INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

Understanding Malaria Incidence and Associations on the Advent of the Forcibly Displaced Myanmar Nationals- The Rohingyas in Bangladesh

Md. Ariful Anwar Khan*

Department of Zoology, Government Hazi Muhammad Mohsin College, Chattogram-4000, Bangladesh

***Correspondence Author**

DOI: https://dx.doi.org/10.47772/IJRISS.2025.905000118

Received: 08 April 2025; Accepted: 12 April 2025; Published: 02 June 2025

ABSTRACT

Background & objectives: Malaria is a plasmodial infectious disease in the tropical and subtropical region including Bangladesh. The country's malaria programme sets 2030 by which the disease will be eliminated nationally. Malaria incidences in the country persist with unsteady and clustered case patterns posing uncertainties in eliminating the disease. This review aimed to investigate into malaria situation in Bangladesh with regard to case incidences, associations, and the risk factors on the advent of the Rohingyas from Myanmar in the country. This is to offer an integrated and comprehensive strategy of combating malaria while underpinning the implications, challenges, and pathways in the country's malaria elimination efforts.

Methods: The relevant published studies from different sources, online (google scholar, etc.) and offline (libraries) were explored and consulted. Malaria situation in both peacetime and humanitarian crisis settings in and around the country were analyzed.

Results: In recent past, Bangladesh has significantly reduced both malaria case and death incidences. Still, there are some challenges especially in the remote and hard to reach border lined areas that undergo humanitarian emergencies intermittently. The forested hotspots of the disease there potentially act as transmission reservoir on the back of the diverse species specific vectorial, plasmodial, and poor surveillance provisions in many instances.

Interpretation & conclusion: Success in eliminating malaria in the country apparently rests on removing the potential sources of infection- the reservoirs, and disrupting its transmission pathways through intervening the infective and/or infected mosquito bites in and around the areas of epidemiological concerns in the country.

Keywords: Malaria incidence, associations, forcibly displaced Myanmar nationals, Rohingyas, Bangladesh

INTRODUCTION

Malaria is an anopheline female mosquito borne infectious disease caused by plasmodial species imposing significant loss to human lives and properties. It is a major public health concern in tropical and subtropical areas including Bangladesh. The country has been a malaria endemic country for long in south-east Asia incurring high malaria morbidity and mortality in a heterogeneous transmission dynamics- demographical, spatial, and temporal (Islam *et al.*, 2013). With a significant progress in combating malaria in recent past, Bangladesh now on the way to eliminating the disease (three consecutive years of zero indigenous *Plasmodium falciparum* infections) by 2030. A significant decline in malaria cases and deaths in its plain areas, however is intrigued with in-country as well as cross-border human movement to and from the hilly forests in and around Chittagong Hill Tracts. The CHTs shelters diverse species of the vectors (forest mosquitoes), and the nonhuman reservoir hosts (monkeys, gibbons, etc.) to work as a source of infections of the disease. This forest malaria remains a big threat to the country's malaria elimination success (Bashar & Tuno, 2014; Chang, 2019; Khan *et. al*., 2023; Rosenberg & Maheswary, 1982).

In the country, there are some stable hotspots and transmission paths of malaria that have been managed for significant decline to case fatality, incidence, morbidity, and mortality, especially following 2010. Nonetheless, the country should recognize both expected and unexpected barriers to total elimination of the disease. It needs strengthening mobilization of malaria investment. But proper investment for strategic implementation programme needs proper research and development aspect under well focused surveillance with effective interventions for cutting the 'long-lusting' malaria transmission pathways. In this case, as mentioned, Bangladesh is experiencing consistently chronic dominance of forest origin malaria cases across its malaria hotspots that has been a major elimination threat. In many instances, finding a vectorial breeding ground in the dense canopies of the forests, the forest malaria poses a lasting threat to local elimination assay. Anyway, for the last couple of years, Bangladesh has maintained a steady track record of reducing malaria infections significantly. Regarding the management of malaria situation and the deployment of malaria control interventions unto union level in Bangladesh, the BRAC led NGO Consortium (BLNC) provides 'Shasthay Kormis' at field level who are community health workers and perform various control activities including rapid tests, counselling, and supervising health volunteers under direct malaria combating program (BRAC, 2012 , 2015). By 2017, the country scored a reduction of 50% of case incidence and 54% death incidence from malaria compared to that in 2010 (WHO, 2018). The country made this success with regard to peace time situation that prevailed across the whole country until the influx of around one million Rohingya population from Myanmar since 25th August 2017. Given this, various transmission factors and issues of malaria epidemiology in Bangladesh's national territorial peace time and trans-border humanitarian emergency settings have drawn attention of malaria elimination efforts at local, regional, and global scales.

METHODOLOGY

The distribution of malaria cases and their associations (risks) in relevant instances and settings published in literary sources, both offline (books, papers, etc.) and online (Google scholar) have been consulted and reviewed in some epidemiological points of view. Because of the scarcity of consistently regular surveillance data in the country's remote border lined areas under both peace time and humanitarian crisis situations in recent past, a wider literary sources were approached to generate the information hub for bridging the knowledge gap. In the pursuit of the literature at first, the national relevance and implications of malaria elimination in south-east Asia has been focused whilst the trans-border transmission factors of malaria occurrences are intermingled within a greater cross border area of the three south-east Asian countries- India, Bangladesh, and Myanmar. So, beside peace time situation, the impacts and influences of population displacement on malaria transmission dynamics from the rapid environmental changes, say ecological, biological, social, and political were revisited. This integrated approach helped unearth the challenges of eliminating malaria through redrawing its transmission picture in the country.

RESULTS AND DISCUSSION

Malaria in Bangladesh has had been a major cause of morbidity and mortality since the ancient time of evolving mosquito borne infectious diseases in the country

It is 2-3 million years that the human malaria parasites might have been originated as estimated from genetic research while some other research opined a later emergence of the pathogens, about ten thousand years back in human populations (Hay *et al.*, 2008, Rich *et al.*, 2009). Since then malaria has occupied a major portion of the global morbidity and mortality accounts of infectious diseases. Five parasitic species, namely *Plasmodium falciparum, P. vivax, P. malariae, P. ovale,* and *P. knowlesi* that are transmitted by the female anopheline mosquitoes are incriminated to cause the disease. Malaria is an endemic disease of the tropical and sub-tropical regions of the world. The Americas, Africa, Europe, and Asia-Pacific countries are afflicted by malaria with a huge health burden from morbidity and mortality. An estimated 219 million malaria cases and 435000 malaria deaths occurred worldwide in 2017. WHO (2019) also estimated around 1.61 billion people in south-east Asia to be at malaria risk. In 2018, this region had almost 8 million malaria cases with 11600 deaths. This figure, both morbidity and mortality shows a clear reduction of 69% and 70% respectively compared with that of 2010. Besides, in 2018, three countries in this region, namely India, Indonesia, and Myanmar together incurred around 98 percent of the total incidence cases with an individual score of 58%, 30%, and 10% respectively

(WHO, 2019). Again, while in 2020, the counts stood respectively 241 million and 627000 (WHO, 2018, 2021). In 2021, WHO (2022) estimated 247 million malaria cases in 84 malaria endemic countries that was 245 million in 2020. Countries in the WHO African Region incurred most of the cases (> 90%). Both India and Myanmar share their border with Bangladesh that is an endemic country for malaria and has a long history of incurring huge loss to human life and wealth. About 33.6% of the total population of Bangladesh is at risk of malaria and the majority of cases are reported from the south-east part of the country that shelters around 1.2 million Rohingyas- the forcibly displaced Myanmar nationals (Khan *et al.*, 2023). Due to the age long persistence of the Rohingya refugees, malaria control or elimination strategies in Bangladesh has had needed to rely on understanding the disease transmission dynamics with regard to variation in environmental and interventional factors of different perspectives of both Myanmar and Bangladesh in the greater south east Asian region. It is because, the mobile parasite carrying individuals usually accelerate malaria transmission in the receptive areas with spreading drug resistant strains of the parasites and reducing the effectiveness of control strategies. Given this, identifying the mobile demographic groups and their traveling history and malaria risks in connecting differing transmission zones potentially helps use of limited resources for interventions being targeted effectively over space, time, and populations. Note, an estimated seventy thousand laboratory confirmed and ninety thousand clinically diagnosed malaria cases with more than five hundred deaths per year were reported in Bangladesh in the late 1990s (WHO, 1997, Bangali *et al.*, 2000, Faiz *et al.*, 2002). Bandarban is identified as the highest epidemic district in Bangladesh logging 60% of its total annual case incidences. As this hilly district shares its land with Myanmar and approaches Cox's Bazar and its refugee areas, malaria epidemics and its outbreak in Cox's Bazar has been considered to be more concerning matter than ever (NMEP, 2019, 25th April). Having a long history of huge disease burden and mortality records in recent past, one study of ICDDR, B (2006) estimated 4.2 (per 1000 population at risk) annual parasite incidence (API) with around 0.6 million annual clinical cases of malaria in endemic areas of Bangladesh. Besides, 61495 laboratory confirmed cases were reported in the country from routine surveillance in 2002. Malaria mortality in that year was 598. *Plasmodium falciparum* showed dominance over other species (61-71%) while *Anopheles dirus* was found to be the principal vector. But the data of World Bank (2022) showed an overall API of 6.9 in the same year, 2002. Again the overall API of malaria in Bangladesh between 2013 and 2016 stood 2.62 per 1000 population at risk while 4.53 for its south-east and 0.14 for north-east area as reported by Noe *et al.* (2018). This estimate also differed with that of World Bank (2022) where overall API appeared 1.9 in the year of 2016 followed by 1.9, 0.7, 1.2, and 0.4 respectively in 2017, 2018, 2019, and 2020. Therefore, annual malaria incidence pattern in Bangladesh consistently fluctuated within the range of 0.4 to 4.4 since the year of 2010. Conversely, this account of API allows Bangladesh to be considered as a hypo endemic country for malaria (Hay *et al.*, 2008). A joint malaria survey of BRAC and ICDDR, B (2006) found 2.94% and 0.07% morbidity rates respectively in five south-eastern districts including Cox's Bazar and the eight north-eastern districts. Such findings were quite consistent with that of a survey in Bandarban done by WHO (2008). This was supported by Starzengruber *et al.* (2013) in their study that did a cross-sectional survey on malaria in Bandarban and underscored the complications of maintaining, a rather limited surveillance and epidemiological data on malaria from the Chittagong hill tracts (CHTs) nationally. The study used a multistage cluster sampling technique to collect blood samples from febrile and afebrile participants. It also used malaria microscopy and standardized nested PCR for diagnosis. Demographic data and vital signs were recorded. From the analysis of the outcomes of the study, a large proportion of asymptomatic plasmodial infections were found which were thought to act as a reservoir of transmission. This has had major implications for ongoing malaria control program that are based on the treatment of symptomatic patients. Eventually, the study highlighted the need for new intervention strategies targeting asymptomatic carriers. Noted that a series of clinical episodes follow after an individual is inoculated with a *Plasmodium* parasite: Infection → asymptomatic parasitemia → uncomplicated illness → severe malaria → death (WHO, 2014). Besides, many factors influence the disease manifestations of the infection and the likelihood of progression to the last two categories, severe malaria and the death. These factors include, the species of the infecting parasite, the levels of innate and acquired immunity of the human host, and the timing and efficacy of treatment, if any. Of these, malaria immunity issue varies with experiences of encountering the infective mosquito bites and the physiological stage of the individuals across their age and sex, and cultural features in some extent, especially with regard to adopting protective measures (WHO, 2010, Anderson *et al.*, 2011). Accordingly, the pregnant women and young children with relatively lower immunity are more susceptible to malaria and are included among the highest risk populations for malarial infection and severe malaria (WHO, 2010). In addition, *P. falciparum* infection severity ranges from severe and complicated, to mild and uncomplicated, to asymptomatic. So, understanding the impact of *P. falciparum* on the human host across this range is critical for learning how to improve the management of the disease while a better understanding on the underlying causes of perennial malaria transmission and the risk factors is needed for an effective and sustaining antimalarial fight (Al-Amin *et al.*, 2015).On the other hand, as opined by Alam *et al.* (2012), an accurate description of the incidence and distribution of severe malaria requires identification of cases whilst two factors make this problematic: malaria is most prevalent where there is poverty and where methods of disease identification, documentation and reporting are weakest, and a large proportion of severe malaria illness and death occurs in peoples' homes without coming to the attention of a formal health service, especially in remote and hard to reach endemic areas and complex settings as the present study camps.

Demographical, spatiotemporal and interventional segmentations of the population act as malaria risk factors in the country's refugee dominating areas

Bangladesh's progress towards controlling malaria in recent past has apparently occupied all the basic epidemiological areas including the spatial and temporal peculiarities pertained with peacetime situations except the outstanding crisis situation in its refugee dominating areas on Bangladesh-Myanmar border. The NGO consortium of BRAC conducted a total of 7942167 RDTs and microscopies between 2007 and 2020 in the peace time settings in Bangladesh (Khan *et al.*, 2023). The refugee camps in the country's south-east part were not included in the program. However, the program constituted about 75% of the total countrywide RDT and microscopies during the period. The consortium diagnosed as well as treated 374,808 malaria cases contributing67% of the total number of confirmed malaria cases receiving treatment in the country through 2007-2020. Besides, 12,732,804 long lasting insecticidal nets (LLINs) were distributed by the program in 2008-2020. This, along with government run other ventures is considered to bring considerable outcomes in malaria elimination in Bangladesh. The incidence of malaria cases in the country declined by 93% to 6130 malaria positive cases in 2020 from84,690 positive cases in 2008. Malaria severity also reduced to a large extent. The number of severe malaria was 3,042 in 2008 whereas it was 92 in 2020 giving the score of reduction to the infection severity by 97% in the period. Moreover, a countrywide malaria death toll of 9 in 2020 against 154 in 2008 was explained as 94% reduction in the disease mortality**.** Furthermore, the annual parasite incidence (API) which denotes the number of new and confirmed malaria cases per 1000 individuals per year under surveillance, showed significant reduction. The collective API in 2020 in the thirteen malaria endemic districts stood 0.33 while it was more than 1 only for two districts each. But in 2008, each of the thirteen districts showed more than 1 case on the API scale that underscored an effective antimalarial campaign to run in especially the peacetime endemic settings during 2007-2020.

Such accomplishments in Bangladesh's malaria control pushed its national malaria control program towards 'malaria elimination by 2030' phase. But the recent inadvertent and extra ordinary refugee crisis with the millions of Rohingyas' arrival and living in the country's south-east remote, hard to reach, and marginally placed refugee camps has potentially posed various threats in eliminating the disease in the region (Rowland & Nosten, 2001; Sullivan, 2000). Otherwise, the malaria combating success as mentioned was a testament of the joint impact of a range of scaled-up initiatives, viz. real-time malaria case reporting, mobile health services, regular monitoring, prevention and management interventions, screening malaria through mass blood examination, focus on high-risk groups, insecticidal net distribution, case investigation in the elimination areas where the malaria burden is considered low, and the uninterrupted surveillance, both active and passive. Anyway, all these interventions are quite difficult to maintain properly in many instances of a refugee dominating setting. It is also noticeable that the unexpected inflow of the Rohingyas in Bangladesh in 2017 surged the challenges of addressing the potentially new implications with malaria transmission and control in both local and regional contexts. The implications includes: new demographics, vectorial environment, transmission routes, population movement, cultural gaps, and the interventions with 'test-treat-track' in the camps that obviously differ with that in peacetime settings. These all together have had made the national experience and records of success in combating malaria hard to sustain towards maintaining the ongoing national malaria elimination phase. Nonetheless, the theory of eliminating malaria needs to be understood in a more practical way being applicable in any setting in an endemic area. Anyway, a two-pronged approach is required to eliminate malaria. First, new treatments must be developed that attack the malaria parasites in novel and effective ways to wards complete cure, in case resistance against current treatments spreads. Second, within malaria-endemic countries, a large proportion of people carry asymptomatic infections. So, identifying these individuals for treatment is an important intervention to achieve the goal of malaria elimination. The report also stressed on the need for introducing Long-lasting Insecticide-treated Nets (LLINs) to ensure effective vector control and thus beat the disease in transmission prone areas. It is notable that Bangladesh has shown a significant progress against malaria since 2010 with more than 50% reduction in case incidence and 54% reduction in malaria death cases. Still, about 18 million people are at malaria risk, and the country awaits a long path towards the target of total malaria elimination by 2030 as annexed to the sustainable development goal-3. In spite of the relentless combating efforts of the National Malaria Elimination Program (NMEP), the country's south-eastern part lies apparently under a significant threat of malaria morbidity and mortality. On countrywide malaria control aspect, it is worth to note that the national malaria control program (NMCP) interventions started in 2007 and in 2015 it was transformed into National Malaria Elimination Program (NMEP) in line with the provisions of Global Technical Strategy for Malaria, 2016-2030. In an effort of further investigation, the global fund to fight AIDS, Tuberculosis, and Malaria (GFFATM) helped Bangladesh a lot to support its malaria control efforts under the Ministry of Health in collaboration with BRAC. The program entailed three goals for controlling malaria, namely reducing malaria morbidity and mortality by providing community based services for microscopic diagnosis, treatment with artemisinin based combination therapy (ACT) in hard to reach regions and population, long lasting insecticidal nets (LLINs) to 100% of households in the CHTs and 80% coverage to other endemic districts of the country, and periodic treatment of non-LLINs with proper insecticides, strengthening malaria epidemiological surveillance, and strengthening partnership in malaria control (Haque, *et al.*, 2014). But this package of combating actions against malaria potentially suffer most from poor diagnosis and treatment facilities, lack of monitoring and surveillance, presence of sub-patent infections as a potential reservoir for transmission, drug and insecticide resistance in parasites and vectors respectively, and in and out-migration of people as the prominent malaria risk factors in Bangladesh. Nay, the porous border areas with Myanmar and Indian states of Assam, Tripura, Meghalaya, and Mizoram also pose a big threat to a successful elimination plan for malaria in national and regional contexts. These cross-border areas comprise mountains with forest reserves that makes it mandatory for Bangladesh to ensure inter-regional collaboration in malaria elimination strategy with Myanmar and India. But the success of NMEP (as has already been inferred to some extent in this work) is challenged by a potentially new malaria situation from the country's refugee crisis. This also implicates the sustainability of the control and elimination success on national level of such neighboring areas and countries. This consists with Haque *et al*. (2014) that advocated for maintaining effective border screening and cross-border collaborations guaranties for a successful anti-malaria campaign in Bangladesh. So, Bangladesh now needs to address both peacetime and emergency situation malaria issues in an integrated and comprehensive way while both settings reciprocally matter for addressing the transmission pathways and factors in combating malaria. Another thing is that, malaria could potentially become a major cause of disease and death burden in humanitarian emergencies with sudden outbreak and uncontrolled spread of the parasitic disease. This is because, on exploring a rather few available literature, malaria in humanitarian crisis settings in endemic regions is found to act as major concern of public health and property. Nearly one-third of the global malaria mortality occurs in the emergency situations as claimed by Nafo-Traoré & Nabarro (2005), and supported by Hook (2005) who observed the agencies for the emergency settings to struggle hard for controlling malaria and other diseases in malaria endemic diseases. With similar tone, Rowland and Nosten (2001) stressed on conducting operational research in emergency complex situations anywhere in the world to produce evidential guidelines to control malaria epidemic there as revealed from their study on malaria incidence in the Afghan and Karen refugees in Pakistan and Thailand respectively.

Interestingly, World Health Organization (2019) observed the humanitarian crisis in the refugee camps in Bangladesh to pose a serious threat of malaria transmission for which effective disease surveillance is needed to rapidly detect and respond to malaria alerts and outbreaks that was supported by Autino *et al*. (2012) also. Conversely, the Inter Sector Coordination Group (ISCG) (2017) found that after the hundreds of thousands of Rohingyas' arrival in Cox's Bazar, a significant proportion (29%) of the total number of treatment consultations in the two upazilas (i.e. Ukhiya and Teknaf) was spotted to be for fever of unexplained origin with a few cases of RDT based malaria positive cases in the refugee settlements in the district. Anyway, refugee the camps in the present study still remain unstable that finding an effective health service there is a far cry. During the literature search, it was clear that similar climatic and geographic features in south-east Asia advocates both Myanmar and Bangladesh to share their mutual experiences in combating malaria successfully. Nevertheless, the literature concerned seemingly fails to reflect the overall situation analysis and experiences of dealing with malaria cases in the two major Rohingya camps in the present study that experienced regular diagnostic and treatment efforts under the local malaria surveillance system. To add, the new national strategic plan for malaria (2017-2021) in Bangladesh advocated that Cox's Bazar needs to be kept under strong monitoring so that malaria case incidence in the district could be kept under 0.46 (per 1000 population at risk) by 2021 before it is declared malaria free by 2025. But the emergency presence of the displaced people from the neighboring country of Myanmar has caused the national malaria elimination program to face new challenges for a quite new complex and emergency situation ever in the country.

To add, as highlighted by Haque *et al*. (2009), failure to push for elimination of malaria that is otherwise an achievable prospect in Bangladesh will lead the country to a resurgence of disease. The apprehension is that the presence of millions of Rohingyas in the refugee camp area in the present study could halt all the success in the NMP of the country unless an updated data driven malaria surveillance run in epidemiological viewpoints. Given this, the present study has offered a bridge in the concerned epidemiological knowledge and information gaps in intervening malaria incidence in a complex humanitarian situation first ever in Bangladesh. On spatial context, Bangladesh- the host country for the Rohingya population is considered to either pose or be posed of additional malaria risks to and from the ongoing Refugees crisis deteriorating local malaria burden. Dhaka Tribune (2019, April 25) referred the Directorate General of Health Services (DGHS) and reported that malaria in Bangladesh needs to be handled more cautiously under the new national plan for malaria in the country. It also underscored that Bangladesh incurred 39719 malaria incidence in 2015 while in 2018 the figure declined to 10523- a steep fall that must be maintained uninterrupted to achieve the goal of malaria elimination by 2030. Besides, malaria case incidence rate in the CHTs declined to 9540 in 2018 from 35968 in 2015. The report also showed that two endemic districts, Kurigram and Sherpur stand very close to elimination phase as both the districts reported only two cases each in 2018, and three in 2016 and 2015 each. The intermittent anomaly in malaria case statistics, apparently results from different data reporting sources in a relatively flexible coordination between the local and national offices of the country- an experience faced intermittently in the present work also. It also highlights the likeliness of using incomplete or improperly collated data as a risk factor under the national malaria surveillance system.

The reasons for why malaria persists in the endemic districts, especially in the CHTs while the number of people contracting malaria has declined significantly are reportedly trans- border movement, the parasite biology of the *Plasmodium* to enable itself somehow adapted for continuing the plasmodial life cycle, the human host immunity complexities, and the overall ecology to support the mosquito transmitted disease**.** The study of Kamala *et al.* (2009) that examined the efficacy of a combination drug of quinine and salphadoxine-pyrimethamine (sp) administered in-vitro on a sample population of Bangladesh and India found that Bangladesh potentially acts as an important gate way for antimalarial resistance or drug resistance in Indian subcontinent**.** Trans-border human migration in the form of refugees might play effective role in this context (Dhaka Tribune, 2019 April 25). Again, a pattern of seasonality is maintained by *P. falciparum* in Cox's Bazar and other hypo endemic districts of Bangladesh so that malaria incidence remain significantly highest during the rainy season of monsoon (June- October) as demonstrated by Ahmed *et al.* (2013). The authors also opined that a third of the total population in the districts belong to malaria hotspots that contributed 80% of the symptomatic malaria. Therefore, strengthening malaria control efforts in geographic hotspots appears to be imperative to achieve malaria elimination in an effective way. In addition, a successful reduction of malaria incidence in a hotspot or stable area of malaria occurrence could reduce the malaria transmission in adjacent community that also could be cost effective means to reach elimination goals (Bejon *et al.*, 2010). This latter would also justify unequal but equitable allocation of resources under malaria elimination program in Bangladesh. However, supporting the study of Cosner *et al.* (2009), Cotter *et al.* (2013) found the reduction of malaria transmission in targeted areas to work for reducing the disease occurrence in wider community that also was meant for a cost effective approach in eliminating the disease (Simini *et al.*, 2012). This goes consistent with Adams & Kapan (2009) while, again justifying the proposition of maintaining unequal but equitable allocation of resources in combating malaria in any endemic zone. Besides, infections of malaria can vary though uncomplicated to complicated or sever phases mainly by the plasmodial species. Given this, as mentioned already, in many areas, especially the CHTs in Bangladesh, *P. falciparum* appears to be the most common and dominating malaria parasite (Alam *et al.*, 2010) that is well grounded on many similar findings (Karim *et al.,* 2012, WHO, 2017) A set of recent studies on the infective anopheline mosquitoes in the endemic areas of Bangladesh also confirmed the highest dominance of *P. falciparum* infections followed by *P. vivax* and mixed infections. Alam *et al.* (2012) revealed 0.6% of the mosquitoes to be infected with *P. falciparum* while 0.4% by *P. vivax*. Conversely, the incidence of *P. malariae* and *P. ovale* in the border areas of Bangladesh is conjectured to be of cross-border ecotonic privilege in increased species diversity of the genus *Plasmodium* (Alam *et al.*, 2010). However, on agreeing with the possible malaria risk from the species diversity of the vector mosquitoes on spatial and temporal contexts these studies weighed much on the demographics of the population at risk while the exposure-outcome association with regard to encountering the infected mosquito bites potentially varies with age, sex, and pregnancy (WHO, 2010). Given this Islam *et al.* (2013) found children of under 5 years age in Bangladesh to be more vulnerable to malaria attack than any other age groups. This was quite in consistent with many other studies, especially those in emergency settings of refugee crisis situation (Rowland and Nosten, 2001, Graham *et al.*, 2004, Anderson, *et al.*, 2011) as described in the preceding few sections. Besides, males are reportedly more risk prone for malaria than female seemingly for their more chances for frequent meeting with female anopheline mosquitoes, especially during working outside their residences as a part of their earning livelihood (Haque *et al.,* 2009).

Apart from, like other endemic countries, all age and sex groups in Bangladesh are affected by malaria though the adult males are found to be affected commonly due apparently to occupations and behavior lead them to encounter higher chances for mosquito bites. On reviewing the previous sections the further potential malaria risk groups of Bangladesh population include children <5 year and the pregnant women being at higher risk in mainly in biological context of chances for offering lower resistance to the infections and the develop of severe malaria from low level of immunity (Rowland and Nosten, 2010, Islam, 2013, Haque *et al.*, 214, WHO, 2017). Besides, refugees, mobile population, travelers between endemic and non-endemic areas, the forest goers, and the people with HIV and/ or TB infections are commonly mentioned malaria risk groups round the world (WHO, 2010, 2014, 2018, and 2019). So, in these cases of risk factors in malaria transmission, applying all epidemiological tools to define epidemiological associations and trends in malaria occurrences, commonalities, differences in species identity, and disease severity in any area, especially the remote and marginalized border area is a priority. This is important also to further recognize all the potential risk factors in eliminating malaria in the region.

Noted that refugee settings in the study of Khan *et al.* (2023) is filled with dense tropical forest, both natural and artificial through tree plantation and rubber gardening that stands most suitable for the vector mosquitoes' breeding and resting habitat during the monsoon (Figures:1-4). This along with ethno cultural factors are thought to contribute a lot to maintain a chronic and complex malaria incidence in the border line area (Haque *et al.* 2014). This was consistent with a report of the Kaler kantho (2019, 25 April). The report claimed that 91 percent of the annual malaria cases in Bangladesh are reported from the three districts of the CHTs including Bandarban that comprised the destination forests for the malaria positive cases in the present study. Moreover, this hill tract district has experienced the highest annual malaria case and death incidence records in the recent past. On top, in 2018, 3 out of the total national count of 7 malaria deaths were reported from the district as the report added. However, this significant success in reducing both case morbidity and mortality burden in Bandarban and the whole CHTs is considered to be backed and supported by some expensive research based control program in the region. The district was brought under a combined curative intervention with antimalarial drugs and preventive intervention with ITNs since 2004 (ICDDR, B, 2006). In the following years the program was extended to cover the whole terrain with close monitoring and tracking. This along with other efforts, e.g., prompt diagnosis and treatment in malaria surveillance seemingly helped bring significant success in reducing the overall malaria incidence in the district like many other similar settings (Alam *et al.*, 2010**,**Haque *et al.,* 2014, Noé *et al.,* 2018, WHO, 2019).

By the way, more study is needed to define the potential malaria risk factors in the CHTs and its adjacent areas including the present study sites. This is because of the peculiar demography and geo-climatic indicators in an area with international border and trans-border complex settings to redefine the vector, parasite and the host populations towards constructing new epidemiology of the disease as a whole (Anderson *et al.*, 2011, WHO,

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

2018). So, it can be assumed that for eliminating malaria in Cox's Bazar on arrival of the refugees, Bangladesh earnestly needs unearth the malaria status and exposures in the new population, seek inter-country partnership and collaboration for winning ultimately a common goal of malaria elimination in the region. This because the vector mosquitoes have no political border while the infected human movement between the two countries cannot be restricted to zero case, and the undertreated malaria human host could cause uninterrupted transmission of the disease in the region (Martens and Hall, 2000, WHO, 2017). So, much of the challenges of combating malaria domestically, go in parallel to those of the global malaria responses. To this end, WHO (2018) clearly highlighted the immediate barriers to achieving the fast-approaching GTS milestones for 2020 and 2025. The most cognizable challenges includes: A continued rise in malaria case incidence in countries with the highest burden of the disease, the downward trend in the size of international and domestic fund, and the continued emergence of the resistant parasites against antimalarial drug and the vector resistance to insecticides in many malaria endemic areas. Africa is assessed to incur around US dollar 12 billion every year for malaria treatment and prevention and the loss of productivity through illness and death. So, fund crunch in conducting an effective malaria surveillance programme turns a risk factor that potentially widen the persistency of two additional risk factors- drug resistance and insecticide resistance as key obstacle in effective antimalarial efforts.

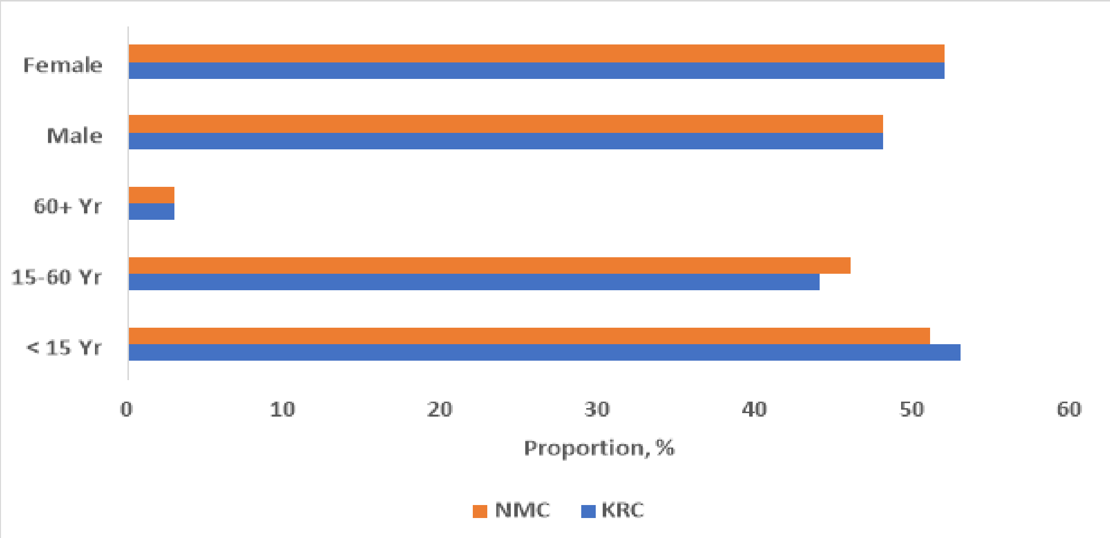
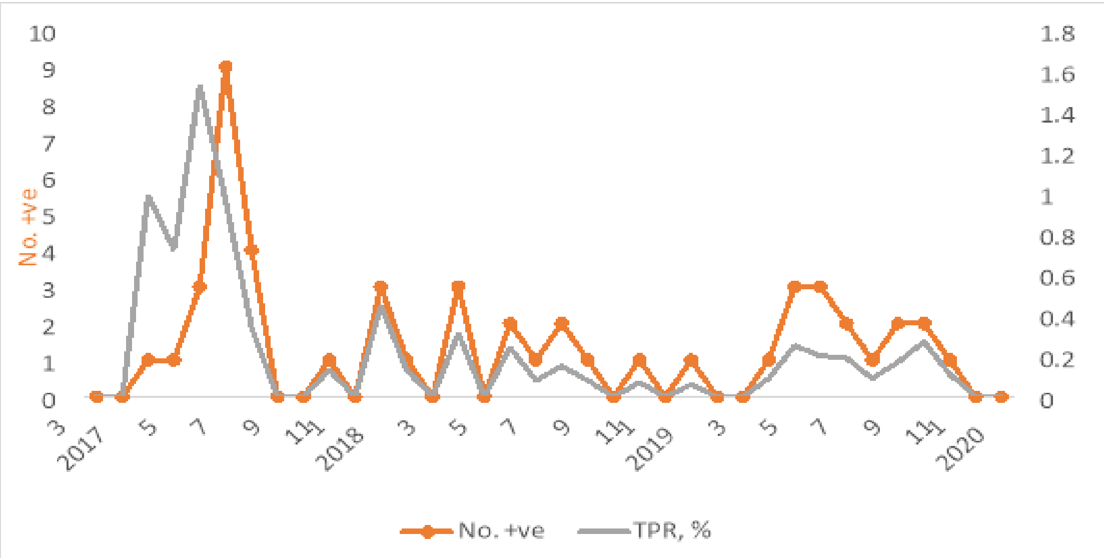


Figure-1. Demographic breakdown of the Rohingya refuges in the two major camps (KRC-Kutupalong registered camp and NMC-Nayapara mega camp) in Bangladesh during 2017-2020 (Adapted from UNHCR, 2019)



Fiure-2. Malaria incidence among the Rohingyas in Bangladesh during 2017-2021 (Adapted from Khan *et al*., 2023)

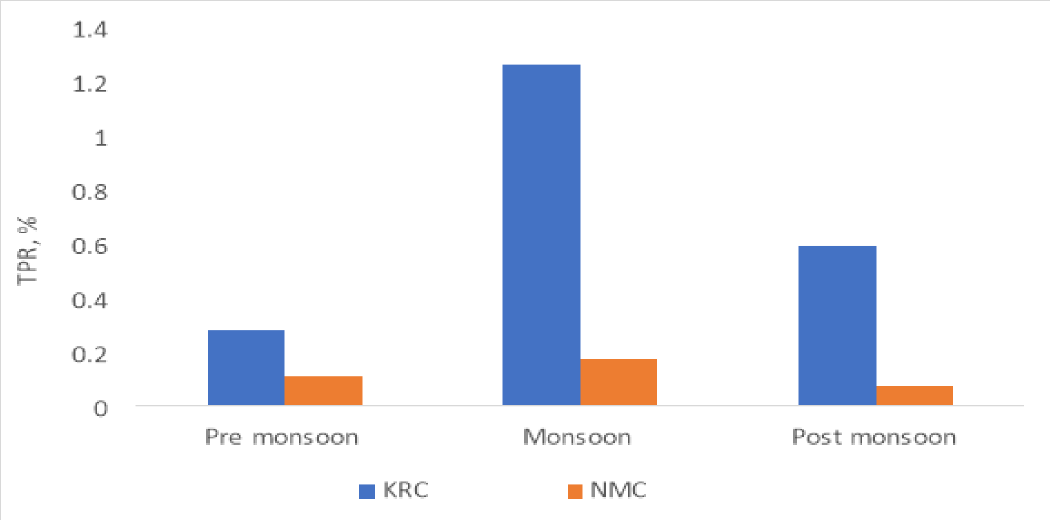


Figure-3. Camp specific **s**um totaled seasonal malaria incidence among the Rohingyas in Bangladesh during 2017-2020 (Adapted from Khan *et al*., 2023)

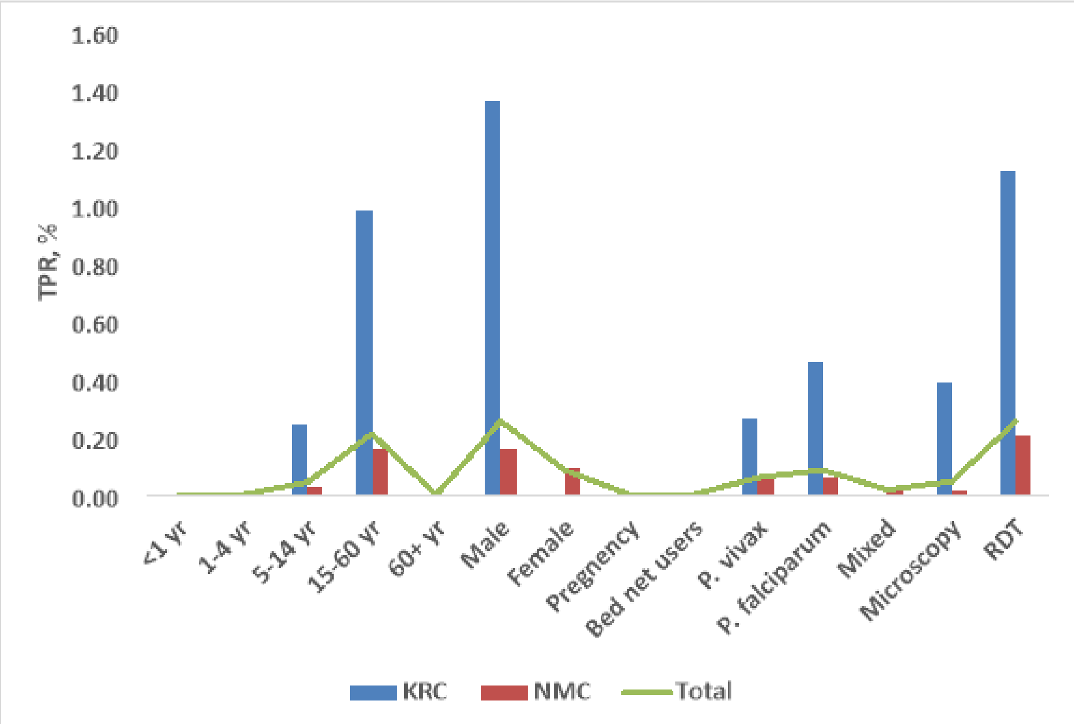


Figure-4. Sum totaled malaria incidence by demographics, parasite species, and diagnostics in the two refugee camps during 2017-2020 (Adapted from Khan *et al*., 2023)

There was no evidence for antimalarial drug resistance in the new situation of the humanitarian emergencies in a clear contradiction with peace time experiences

The traditional medicines used globally to treat malaria are reported to lose their effectiveness because of parasite resistance. Khanum *et al.* (2015) observed that the first line antimalarial chloroquine has already been replaced by Artemisinin-based Combination Therapies (ACTs) to treat *P. falciparum* malaria and practiced in Bangladesh since 2004. ACTs are highly advised and used treatment regimens round the world. To maintain the recent success of global malaria control protecting the efficacy of ACTs is a global health priority (WHO, 2017). Many studies conducted between 2010 and 2017 ensured of the positive effectiveness of ACTs by 95% success in providing cure to the malaria patients outside the Greater Mekong Sub region (GMS) (WHO, 2018). Though having apprehension of developing resistance, not full but partially at least to ACT in African high risk malaria zone, there was yet no report before 2014 on parasite resistance to ACT in Bangladesh. In a surveillance data based study, Haque *et al.* (2014) found a number of cases of parasite resistance to ACT first ever of its type until 2020 in Bangladesh. But multidrug resistance including ACTs resistance (partial) has been reported in 4 GMS countries, viz. Myanmar, Thailand, Cambodia, and Vietnam. Considering the ethnicity of the study population drug resistance potentially have had been apprehended during data collation in this work. Anyway, there is a significant progress in reducing malaria cases and deaths in the GMS (WHO, 2019). But to track on the efficacy of ACTs in a malaria prone population of GMS needs updating of malaria treatment policies (WHO, 2020).

Interestingly, as ACTs are proved to be very effective for quick come round, maintaining its efficacy and keeping it free from resistance are some priorities under malaria combating program. In many studies, the efficacy of ACTs was found to remain greater than 95% in all but a few GMS countries where some reports on resistance to the antimalarials have recently been published (Daily Star, 2019, August 25). So, monitoring the drug resistance issue of malaria control in GMS countries has caused prompt updating of the treatment regimen of ACTs there. But there has potentially emerged a puling factor in malaria combating efforts based on ACT treatment. This is the evolution of the KEL 1/PLA 1 strain that is resistant to two key drugs in Vietnam, Laos, and northern Thailand. This is a dire concerning matter in fighting against malaria in and around the GMS countries. It has evolved through new genetic mutations to make it more resistant whilst spreading aggressively replacing the local malaria parasites. Such resistant parasite strain is capable of invading new territories by acquiring new genetic properties and thus has the threat of increasing the malaria morbidity and mortality anew in the region (Daily Star, 2019, August 25). As noted already, drug resistance in malaria cases in GMS region was first detected in Batambang and Pailin of West Cambodia from the identification of a *Plasmodium falciparum* strain with reduced susceptibility to artisunate mono-therapy (Imwong *et al.*, 2015). However, the matter of drug resistance in Bangladesh context seemingly requires further investigations while the country has been experiencing significant reduction to both morbidity and mortality by resorting on conventionally used first line drug regimens as inferred already.

Insecticide resistance complexities should be aligned with malaria interventions

On secured sustenance of an effective malaria control and prevention purpose, understanding vectorial resistance to insecticides, especially those used in LLITNs/ITNs occupies important area in any successful malaria response worldwide. In the context of insecticide resistance, repelling or killing of vector mosquitoes is a second to none remedy for malaria incidence anywhere in the world (WHO, 2008, Al-Amin *et al.*, 2015,). It came true in the case of the Rohingya refugee camps in Bangladesh while the use of proper insecticides on bed nets (ITNs), indoor residual sprays (IRS), and other chemical insecticidal resorts there undid the mosquito bites and the chance for completing plasmodial life cycle with zero case positivity among those who used to sleep under mosquito nets (Khan e*t al*., 2023). But the feminine anopheline mosquitoes' rich species diversity, richness of the *Anopheles* spp, preference for human blood, ability to be zoophilic beside anthropophilic, and capability to develop resistance to insecticides have challenged some antimalarial programme based on repelling and/or killing the mosquitoes round the world. It is a concerning matter that many anopheline mosquitoes have already developed resistance of different range to pyrethroids, organochlorine, carbamates and organophosphates in all major malaria vectors across the WHO regions of Africa, the Americas, south-east Asia, the Eastern Mediterranean and the Western Pacific (WHO, 2018). According to Hemingway *et al.* (2016), resistance to pyrethroids on ITNs showed that at least one mosquito vector carried this insecticide in more than two-third of the sites tested. Such resistance is highest in Eastern Mediterranean and Africa. But resistance to organochlorine as used in IRS was detected in at least one malaria vector in about two- third of the sites investigated and was highest in the WHO south-east Asia region. On the other hand, resistance to carbamates and organophosphates grew less and was confirmed in 33% and 27% of the tested sites respectively. So, resistance to 4 major insecticides, viz. pyrethroids, carbamates, organochlorine, and organophosphates have been reported to develop in nearly all major malaria vectors worldwide to date that the proper use of mosquito killers or repellent must be ensured to avoid insecticide resistance threat in malaria elimination effort. Given this, a timely managed insecticide application is argued by WHO to be a good solution to insecticidal resistance threat in any setting. Accordingly, WHO has devised out a plan– 'WHO global plan for insecticide resistance management in malaria vectors' that all the malaria prone member countries are supposed to follow (WHO, 2018 & 2019).So, considering the safety and availability in a setting, peacetime or emergency, monitoring on the insecticide resistance and its management plan should be an integral part of a successful malaria surveillance. It could be fundamental for any national goal achievement in malaria elimination as proved by a large scale multi-country evaluation approach led by WHO between 2011 and 2016 in 5 high malaria endemic countries (WHO, 2018 & 2019).

Malaria vector diversity and complexities should lie in the focus of the preventive strategies

Malaria transmission and the various issues with the presence of the anopheline mosquitoes in any malaria endemic area is crucial for uncovering the complete picture of malaria epidemiology. A number of studies helped this review to understand the species diversity, plasmodial infectivity, and the possible implications against the anopheline mosquitoes' spatiotemporal distribution in the area of interest. Sinka *et al.* (2011) could extract the occurrence and distribution of 19 dominant malaria vector species (DVS) in the Asia-Pacific region out of 41 global DVS from reputed published literature. Species complexities, plasticity of behavior, sympatric occurrence and suspected species complex were the complications with studying the concurrent bionomics of the malaria vectors as they noticed for that of the Asia-Pacific region not in other parts of the world. They related the environmental and climatic variables with distribution model for each of the 19 DVS by using Boosted Regression Tree Model. The study gave a relatively complete data base on the contemporary global distribution of the DVS of malaria, their status, epidemiology, and ecology in the Asia-Pacific region for the first ever of its type. The data base shows that *Anopheles stephensi* occurs in Bangladesh, India, Iran, Iraq, Myanmar (Burma), Afghanistan, Bahrain, Bangladesh, China, Egypt, Nepal, Oman, Pakistan, Saudi Arabia, Thailand whereas distribution of *Anopheles minimus* is highly reported from Bangladesh, Cambodia, China**,** India, Indonesia, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam. The survey type study of Tananchai *et al.* (2012) on 9,824 female mosquitoes using human landing indoor (HLI), human landing outdoor (HLO), and cattle baited collection (CBC) found that in western Thailand, *Minimus* complex (*An. minimus* 4.95% and *An. harrisoni* 84.65%), Dirus complex (*An.* dirus 6.09% and *An. baimaii* 0.59%),) and Maculatus group (*An. maculatus* 2.43% and *An. sawadwongporni* 1.29%) are common. Besides, exophagic and zoophilic behavior were found in *An.* dirus and *An. baimaii while a si*gnificant number of *An.* dirus and *An. baimaii* were collected from cattle. Moreover, Bashar and Tuno (2014) found *P. falciparum* to dominate in infecting indigenous anopheline mosquitoes of Bangladesh over the *P. vivax* in their direct observational method of identifying plasmodial circum sporozoite protein (CSP) in infected malaria vectors in border line area of the country. To add, in a CSP-ELISA approach, the highest diversity of *Anopheles* species was found in areas near to Bangladesh-Myanmar and Bangladesh-India border. Besides, some species that were deemed previously to play little role in local malaria transmission, significantly outnumbered the once thought principal vector species and was attributed to play a significant role in malaria transmission in the study areas (Al-Amin *et al.*, 2015).

In all cases, bionomics of the vector mosquitoes revealed an important part of understanding the real epidemiology of the plasmodial infections in given settings. As reported in WHO (2019), the breeding habitats, population density, and continuation of life cycle of malaria vector mosquitoes greatly depend on environmental changes, meteorological factors and human interventions. In a peacetime setting, understanding the functional relationship between climate factors and mosquito abundance gives us important information on parasite activity levels and its contribution to the disease risk. But in humanitarian crisis situation as in the present study, the rapid environmental changes are crucial to determining the vectorial roles of mosquitoes in malaria transmission in the new settings. To develop effective vector control programs in a region, proper information on mosquito fauna in seasonal variation is important.

CONCLUSION AND RECOMMENDATIONS

With this view, the biological, environmental, and interventional factors and their implications in understanding the distributions and associations of malaria case morbidity and mortality among the FDMNs-the Rohingyas in Bangladesh has been uncovered. While the country has had a long history of fighting against malaria morbidity and mortality burden, the immigration of hundreds of thousands of people from one of its border lined neighboring countries was considered to potentially pose serious threat of additional malaria counts in its local and national registers. Other than the fact that the forest travel linked malarias dominated in the camps on many occasions. This obviously needs a separate study exclusively for forest travelers to unmask the transmission pathways of malaria incidences in an endemic area that comprises suitable geography for maintaining the bionomics of the vector mosquitoes. In addition, the present study lacks in with data on prevalence of infected or infective anopheline mosquitoes in the study area so that the vector aspects in malaria cycles and transmission could not be figured out. This indicated that the study population was potentially living in a very low transmission area for malaria during the data collection period of 2017-2020 by Khan *et al.* (2023). No evidence was there, that the locally transmitted malaria posed significant threat of malaria alarms and outbreaks in the camps. There was also no instance of stopping the importation of plasmodial infections from outside the camps by cutting off the 'camp-forest' transmission pathways. On diagnostic viewpoint, malaria test positivity in RDT was significantly higher than that in microscopy though a significant proportion of the total malaria tests was based on the later. In such, further exploration and investigation are sought before giving the final judgment on the real status of malaria infections in the refugee camps. Given its origin and treatment history in Myanmar, the study population could be tested for malaria with molecular diagnostic techniques including PCR not *en masse* but on selective experimental designs. Therefore, from epidemiological points of view, other than that in forest linked high risk accounts, malaria in the present work has been implicated with a rather little number of risk factors not to individual camp or year contexts always but in a number of grand total and overall perspectives. This along with other findings and implications in malaria occurrence the Rohingya population in Bangladesh has led us towards offering a set of insights and questions in need of further exploration:

1. The RDT negative samples should be cross checked by 'high quality microscopy' instead of single tests to help better confirmation of an otherwise very little number of malaria case positivity in the refugee crisis settings
2. As a priority intervention, malaria resources should be mobilized upon targeting potential infection reservoir in forests and controlling human movement in and outside the camps to better combat malaria in the south-east border area of Bangladesh. With this, malaria transmission cycles in remote forested areas in Chittagong Hill Tracts can be disrupted by cutting-edge technologies including genetic modification of mosquitoes. Building more roads, schools, industries, clinics, and other infrastructure to further streamline the dissemination of malaria resources in otherwise hard to reach malaria hotspots in the CHTs will better promote the country's move to beat malaria.
3. A prospective cross-sectional study on both local and refugee populations in Bangladesh is needed to bring a comparative picture of the potential malaria risk factors from the movement of human populations of diverse ethnicity and cultures in the refugee- dominant areas
4. Asymptomatic plasmodial infections could constitute reservoir source for malaria infections in low transmission settings that conducting an active surveillance on people from all age groups can complement and extract better meaning in crisis time malaria situation in refugee camps. This can cover more avenues with detecting the sub-clinical infection sources of malaria transmission in the camps.
5. Malaria and anopheline mosquitoes are inseparable. So, undertaking a full investigation into species identity of the malaria vectors in the refugee camps will help unmask the vectorial implications in malaria transmission in the extra ordinary settings in the camp areas.
6. Since malaria among the Rohingyas revealed very uncommon in some studies, treating clinicians in the Rohingya camp areas should maintain a 'high index of suspicion' for other causes of undifferentiated febrile cases.
7. The Rohingya refugee camps in Bangladesh belong to a trans-border area of the country with Myanmar and India in the greater south-east Asian region of malaria endemicity. Accordingly, a joint and collaborative surveillance programme for eliminating malaria in any setting matters a lot for the respective national, regional, and global antimalarial campaigns. In this regard, we need to be vigil that, no area and parts of Bangladesh should be under the risk of malaria transmission as a result of either building of human reservoir hosts or reconstruction of new transmission routs in remote areas neighbouring India and Myanmar.

It must be asserted, that allocation of malaria resources should be focus and target oriented. The properly targeted place, time, and population are integral to an effective malaria control and elimination programme. This all can only be directed towards a meaningful end upon proper constitution of malaria epidemiology in peacetime in general, whilst on urgency, in complex humanitarian emergencies followed by better responding to malaria alarm and outbreak. Eventually, this can save significant cost on human life and properties from the mosquito borne infectious disease in any situation.

REFERENCES

1. Alam, M. S., Chakma, S., Khan, W. A., Glass, G. E., Mohon, A. N., Elahi, R., .& Norris, D. E. (2012). Diversity of anopheline species and their Plasmodium infection status in rural Bandarban, Bangladesh. Parasites & vectors, 5(1), 1-9.
2. Al-Amin, H. M., Elahi, R., Mohon, A. N., Kafi, M. A. H., Chakma, S., Lord, J. S., & Alam, M.S. (2015). Role of underappreciated vectors in malaria transmission in an endemic region of Bangladesh-India border. Parasites & vectors, 8(1), 1-9.
3. Anderson, J. Doocy, S., Haskew, C., Spiegel, P. and Moss, W. J. (2011). The burden of malaria in post-emergency refugee sites: A retrospective study. Conflict and Health. Retrieved at https://conflictandhealth.biomedcentral.com/articles/10.1186/1752-1505-5-17
4. Bangali, A. M., Mahmood, A. H., & Rahman, M. (2000). The malaria situation in Bangladesh. In Mekong Malaria Forum (Vol. 6, pp. 16-23).
5. Bashar, K. & Tuno, N. (2014). Seasonal abundance of anopheles mosquitoes and their association with meteorological factors and malaria incidence in Bangladesh. Parasites & Vectors. 7(442). Retrieved at doi: 10.1186/1756-3305-7-442. Retrieved at https://parasitesandvectors.biomedcentral.com/articles/10.1186/1756-3305-7-442#citeas
6. Daily Star (2019, August 25). Two Years of Malaria Struggle. The Daily Star, vol. xxix (215), 1. Retrieved at www.thedailystar.net
7. Faiz, M. A., Yunus, E. B., Rahman, M. R., Hossain, M. A., Pang, L. W., Rahman, M. E., & Bhuiyan, S. N. (2002). Failure of national guidelines to diagnose uncomplicated malaria in Bangladesh. The American journal of tropical medicine and hygiene, 67(4), 396-399.
8. Hay, S. I., Smith, D. L., & Snow, R. W. (2008). Measuring malaria endemicity from intense to interrupted transmission. The Lancet infectious diseases, 8(6), 369-378.
9. Haque, U., Ahmed, S. M., Hossain, S., Huda, M., Hossain, A., Alam, M. S., & Haque, R. (2009). Malaria prevalence in endemic districts of Bangladesh. PloS one, 4(8), e6737.
10. Haque, U., Overgaard, H. J., Clements, A. C., Norris, D. E., Islam, N., Karim, J., & Glass, G. E. (2014). Malaria burden and control in Bangladesh and prospects for elimination: an epidemiological and economic assessment. The Lancet Global Health, 2(2), e98-e105.
11. Hemingway, J., Ranson, H., Magill, A., Kolaczinski, J., Fornadel, C., Gimnig, J., & Hamon, N. (2016). Averting a malaria disaster: will insecticide resistance derail malaria control? The Lancet, 387(10029), 1785-1788.
12. Hook, C. (2005). Malaria in emergencies: treatment, diagnosis and vulnerable groups. Humanitarian Practice Network. Retrieved at https://odihpn.org/magazine/malaria-in-emergencies-treatment-diagnosis-and-vulnerable-groups/
13. ICDDR, B. (2006). Vector borne diseases in Bangladesh. Health and Science Bulletin, 4(3), September 2006. (Am J Trop Med Hyg. October 2006, vol. 75, pp 645-654)
14. Imwong, M., Nguyen, T. N., Tripura, R., Peto, T. J., Lee, S. J., Lwin, K. M., & Nosten, F. (2015). The epidemiology of subclinical malaria infections in South-East Asia: findings from cross-sectional surveys in Thailand–Myanmar border areas, Cambodia, and Vietnam. Malaria journal, 14(1), 1-13.
15. Khanum, H., Abedin, J., & Hossain, M. (2015). Application of Technologies for Diagnosis, Treatment, Prevention and Control of Malaria, Kala-Azar and Filaia in Endemic Areas of Bangladesh. Institute of Research Engineers and Doctors, USA. Retrieved at https://pdfs.semanticscholar.org/8f8b/c1af3f2d8b3b530f607b504102d0f885468f.pdf, doi: 10.15224/ 978-1-63248-055-2-73
16. Khan, M. A. A., Maude, R. J., Musa, S., & Khanum, H. (2023). Epidemiology of malaria in Rohingya refugee camps in Bangladesh within 2017–2020. Malaria Journal, 22(1), 288.
17. Nafo-Traoré, F., & Nabarro, D. (2005). Breaking the Cycle of Malaria and Death in Emergencies: The Way Forward. Humanitarian Change, 31, 3-5. (https://odihpn.org/magazine/breaking-the-cycle-of-malaria-and-death-in-emergencies-the-way-forward/)
18. National Malaria Elimination Programme (NMEP) (2019, 25 April). Progress in controlling malaria in Bangladesh. Retrieved at https://nmcp.gov.bd/

19. Noé, A., Zaman, S. I., Rahman, M., Saha, A. K., Aktaruzzaman, M. M., & Maude, R. J. (2018). Mapping the stability of malaria hotspots in Bangladesh from 2013 to 2016. Malaria journal, 17(1), 1-21.
20. Rich, S. M., Leendertz, F. H., Xu, G., LeBreton, M., Djoko, C. F., Aminake, M. N., & Wolfe, N. D. (2009). The origin of malignant malaria. Proceedings of the National Academy of Sciences, 106(35), 14902-14907.
21. Rowland, M. & Nosten, F. (2001). Malaria epidemiology and control in refugee camps and complex emergencies. Annals of Tropical Medicine & Parasitology, 95(8), 741-754. Retrievedathttps://www.tandfonline.com/action/showCitFormats, https://www.ncbi.nlm.nih.gov/pubmed/11784429, doi: 10.1080%2F00034983.2001.11813694
22. Sinka, M. E. et al. (2011). The dominant Anopheles vectors of human malaria in the Asia-Pacific region: occurrence data, distribution maps and bionomic précis. Parasites Vectors 4 (89). Retrieved at https://parasitesandvectors.biomedcentral.com/articles/10.1186/1756-3305-4-89#citeas, doi: 10.1186/1756-3305-4-89
23. Starzengruber, Peter & Fuehrer, Hans-Peter & Swoboda, Paul & Khan, Wasif & Yunus, Emran & Hossain, Shah & Walochnik, Julia & Noedl, Harald. (2010).The first case of Plasmodium ovale malaria from Bangladesh. BMJ case reports. 10(1136/bcr) .03.2010.2865. Retrieved at DOI: 10.1136/bcr.03.2010.2865, https://www.researchgate.net/publication/229016216_The_first_case_of_Plasmodium_ovale_malaria_from_Bangladesh
24. Sullivan, P. (2000). Poor conditions in refugee camps make malaria screening difficult: expert. CMAJ, 163(8) 1036. Retrieved at https://europepmc.org/article/PMC/80563
25. Tananchai, C., Tisgratog, R., Juntarajumnong, W. et al. (2012). Species diversity and biting activity of Anopheles dirus and Anopheles baimaii (Diptera: Culicidae) in a malaria prone area of western Thailand. Parasites & Vectors **5,** 211. Retrieved at doi: 10.1186/1756-3305-5-211,https://parasitesandvectors.biomedcentral.com/articles/10.1186/1756-3305-5-211#citeas
26. United Nations High Commissioner for Refugees, UNHCR (2019). Population Map Retrieved at https://www.malteser-international.org/en/our-work/asia/bangladesh/life-in-a-refugee-camp.html
27. World Bank (2022). Incidence of malaria (per 1,000 population at risk) - India, Myanmar, Bangladesh. Retrieved at https://data.worldbank.org/indicator/SH.MLR.INCD.P3?locations=IN-MM-BD
28. World Health Organization (1997). World malaria report, 2008. World Health Organization.
29. World Health Organization (2008). World malaria report, 2008. World Health Organization.
30. World Health Organization (2010). World malaria report, 2008. World Health Organization.
31. World Health Organization (2011). World malaria report, 2008. World Health Organization.
32. World Health Organization (2014). Tropical Health and International Health. 2014. WHO Press, 19(l 1): 7- 131.
33. World Health Organization (2017). Disease Surveillance. Inter Sector Coordination Group, Health Sector Bulletin, No.1 (1/10/17-15/11/17)
34. World Health Organization (2018). Help prevent malaria. World Health Organization Myanmar Newsletter special, September 2018. Retrieved at https://www.World Health Organization.int/docs/default-source/searo/myanmar/help-prevent-malaria-(english).pdf?
35. World Health Organization (2018). This Year's Report at a glance. World Malaria Report 2018.
36. World Health Organization (2019). Global Health Observatory Data Repository/World Health Statistics Retrieved at http://apps.World Health Organization.int/ghodata/
37. World Health Organization (2019). Compendium of World Health Organization malaria guidance prevention, diagnosis, treatment, surveillance and elimination (No. World Health Organization/CDS/GMP/2019.03). World Health Organization.
38. World Health Organization (2019). This Year's Report at a glance. World Malaria Report 2019. Retrieved at https://www.World Health Organization.int/publications-detail/world-malaria-report-2019
39. World Health Organization (2020). This Year's Report at a glance. World Malaria Report 2020. Retrieved at https://www.World Health Organization.int/publications-detail/world-malaria-report-2020
40. World Health Organization (2022). This Year's Report at a glance. World Malaria Report 2022. Retrieved at https://www.World Health Organization.int/publications-detail/world-malaria-report-2022