized by rainfall between 20" and 150", temperature 83.7-85.9 °F and 80-94% relative humidity include November-March: dry, cool, and sunny; April-May: very hot, humid, and sunny; June-October: wet, warm, cloudy and heavy rainfall.

4.2 Multiethnic Setting:

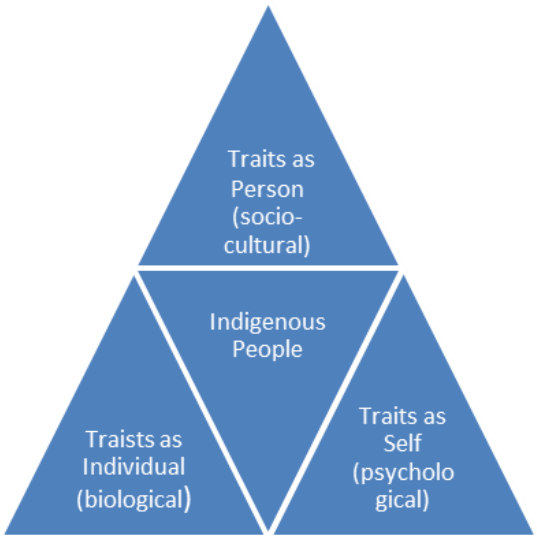
With the great impact of long colonialism from the eighteen century the ethnic setting of the area consists of various ethno-linguistic indigenous groups and their cultures that are probably the remnants of a great variety of people. They represent the early stages of migration of groups from southern Tibet or Indo-China and Indo-Aryan with inter-mixture between the earlier inhabitants and later arrivals. With an estimated total population of 1.6 million in 2011, the CHT is inhabited by eleven distinct non-Bengali ethnolinguistic groups (Kamal *et al*., 2007, 2010; Chakma *et al*., 2010). These are: (in alphabetical order): Bom, Chak, Chakma, Khiyang, Khumi, Lusai, Marma, Mro, Pankho, Tanchangya, Tripura (Islam, 2005; Chakma *et al*., 2010). Bengalis are the majority group in the CHT also in Bangladesh while other groups are treated officially as *khudra nrigosthi* (ethnic minority groups) and literary as *adivasi* (indigenous group) and/or as *upajati* (tribal) and sometimes as *pahari* (Hillman). Culture and ethnic relationships of 'minority' groups have a longstanding history as they migrated into the CHT from neighboring regions sometime in the last six hundred years. Though they are linguistically different twelve groups' ethnographic setting which differs from that of Bengali is determined by many characteristics of neighboring natives and minorities of Southeast Asia and Northeastern India, for instance, including language, religions, cultures, *jhum* agriculture, homogeneity, kinship-based social organization, and ethnic affiliation. Though all major religions Buddhism, Hinduism, Christianity, and Islam are represented among the CHT peoples, worldviews with a number of components, beliefs, rites, and rituals of their own 'tribal', ' local', 'traditional' religions seem to be existed and followed. Spatial distribution of ethnic groups shows how they adapted to their physical environments. Some groups are exclusively *jhum* framers and dwell on the mountain slopes. Some groups practicing wet-rice cultivation live in the valleys along the stream sides, river banks, and lakeside. To the north, east, and south *jhum* agriculture is predominant and to the west is permanent wet-rice/plough cultivation. There are a few groups who depend on both means of cultivation. Bengalis traditionally are wet-rice farmers. Thus a major ecological difference existed among them by category of settlement: *toungtha* and *khyoungtha* situated respectively on hill ridges and narrow riverside valleys (Lewin, 1870). Indeed, many families among all ethnic groups are observed who have other ways of livelihood like job, business, and wage labor and live in urban areas.

Non-Bengali ethnic groups' housing is characteristic in the CHT while Bengalis' housing is similar to that of plain land. Patterns of the floor and room setting let the housing of non-Bengali groups to be unique in the country (Islam *et al*., 2000). The floor is made of bamboo and wood and put on 5-15 feet wooden or bamboo pillars. Ideally, a house consists of approximately 10 rooms. Indeed, the house along with those of relatives, neighbors, and other villagers, and the homestead surrounded by other parts of the environment *e. g*., hills, jungles, forests, water bodies, schools, hospitals, crop fields (*jhum*, wetlands, and garden) works as an ecological niche of indigenous people. The field data revealed a range of approaches to interpersonal dealing in an ethnic group's society. These ways and their possible effects on malaria have been of interest to this research. From birth to older age, throughout life, the process of growing up persons, promoting and supporting their health, education, and development continues through a set of practices that inevitably include dealings with disease and illness.

5. Indigenous People's Traits

Biological phenomena over the life course may serve as the building blocks for corresponding cultural models of the life span (Lancy, 2015). This article asserts the indigenous people's traits as well as characteristics which are distinguished among 'individual', 'self', and 'person' as respectively biological, psychological, and socio-cultural modes of view (figure no. 6). 'Traits as individual' are understood by viewing people as biological (living) beings, 'traits as self' as psychological beings and 'traits as a person' as socio-cultural beings. Biological traits are inborn, acquired instinctively, and involitional while psychological and socio-cultural traits are behavioral and volitional resulted respectively from mental and socio-cultural processes. All these are interrelated and influence malaria risk and, on a larger scale, the overall malaria ecology.

Figure 7: Traits of Indigenous People Influencing Malaria Risk



5.1 Traits as Individual:

These can protect against certain types of malaria (CDC, 2016). Two genetic factors, both associated with human red blood cells, have been shown to be epidemiologically important. People who have the sickle cell trait (heterozygotes for the abnormal hemoglobin gene HbS) are relatively protected against *P. falciparum* malaria and thus enjoy a biological advantage. In the area where the sickle cell trait is more frequently found *P. falciparum* malaria has been a leading cause of death. In general, the prevalence of hemoglobin-related disorders and other blood cell dyscrasias, such as Hemoglobin C, thalassemias, and G6PD deficiency, are more prevalent in malaria endemic areas and are thought to provide protection from malarial. People who are negative for the Duffy blood group have red blood cells that are resistant to infection by *P. vivax*. Among the majority of people with Duffy negative *P. vivax* is rare. As Figure 4 shows, *P. vivax* proportion in Bandarban is 7% though no exact data were found about Duffy negative people. In this group, the niche of *P. vivax* has been taken over by *P. ovale*, a very similar parasite that does infect Duffy-negative persons. Other genetic factors related to red blood cells also influence malaria but to a lesser extent. Various genetic determinants such as the "HLA Complex" which plays a role in the control of immune responses may equally influence risk of developing severe malaria.

Host defense mechanisms consist of innate immunity, which mediates the initial protection against infections, and acquired immunity – this has adaptive value, which develops more slowly and mediates the later, even more effective, defense against infections (Abbas & Litchman, 2011). Acquired immunity greatly influences how malaria affects one. After repeated attacks of malaria, a patient may develop partially protective immunity. Such ‘semi-immune’ people often can still be infected by malaria parasites but may not develop severe disease, and, in fact, frequently lack any typical malaria symptoms. In Bandarban, as a high *P. falciparum* transmission area where *P. falciparum* malaria percentage is 67.48 (figure 4) newborns will be protected during the first few months of life presumably by maternal antibodies transferred to them through the placenta. As these antibodies decrease with time, these young children become vulnerable to disease and death by malaria. If they survive repeated infections to an older age (2-5 years) they will have reached a protective semi-immune status. Thus inhabitants of Bandarban, a high transmission area are a major risk group and became targeted preferentially by malaria control interventions. During the ‘non-malaria season’ (September-May) the CHT is an area with lower transmission, and infections are less frequent (see figure no. 3) but as a larger proportion of the older children and adults have no protective immunity malaria disease is found in all age groups, and epidemics can occur. Some mothers and their newborns having malaria with infection of the placenta were observed in the hospitals. Besides, Figure 2 shows that 166 pregnant women became infected in Bandarban from 2011 to 2015. It has been proved in several researches that pregnancy decreases immunity against many infectious diseases. Women who have developed protective immunity against *P. falciparum* tend to lose this protection when they become pregnant, especially during the first and second pregnancies. This research realizes a separate study on anemia in infants (between the ages of 6 and 24 months) in the CHT since decreasing anemia after 24 months they have built up their acquired immunity against malaria and its consequence, anemia.

5.2 Traits as Self:

These traits influence the risk of malaria for individuals and communities. The research reveals that indigenous people's behavior in the CHT as an endemic area also determines in part how successful malaria control activities will be in their efforts to decrease transmission. Though newborn babies are seen as helpless, and researchers long assumed that they were passive receivers of care, in this research an experiment with babies whose average age was thirty-four hours proves that they could discriminate and imitate happy, sad, and surprised facial expressions. The traits as self involve two fundamental characteristics of individuals' psychology, firstly, self-awareness and secondly attachment to others. As the research identified, both kinds influence the risk of malaria for indigenous people of the CHT contacting female Anopheles mosquitoes. Constituting the self-awareness traits start in infancy by increasing the separation of the 'I' or 'me' (self) from the 'other' of his/her environment. As a person develops self-awareness, perception – a kind of vague awareness of one's existence – precedes conception, or more specific knowledge of the interrelated needs, attitudes, concerns, and interests that define what one is. This has to involve a definition of self, and in this definition, language plays a crucial role. This is why in all cultures individuals become competent at using personal and possessive pronouns at an early age. For self-awareness to emerge and function, basic orientations are necessary to structure the psychological field the self is prepared to act. Thus, each individual must learn about a world of objects other than the self. The basis of this world of other-than-self is what we would think of as the physical environment of mosquitoes. The physical environment, though, is organized culturally and mediated symbolically through language. Names of self and other things of environments including malaria patients, mosquitoes, malaria, malaria patients, mosquito nets, medical center, and health, etc. are important devices for perceiving malaria, vector, and transmission. It has been observed that persons who know the above things are less infected than those who do not know.

Attachment is a strong feeling of affection for others. Focusing on biological and evolutionary bases of behavior notion of attachment traits looks beyond the immediate adaptive value of behavior for a person to its function in promoting the survival of the indigenous people in malaria endemic areas. For each individual, a variety of innate, species- and age-specific behavior has evolved to increase the odds of survival. There are some adaptive behaviors in childhood for example, an infant needs to stay close to the mother, but an older child is more independent. Separating or bonding in relationships between children and mothers is significant for malaria transmission in children.

5.3 Traits as Person:

These traits have important adaptive value because they increase or reduce malaria vectors and transmission of infections. They determine geographical mobility, practices that have preventive roles, and health service seeking after infections. Exploring these traits members of indigenous groups are viewed as active participants and agents of the society, culture, and their various components (Islam, 2010). The field data reveal many forms that the socio-cultural traits of them as a person take though the ultimate causation of these traits can be traced to other factors like environmental, biological, and psychological. Socio-cultural traits at first include characteristic settlement patterns and the traditional land utilization of inverse transhumance e.g., keeping pigs. Raising

domestic animals near the household may provide alternate sources of blood meals for Anopheles mosquitoes and thus decrease human exposure. Not only the housing pattern – it is discussed earlier but practicing bed nets also determines users' exposure to mosquitoes. Though now the bed nets are widely used in the CHT there was a time when mosquito was often ignored. As it is mentioned above *jhum* cultivation is the mainstream means of agro production among non-Bengali groups which has associations with malaria transmission. Agricultural work such as harvesting (also influenced by climate) may force increased nighttime exposure to mosquito bites. Since attachment for the parent-children accompanies them on the jhum field for a long time. They often lack the knowledge to recognize malaria and treat it promptly and correctly. Often, cultural beliefs result in the use of traditional, ineffective methods of treatment. Ethnomedicine is observed that it has related concepts of 'bad airs' and 'evil deities'. Ethnomedical theories reinforced all levels of adaptations, and it is hypothesized that behaviors prescribed by this belief system reduced the probability of malaria relapse. Other socio-cultural activities e.g., irrigation ditch, burrow pits, deforestation, can create breeding sites for larvae.

6. Conclusion

Having the tie of various relationships, the CHT's indigenous people belong to a malaria-prone zone and they undergo the process of 'becoming malaria host'. This does not only refer to the person as a malaria patient but also signifies the person containing the possibility to become the cause of infecting other ones. From diagnosis to control, this paper looks at several aspects of malaria so as to explore adaptations of people in the CHT. Following the etiological law – cause/effect relationship, malaria originates at the cellular level and exists with pathos (suffering) while epidemiology is underpinned by molecular biology (van der Maesen & Nijhuis, 2000; Mitchell, 2015). The ecology of malaria among indigenous people is organized into four levels: climate, topography, ethnic setting, and personal care. These also serve as levels for adaptations to be situated. Individuals' traits contain adaptive value that influences malaria transmission and chances for survival in the endemic malaria zone. The paper, thus, has provided an ecologically oriented interpretation of, and adaptations to, malaria among indigenous people of the CHT which would beget more fruitful discussions in the public health sector.

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