Research Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2025.62.009701

Malaria Incidence and Elimination Implications in Humanitarian Emergency Settings in Africa and South-East Asia

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ARTICLE INFO

Received: May 15, 2025

Published: June 02, 2025

Citation: Md. Ariful Anwar Khan. Malaria Incidence and Elimination Implications in Humanitarian Emergency Settings in Africa and South-East Asia. Biomed J Sci & Tech Res 62(2)-2025. BJSTR. MS.ID.009701.

ABSTRACT

Malaria causes significant loss to public health and properties in both peace time and refugee led humanitarian emergencies in Africa and south-east Asia. Higher malaria burden among refugees may occur from a rather compromised and weak disease surveillance compared with that in peace time situation. Incurring a chronic malaria burden Africa and south-east Asia further suffer from conflict and war led population migration and displacement crises intermittently. This exacerbates malaria situation in the two regions. Peace time malaria transmission dynamics evidently turns complicated with in-country as well as cross-border human movement across the endemic and/or non-endemic territories. This helps develop imported or introduced plasmodial infections that act as the key challenge for controlling or eliminating malaria in an area inflicted with refugee crisis. Exploring malaria incidence and experiences in the key refugee camps in Africa and south-east Asia in this review paper has helped understand new ideas of combating malaria, and added to the existing data base of the disease experiences. Compared with that in chronic and stable situation, the acute and unstable humanitarian situation in some refugee camps in malaria endemic areas intrigues the disease transmission dynamics and the toll with greater fluctuation in terms of case morbidity and mortality. Then the ideas and understanding from a thorough review of malaria situation in humanitarian emergency time as attempted here will further inform the data base for effective malaria surveillance in an integrated and comprehensive way so that the disease could be defeated in proper time and context.

Keywords: Malaria Incidence; Elimination Implications; Humanitarian Emergency; Africa and South-East Asia

Introduction

Malaria is an infectious disease caused by *Plasmodium* spp, and transmitted mainly by female anopheline mosquitoes in tropical and subtropical regions. Its occurrence in refugee camps during humanitarian emergencies within a greater peace time endemic area adds to the overall case morbidity and mortality among the human population at risk (United Nations Humanitarian Commission for Refugees, UNHCR, 2018). The global malaria account, 2023 estimates 263 million case morbidity (60.4 cases per 1000 population at risk) and 597 000 case mortality with the majority in Africa followed by Asia (WHO, 2024). Human movement seems to be a major contributor to changes in malaria transmission in both intra and inter countries through circulation between countries across a continuum of malaria endemecity. This is apparently supported by reintroduction of the infections to formerly endemic regions and/or new areas (Pindolia, et al. [1]). In such, malaria surveillance in mobile and migrant populations turns more challenging than in static populations. Also, their contribution to disease burden may be under-recognized. Understanding malaria transmission dynamics in different settings in endemic regions under an effective surveillance lies on addressing local, regional, and global implications in eliminating the disease. Interestingly, tracking malaria incidence in emergency settings of refugee crisis areas turns difficult whilst the extra ordinary surveillance there needs to address new environmental, political, social, cultural, demographic, and interventional issues.

Conducting malaria research then appears difficult in addition to a potentially poor documentation of the latter. Nevertheless, for eradicating malaria, the international community's effort of eliminating malaria must sustain defeating its reintroduction, resurgence, or recurrence anywhere on the earth. Grasping an oversight on malaria incidence and its burden in the humanitarian situation in various refugee camps in two mostly endemic regions of the earth was attempted in this literature review. This was done critically in a systematic and mutually supportive way intricating a conventional methodology as follows.

Materials and Methods

Meeting the knowledge gap in the preceding section was attempted through understanding updated version of malaria transmission dynamics in various settings ridden with refugee crisis in the malaria endemic regions on this planet. A series of varied works on malaria incidences and their associations (risks) was reviewed from the relevant instances, settings, and accounts. In another words, malaria situation in refugee camps reported in literary sources- offline (books, journals, periodicals, papers, etc.) and online (Google scholar) were consulted with epidemiological viewpoints. At first, the national relevance and implications of malaria elimination in some major African and south-east Asian countries was followed appreciating that the trans-border transmission factors in malaria incidence remain active to keep cumulative impact on framing the disease burden within a greater cross border setting in the regions. On many occasions, instances of new malaria situation in refugee camps was explored in light of relevant peace time settings, methodological contexts, and experiences. This contributed to reorganizing key findings in malaria transmission in the humanitarian emergencies in the camp areas as shown in the following section.

Results and Discussion

Malaria Incidence in Refugee Camps in Major WHO Regions Becomes Worse Mostly by New Demographics, Vector Bionomics, and Unwarranted Interventions from Hardly Managed Malaria Response in A New Environment.

Refugee led humanitarian crisis in malaria risk areas includes increased case morbidity and mortality on many occasions from weak disease surveillance. Malaria cases in the refugee camps in Burundi increased more than 3 million in 2000 from 0.2 million in 1984. Refugee camps in Afghanistan experienced an increase in the annual malaria incidence from 0.3 million in 1970 to 3 million in 1990. About 20 percent of the total malaria infections were identified as *P. falciparum* that spread to northern border of Tajikistan. Again in 2000, refugee settings in Democratic Republic of Congo, DRC faced significant increase in malaria mortality against age long violence in the region (Rowland, et al. [1-5]). Reportedly, most global malaria cases and deaths occur in a number of territories in WHO African region that suffer from intermittent political and socio-economic conflicts and unrest. This led to forced population movement and displacement during refugee crises. Malaria morbidity rate in the region was 222 per 1000 population in 2015 whilst 232 per 1000 population in 2020. Such additional account in malaria morbidity is seemingly attributed to disruptions to health services from Covid-19 (WHO [6]). In 2022, the region incurred 94% of malaria cases and 95% of malaria deaths globally.Besides, children under five year incurred 80% of malaria mortality account in the Region (WHO [7]).

Eritrea, Rwanda, Madagascar, and Zambia could decrease malaria burden by 50% between 2000 and 2009 through extensive control efforts under high national priority. Rwanda could ensure 74% lower rate of confirmed malaria cases between 2005 and 2010. Microscopy positive rate also decreased by 26% to count 9% by addressing chronic refugee problem among others. The country additionally reduced the rate of hospital admission for malaria and its mortality respectively to 65% and 55%. Interestingly, many countries of Africa, like Tanzania, showed significant progress in controlling malaria in the 2010s by strengthened combatting strategies and measures posting high importance on microscopy and rapid diagnostic tests on the back of large scale coverage of insecticidal nets. In 2017, a malaria outbreak at Kalobeyei refugee camp area in Turkanacounty of north-western Kenya killed 4 people. An account of 200 malaria cases per week in the camp underscored a lack of proper health facilities, diagnostic kits, drugs, and trained health workers there to treat the disease effectively (Halake [8]). To add, *P. falciparum* was the most prevalent strain followed by *P. malariae* and *P. vivax*. With a different pattern, malaria incidence in the WHO south-east Asia region estimated around 24 million of confirmed malaria cases in 2010 before declining to 5 million in 2021. Similar to Africa, the region went through persistent refugee caused humanitarian crises, like the Rohingyas Afghans, Khmers, and Karens since 1970s.

Of the cases, India alone accounted 66% and 83% in 2010 and 2021 respectively though a 28% reduction in case incidences took place between 2000 and 2010. In 2010, a total of eight countries in the region incurred 2426 malaria mortality cases most of which was from India. Noticeably, by 2012, Sri Lanka and Democratic People's Republic of Korea advanced into elimination phase while Indonesia, Thailand Bhutan, Nepal, Bangladesh, India, Myanmar, and the Democratic Republic of Timor-Leste left in the control phase (Autino, et al. [9]). Additionally, many of the malaria endemic countries in the region were afflicted with health and humanitarian emergencies time and again. An estimated 268 and 301 million people incurred humanitarian emergencies with refugees in 2021 and 2020 respectively (WHO [10]). Such humanitarian emergencies were contributed mostly by flooding, conflicts, and famine being compounded in many occasions by disease outbreaks. Anyway, on most occasions, the emergence of refugees or population displacement led humanitarian crisis in all WHO malaria regions caused uncontrolled malaria out-

break and further complicated the fight against malaria in both host and neighboring territories for the migrated new population. In each instance, eliminating malaria in a country has been found to potentially rely on the proper evaluation of the disease factors in the contexts of geography, climates, host, vectors, and the local, regional, and global interventions. The endemic areas for malaria apparently offer the concerns of resurgence, reintroduction, importation, insecticide, and drug resistance issues with the onset of the humanitarian emergencies. At this point, further exploration into the incidences of malaria transmission in some key refugee settings of both acute unstable and chronic stable nature should be better useful to the meaning and context of this paper.

On A Rather Limited Available Data, Malaria Incidences and Associations in Acute and Unstable Refugee Camps in Endemic Areas Shows Varied Infection Patterns and Trends Both Demographically and Spatiotemporally

Studies on concurrent malaria situation in many refugee camps appears inadequate. This review yet unravels some published literature on malaria in complex refugee settings including southern Sudan (1983-1999), Liberia (1989-1999), Somalia (1991-1999), Iraq and southern Turkey (1993-1997), Azerbaijan (1993-1995), Pakistan (1989-1999), and Thailand (1980s) (Najera et al., 1998, WHO, 1999). In the works, malaria morbidity and mortality cases, and epidemics in acute unstable and/or chronic stable conditions were explored. In all settings, various relief agencies as combating partners came up with some manuals on dealing with different malaria situations in the relief camps (Glass, et al. [11-16]). This helped better analyses in many studies that followed in framing their evaluations and recommendations. The Karen refugees in Thailand and Afghan refugees in Pakistan had to suffer from the complications of the infectious and communicable diseases including malaria in acute emergency situation followed by reduced case burden in stable post emergency settings. Sudden increase to malaria accounts in the camps apparently contributed to sustaining and extending the endemic malaria further. This was supported by the trans-border movement of infected people fleeing violent situations in border lined countries (Rowland, et al. [2,17]). Similar situation was found in the Karen refugee settings in Thailand. During 2011-2012, a prospective case study in Karen refugee camps did a mass blood survey in a village on the Thailand-Myanmar border.

Citizenship issue there appeared to be a significant risk factor for malaria so that the odds of the infections increased over eight times of that for the host Thai people. Also, malaria diagnosis by microscopy proved less effective compared to polymerase chain reaction (PCR) based molecular diagnosis. Besides, ratios of microscopy positive to PCR positive cases stood 1/9 for *P. falciparum* and 1/10 for *P. vivax*. These and other refugee camps, particularly in sub-Saharan region showed multiple factors to make malaria incidences more alarming. Evidently some of the these factors are: carrying largest proportion (> 90%) of the global malaria case morbidity and mortality occurs in Africa, trans border location and condition in refugee camps promote rapid expansion of the mosquito population, women and children among the refugees are more vulnerable to malaria attack, unscreened existence of sub microscopic (asymptomatic) infections, ignorance of the refugees on nutrition and malaria, one compromised and/or flaccid immune system among the refugees causing increased susceptibility and mortality (Landman, 2016). These factors are usually more prominent and intriguing in unstable refugee settings in endemic areas where malaria transmission trajectory takes new dynamics and implications varying with that in peacetime situation. To cope with the traditional health system, human factors and the total environment for both the vector and human host in peace time malaria and other infectious diseases in humanitarian emergencies (refugee camps) apparently fall into a quick shift towards a rapid deterioration of disease morbidity and mortality in a new environment (Rowland, et al. [2]).

Such epidemiological studies on the complex emergency situations in refugee camps of the Pakistan-Afghanistan and Thailand-Myanmar border areas in 1990s confirmed a significant up rise in malaria incidences. Effective malaria control strategies and case management as adapted into similar settings with refugee crisis in different malaria endemic parts of the world could also be worked out. In all respects, the assumption was that malaria mortality could rise to high in epidemic form uncontrolled before normal health services would properly be established in the camps. The malaria elimination issues then should be addressed effectively with the experiences from a thorough case-management approach in the chronic crisis situation in the refugee camps in a malaria endemic region. For example, as the study unveiled, long-lasting emergencies with severe shortage of resources in the Afghan refugee camps over the border on Pakistan side obviously asked for managing the risk of malaria spread there. This was done through large scale coverage of long lasting insecticidal nets (LLIN) and indoor residual spray (IRS) along with extended use of microscopy and RDTs in the camps. Shoklo Malaria Research unit of the Welcome-Mahidol University-Oxford Tropical Research Program worked on the Karen refugee camps to investigate some transmission issues: new therapies and interventions for fighting severe malaria, multidrug resistance in malaria, and/or resistant malaria management in the camp area.

The experiences were used to develop malaria control and elimination plan in the host country. The generalized intervention suggestion was driving rapid and quick malaria surveillance both active and passive without neglecting the near or far threats left in the disease epidemiology in the area of interest. Following the issues of malaria epidemiology with a sudden shifting of peacetime situation into emergency situations in refugee camps let's explore further some prominent instances of emergency time malaria incidences in the south-east Asia.

Malaria in Refugee Camps on Afghanistan-Pakistan Border Area

In 1979, an estimated three million Afghans fled Soviet invasion to take shelter in more than two hundred camps on the western border part of Pakistan (Rowland, et al. [2]). By 1990s, half of the refugees repatriated though a large proportion continued to live in the camps on the marginal border approaching land. Many camps remained water logged close to rice cultivation wet land offering breeding sites for mosquitoes. Investigation found the Afghan refugees to be non-immune on their arrival whilst they had been under an effective malaria control program in Afghanistan before humanitarian crisis. In the complex emergencies in the camp areas this caused them become susceptible to malaria attack and they experienced a serious malaria burden. Eventually, a malaria epidemic situation arouse in the refugee camps in 1990 with an annual 1,50000 malaria cases spotted at camp the health facilities under the UNHCR in collaboration with the Government of Pakistan and NGOs. *P. falciparum* infections occupied about 30% of the total positive cases while the rest were by *P. vivax* mostly and mixed infections of the two plasmodial species in some instances. On temporal account, malaria transmission in Pakistan is seasonal with highest following the July-August range of monsoon. The country belongs to subtropical climate comprising two peaks for *P. vivax* incidence in a year. The first is spring peak from relapse or delayed attack. The second peak is the summer peak.

On the contrary, *P. falciparum* malaria comprises a single peak following the summer peak for *P. vivax*. Moreover, malaria in Pakistan reportedly show long term periodic cycles bearing testimony for the epidemic form significantly in the middle of 1970s. Climatic variation in the northern edge of the country is deemed to maintain unstable range of *P. falciparum* malaria there. Also, due to increased down pour in autumn or temperature exceeding the average counts in November-December, malaria transmission season in the country prolongs-a recent trend in the ambient climate of Pakistan. Malaria risk factors of such nature should be addressed under the well planned malaria elimination in the country. Another point is that the usual instance of chloroquine resistance across the country has made the malaria situation complicated resulting in high fatality of *P. falciparum* in Pakistan, Afghanistan, and the neighboring Tajikistan. Obviously, human conflicts, war, and population migration and uprising are some additional factors to turn malaria situation worse in the region. On drug sensitivity, *P. falciparum* cases in Afghan refugees were sensitive to sulfadoxine-pyrimethamine (S-P) whereas, *P. vivax* still remained sensitive to chloroquine. Anyway, the Afghan refugees are suspected for carrying malaria to their host country, Pakistan reminding us the fact that refugees are treated as scapegoats in many cases. By the way, some studies claimed that the Afghan refugees became the target of malaria attack transmitted locally in Pakistan in the early 1980s (Rowland, et al. [2]).

The conjecture was that measures of rearing domesticated mammals(the zoo-prophylaxis) in the poverty stricken refugee camps were not enough. Rather exposure to infected and/or infective mosquito bites was easily attainable in the humanitarian extra ordinary situation in the camp areas. However, the preventive measures with chemoprophylaxis or zoo-prophylaxis to warrant for abatement of mosquito bites were not easily accessible to the camp residents. This meant for non-significant interruption to the acceleration of malaria transmission. Nonetheless, as a sort of intervention development, the refugees in the camps were found to rear cattle. A possible vector diverting role thus potentially caused a little difference in malaria incidence between the Afghan refugees and the host (local) Pakistanis in the region. Interestingly, usage of ITNs, IRS, and overhead full body cloth-covering were considered as effectively working preventive interventions there. This was also evident in the refugee camps of Tanzania where in early 1990s, ITNs were proved to give better outcomes whilst IRS worked better in post conflict (stable) situation (Rowland, et al. [2]). Unexpectedly, malaria in Pakistan and its adjacent areas yet prevails with significant public health threats and concerns to human wellbeing (WHO [7]).

Malaria Incidence in Karen Refugee Camps

Over 0.1 million Karen, Karenni, and Mon ethnic minority inhabited in a series of refugee camps on the Myanmar-Thailand border during 1970-1990s (Rowland, et al. [2]). Symptomatic malaria infections were common in all age groups in the endemic area. In 1992 malaria mortality cases accounted 15% of all deaths excluding the death from accidents. Annual malaria morbidity counts were three case per person while about 70% of the total cases were caused by *Plasmodium falciparum* followed by *P. vivax*, (20%). The rest (10%) were of mixed infections of the two infections. Spread of in camp antimalarial resistance revealed as a concerning matter. Conducting reinforced intervention program in the camps during the period of 1995-2000 led to a dramatically fall to the malaria burden. Not surprisingly, the pregnant women and the children in the camps showed a higher susceptibility to malaria whilst the overall incidence of the disease rather posed a less to minor threat since 2013 until the artemisinin based combination therapy (ACT) resistant strain of *P. falciparum* emerged recently in the Greater Mekong Sub-region (GMS) (Background | Shoklo Malaria Research Unit [18]). On annual average account, each child incurred 1/2 malaria infection. P. falciparum infection dominated among the adults under 20-29 year while *P. vivax* incidence among the young. The infection was clustered in households of Afghan refugees though the severity and mortality of malaria was higher in young age not in older ages.

The mixed infections offered less severity compared with *P. vivax/ P. falciparum* mono infections. Worth to note, the *P. vivax* incidence in mixed infections was assumed to pose a positive effect to ward off

the severity of *P. falciparum* infections. Nonetheless, by the late 1980s, compared with other infectious diseases, malaria in the camp areas, ended in with highest case morbidity (45%) and mortality (15%) among the Karen refugees. Malaria burden in pregnancy in the camp areas also caused an estimated 1% death in one account and 1% death resulted from cerebral malaria in pregnancy in another estimate. This guided malaria programme in the camps towards strengthening the combined health system targeting the pregnancy and childhood cases that finally helped decline malaria mortality burden. The Karen refugee camps were somewhat unstable under low malaria transmission area while the in camp malaria surveillance data produced for the first time a detailed picture of *P. falciparum* incidence in pregnancy. The surveillance system deployed clinical symptom based and parasitological (microscopy and RDT) test based treatment as well. Noteworthy, in the Karen refugee camps, the positive predictive value of clinical symptom-based diagnosis in malaria cases was found relatively weak whilst investigating the validity of diagnostic tool, which revealed to be wrong in 51% cases on the best algorithm. This caused 30% non-malaria cases left wrongly spotted as malaria positive (misdiagnosed) (Rowland, et al. [2]).

This advocated for considering microscopy and RDT to be correct malaria diagnostic tools in the emergency situation laden refugee settings. Such finding was consistent with a study that investigated occurrence of asymptomatic reservoir of Plasmodium infections through highly sensitive high blood volume quantitative real-time polymerase chain reaction (PCR) method in three cross sectional surveys in four villages along the Thailand-Myanmar border, three villages in western Cambodia, and four villages in south-east Vietnam (Imwong et al., 2015). The survey respondents in the villages lived more than six months and were invited in the trial. The overall prevalence of the asymptomatic malaria in the eleven villages stood 4%, 5%, and 20% by RDT, microscopy, and high volume ultra-sensitive real time polymerase chain reaction respectively. *P. falciparum*, *P. vivax*, and mixed infections contributed respectively 3%, 7%, and 1%. An estimated 8% of the positive cases showed low parasitaemia though species confirmation was undone. A multivariate regression assay revealed the onset of fever, male-sex, and 15 year or older ages to be independent malaria risks (associations) in the study area. Interestingly, a considerable account of sub-clinical or asymptomatic malaria was identified in low transmission settings. The implication with using different screening measures, viz., Microscopy, RDT, and PCR appeared to be an important factor to estimate the real prevalence status, asymptomatic or symptomatic in a population at risk regardless of the situations- emergency or peace time (Imwong et al., 2015). To the end of the 20th century against some similarities, malaria situation in Karen refugee camps differed to some extent with that of Afghan refugees in Pakistan. The Afghan refugees incurred huge loss to life and property experiencing a malaria epidemic situation nearly by ten years later of their exodus into the host country Pakistan.

The Karen refugees in contrast experienced a decline in both case morbidity and mortality by five years upon enduring an initial upsurge in malaria incidence earlier to their refugee life in Thailand. *P. vivax* dominated in the Afghan refugee camps while *P. falciparum* in Karen refugee camps with developing high antimalarial resistance unlike that in the Afghan camps. Anyway, in both refugee settings, *P. vivax* still remained sensitive to chloroquine though on different ranges. Besides, the vector control efforts differed in many ways between the Karen refugee camp and the Afghan refugee camp areas. Additionally, children of all ages, particularly those under five year among the in Afghan refugees suffered the disease burden more than those among the Karen refugees. Conversely, both refugee populations experienced concerning accounts of case morbidity and mortality among younger children and in pregnancy until an effective malarial program could be operated in proper time and context there.

Malaria Incidence in Khmers on Thai-Cambodian Frontier

In the middle of 1980s, an increase in malaria incidence was found in shabby makeshifts in the camps on the Thailand-Cambodia border area (Meek, et al. [13]). This was attributed to the immigration of infected people- the Khmers into Thailand from higher incidence area in Cambodia. Like those in Rohingya camps in Bangladesh, the camps were surrounded by forested hills. Between 1983 and 1985 the camps were under emergency humanitarian situation and sheltered hundred thousand of Khmers- the displaced Cambodian people. The mixing of two populations- the Thais and the Khmers was assumed to cause exchange of malaria parasites as well as vectors of different susceptibilities to worsen malaria situation in and around the two endemic countries. *Anopheles dirus* was the most dominating malaria vector in the camps whereas using mosquito nets and DDT in indoor residual sprays appeared as remarkable vector deterring measures in malaria control efforts. In the malaria treatment segment, chloroquine and sulfadoxine-pyrimethamine, quinine and tetracycline added primaquine were administered with expected outcomes. Like in many other settings, *P. falciparum* and *P. vivax* dominated with a very little instance of *P. malariae* infections. Without exception, malaria incidence shot up in rainy season (May-October) significantly. On demographics of the disease, all age groups, especially five year children showed higher susceptibility to introduced cases while other children and adults significantly incurred local or indigenous malaria cases. The symptomatic infections were significantly higher in adult males. Malaria in pregnancy was significantly higher that was considered to drum up the complications of spontaneous abortion, still birth, and birth of premature babies.

The adults were assumed to maintain high immunity in the infections. From inclusive inquiry, the control measures and the treatment in 1984-1985 seemed to help reduce case mortality. A decline from 77 to 28 per 100000 was estimated then. However, the annual parasite incidence in the total study spanned between 160 and 190 per 1000 in

different sites. On disease pathology, cerebral (by the attack of *P. falciparum*) and uncomplicated malaria could be documented. Quick malaria response surveillance helped reduce malaria incidences whilst the movement of the camp residents to nearby forests, residences untreated with IRS or lacking cooking fire appeared to be some promoting factors in the transmission of malaria. Also was apprehended that the movement of infected people from higher transmission areas to lower transmission areas help spread malaria infections being affected by the presence of vectors more than the parasites. This apparently advocates for bringing the immigrants under mass treatment to kill gametocytes along with making greater coverage of vector control programme and protection from mosquito bites.

Malaria Incidence Among Rohingya Refugees in Bangladesh

The south-eastern part of Bangladesh experienced large scale refugee crisis since after 25th August 2017 while hundred thousands of Rohingyas fled from Myanmar crossing the international border between the two countries. Both country belong to malaria endemic zone and the population migration from a moderately malaria transmission area (Myanmar) to a low transmission place (Bangladesh) at the frontiers posed new threats of worsening transmission issues in the region. However, in 2019, Bangladesh reportedly contributed less than one percent of the overall malaria cases in the WHO south-east Asia declining from ten percent in 2008 (WHO [19]). Considering the potential threats of disease epidemics, an extensive malaria screening was conducted in the Rohingya refugee camps in Bangladesh from 2017 to 2020 (Khan, et al. [20]). The average population size of the camp residents in the study period was 1.2 million. One concern was that the population at risk could bring a substantial account of malaria infections in Bangladesh from their country of origin. The area they migrated to (refugee camps) was also susceptible for malaria attack from local transmission in and around the camp areas.

Accordingly, the survey adopted self-presenting unselected individuals at the primary health care centers (PHCC), one at Kutupalong registered camp (KRC, population 18,223), and Nayapara mega camp (NMC, population 68,274) under two upazilas (Ukhiya and Teknaf) in Cox's Bazar district of the country. A total of 30460 Rohingyas of all ages were brought under malaria screening using RDTs and/or microscopy of peripheral blood. Criteria for the tests were tympanic temperature >37.5 °C under any age or sex. The surveillance was mostly of passive type (96%) apart from a little (4%) active type on door to door visits by the health workers using the same criteria for malaria test. The tests and data analyses were done in the PHCC in a camp. Data on demographics of the participants, their travel history in the preceding 2 months, and use of bed nets were also analyzed. The annual parasitic incidence (API) was 0.19 per 1000 population during 2017-2020. The average annual test positivity rate (TPR) in malaria incidence accounted 0.05%. TPR was highest among forest travelers at 13.60%. On many occasions, the cases were found clustered among male adults in 15-60 years age group. With clear contrast to other settings stated above, children under five or the pregnant women showed zero case positivity. Even no deaths i.e., zero case mortality was recorded round the study period. Mono infections from *Plasmodium falciparum* and *P. vivax* accounted respectively 53% (TPR 0.09%) and 37% (TPR 0.06%) while 10% (TPR 0.02%) for mixed infections of the two parasites. TPR (0.25%) with RDT was higher than that from microscopy (0.04%, $p < 0.001$). TPR among bed net users was nil (0%).

All cases occurred in people who avoided bed nets to deter infective/infected mosquito bites ($p = 0.01$). The positive cases were cured upon treating with artemether-lumefantrine and chloroquine-primaquine for *P. falciparum* and *P. vivax* respectively. No cases appeared twice rather cured on first treatment thus no evidence of drug resistance or relapse but new infection only. This affirms among others that malaria incidence in Rohingya refugee camps in Bangladesh was very low but those little were mostly acquired from forest travelling by the adult males. The screening data could not argue for the assumption of importation of malaria by the Rohingyas from Myanmar to Bangladesh. Thus efforts to reduce malaria in the forest traveling population seemed to be more useful and sustaining for the total elimination of the disease in the region (Figure 1).

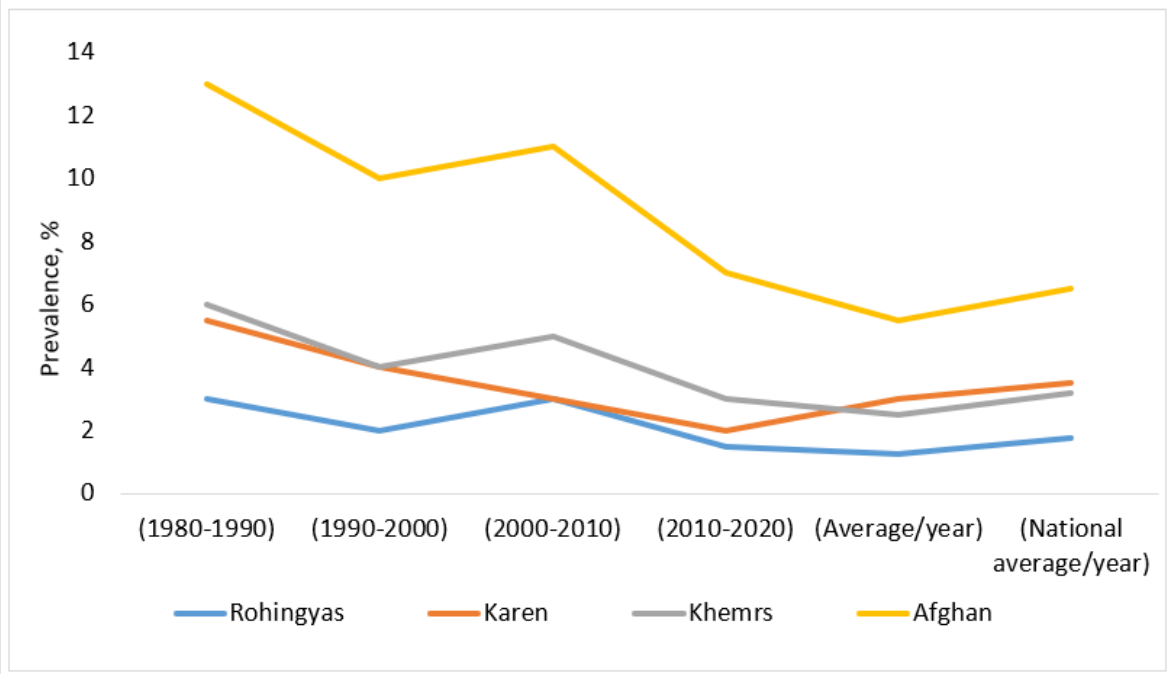

Figure 1: Malaria incidence in the key refugee camps in Asia during 1980-2020 (Reconstructed from Rowland, et al. [1-5,20,37]).

Malaria Incidence in Refugee Camps in Tanzania

In 1998-2004, around 400000 people of Burundi and Democratic Republic of Congo escaped the regional political crisis and conflicts and fled to western Tanzania being sheltered in refugee camps there. In 1998 a malaria screening survey was done jointly by UNHCR, WHO, and the Tanzanian Government that identified malaria as the main cause of death among children under 5 years in the camps (Ezard, et al. [21]). People of all age groups and the pregnant women fell under high risk of sever malaria. The transmission of the disease was evident round the year though turning highest in around the rainy season from May through October. Not traditional chloroquine but sulfadoxine-pyrimethamine was administered for treating the uncomplicated malaria. ITNs and IRS usage was followed along with ensuring the drainage of the standing water and killing the mosquito larvae in the camp areas in the prevention segment of the surveillance on a priority basis. From vector management context, standard entomological data were explored so that periodic net retention could be scaled up and better improved. (Ezard, et al. [21]) reaffirmed the effectivity of quick malaria response with ITNs, IRS, RDT, and like activities in the acute and unstable complex situation in Chad and Tanzanian refugee camps.

This also added a lot to the experiences of the local and international bodies there involved under the overall disease surveillance programme. Prompt case diagnosis and using ACT appeared as two most reliable approaches for combating malaria in Chad and many other similar refugee camps in the region. In a more eloquently succinct disposal, the successful malaria interventions in the two settings comprised estimating case incidence, prompt RDTs, administering SP and ACT in uncomplicated and advanced stage respectively, adopting ITNs and IRS making an effectively functioning malaria surveillance system. To further note is that the risk factors for a malaria epidemic outbreak in refugee areas differ between hilly and plain areas. To effect the vector bionomics, rainfall, climatic region, humidity, land surface, forest cover, altitude, and availability of water reservoir- small or big, and species diversity stand significantly determining factors. To support this (Khan, et al. [20]) found some high land settings flanked by forest in tropical climate region turns hotspots for malaria endemicity. But such endemicity in malaria transmission could vary largely in terms of mortality and morbidity in both intra and inter demographic and geo-climatic contexts. This was evident across a wide range of refugee settings- the Nyarugusu camp in Western Tanzania, Kiziba refugee camps run by UNHCR in Rwanda, the refugee camps in Chad, and the Mahama camp in Rwanda (Rowland, et al. [2]). In another instance, high malaria incidences were recorded among the Nyarugusu refugees in western Tanzania (Schug, et al. [22]).

The camp residents experienced malaria infections in Congo- the country of origin, and endured the infection for long time on the back of a poor national health service system that failed to test, treat, and track malaria properly. Since 1996, the makeshift shelters they used

in the host country have had been within swampy fields that worked as good breeding places for mosquitoes. The camp inhabitants were found to sleep under bed nets flawed in with big holes to giving very poor protection against the infective and/or infected mosquito bites. Consequently, malaria case morbidity and mortality seemingly tuned high in children under 5 year of age. At this point, a comparative analysis into the disease transmission dynamics in the Nyarugusu refugee and the Rohingya camps in Bangladesh appears important in some interventional contexts. Further exploration into other similar settings could make it clear and better meaningful.

Malaria Incidence Among Sudanese Refugees in Chad

In 2003, around 200000 Sudanese of Western Darfur fled ethnic violence and took shelter as refugees in 12 camps on the Chad-Sudan border area (Ezard, et al. [21]). The major portion of the camp population was composed of children and women like many other refugee camps. The camp area was assumed to belong to moderate to high malaria transmission zone being unstable in different seasons conforming that of the refugees' country of origin- Western Sudan. The rainy/wet season spanned from June through October with a maximum 600 mm/year rainfall count. However, the majority of the refugee people were estimated to bear little or poor immunity to malaria to fall into the risk of malaria fatality and death. The population at risk were also found to be unaware of potential malaria outbreak while the disease interventions in high transmission season- the rainy season were poorly managed. Considering malaria endemicity, the WHO, UNHCR, and the Chad Government jointly conducted an initial assessment following the influx of the refugees. This allowed the organizations to decide for a series of interventions involving real case assessment by RDTs, quick treatment using ACT, deterring mosquitoes by ITNs and IRS, etc. A deliberate application management of these priorities in the refugee camp area eventually contributed to reducing case burden and maintain a stable trend of low malaria incidences without significant increase in both morbidity and mortality by the end of 2004. Worth to note, use of ITNs and IRS caused this successful control of malaria transmission in an acute and unstable emergency refugee setting in the African endemic region. Apparently, most of the refugee camps and settings in Africa have undergone a long period of humanitarian emergencies with the initial acute unstable and complex phase through the recent post emergency stable situation. The post conflict or chronic emergency settings (stable) should be adapted with the transmission implications of an infectious disease, here malaria resulting in with a new epidemiology within and without the camp areas. This eventually can offer new ideas and avenues across the transmission scenario of malaria incidences having both similarities and dissimilarities to that in the initial unstable emergencies. At this point, a number of studies are explored to further follow the malaria situation in the post emergency time refugee settings in Africa.

Malaria Incidence in Kiziba and Mahama Camps in Rwanda

In 2015, malaria became the leading cause of sickness in a model refugee camp in Kirehe district of Rwanda set as the erstwhile largest camp in the country hosting more than 23000 Rwandans in a sector homing around 54ooo people (Karema, et al. [23]). The camp scored a toll of 50% of all cases of morbidity from all infectious diseases in the past two years in the district. As in other African settings, the camps residents were persuaded to use ITNs. In collaboration with the UNHCR the Rwandan government deployed IRS extensively in the camp areas. This helped significantly to reduce both case morbidity and mortality in malaria incidences. In another instance, in the Kiziba camp areas in Rwanda 4777 febrile residents were brought under an active surveillance and tested for malaria by RDT and microscopy (Molnarova, et al. [24]). A significant score of 7.77% of the tests showed case positive compared to that in the host community. Such result was meant for considering malaria transmission in a high land area (about 2 kilometer above sea surface) as a big public health concern. It was also apprehended that such settings face difficulties in applying traditional interventions leading to mild malaria symptomatology for high land malaria in Kiziba camps. (Oboth [25]) finds this well-grounded as the result of a kind of uncaring diagnosis and treatment in many instances of managing high land malaria. Upon a generalized points of view,stable (post emergency) humanitarian situation in the refugee settings have had passed through many phases of instability and complexity for a longer time compared with the acute unstable emergencies.

From the detailed study of Anderson, et al. [4] an estimated 1.18 million refugee population experienced malaria attack in such complex situation in a total 60 refugee camps in Thailand, Sudan, Burundi, Chad, Tanzania, Kenya, Cameroon, Uganda, and Ethiopia during 2006-2009, In 2008-2009, the annual average incidence stood 50 cases per 1000 people. Malaria incidence in Tanzanian refugee sites prevailed round the year that revealed 399 positive cases out of 1000 malaria tests excluding the children under 5 year who incurred unusual malaria incidence with 728/1000 case positivity. The study also confirmed the highest case mortality of 0.9 deaths per 1,000 refugee population in the camps in Sudan followed by that in Tanzania and Uganda- 0.7 deaths per 1000 refugees apiece. Besides, children under five years incurred 16% of total malaria mortality in the refugee camps. Younger children in such chronic stable settings are vulnerable to case morbidity and mortality in a significant dynamics of the malaria transmission in the endemic areas. In support of this, the experience of South Africa is evident that sheltered significant number of refugees from the greater sub-Saharan region of Africa. One prominent setting is the refugee camps in Durban city of the KwaZulu-Natal province of South Africa erected in 1994. The camp residents came from some endemic areas including Burundi, DRC, Zimbabwe, and Rwanda that in 2012-2013, they were screened for malaria. This aimed at checking the threat of malaria outbreak among both the refugees and the local host population. In 2012-2013, a malaria survey in the city took sample of 303 (all adult refugee participants in the

city) and found the malaria cases in South Africa to be of imported type from population migration as refugees there (Tsoka-Gwegweni, et al. [26]). This additionally inferred among others that the refugees in South Africa had been potentially immune to malaria and acted as the infection reservoir escaping befitting interventions. Also, Durban and its residents have had been inflicted with the threat of malaria outbreak for persistent refugee crisis in the region while 89% of the refugees tested malaria positive before they sought refuge into the camps. On the same course, in the camps, spot screening with RDT confirmed 3.8% case positivity, microscopy, 5.9% whilst *Plasmodium falciparum* appeared as the dominant infection. The participants were all under 19-64 years. Keeping note, Africa is the home to all types of malaria cases, morbidity, and mortality accounting more than 90% of the world malaria burden (WHO, 2024). This is internationally acknowledged issue that the UNHCR (2019) weighs most on operating malaria programme based on active surveillance, research, primary data, and individual case studies greater endemic part of the Africa. Given that complex refugee settings in Africa contribute around 30% of its total malaria burden, reviewing and understanding malaria studies in UNHCR run African refugee camps appears crucial for combating the disease in many other settings laden with refugee crisis on earth (Figure 2).

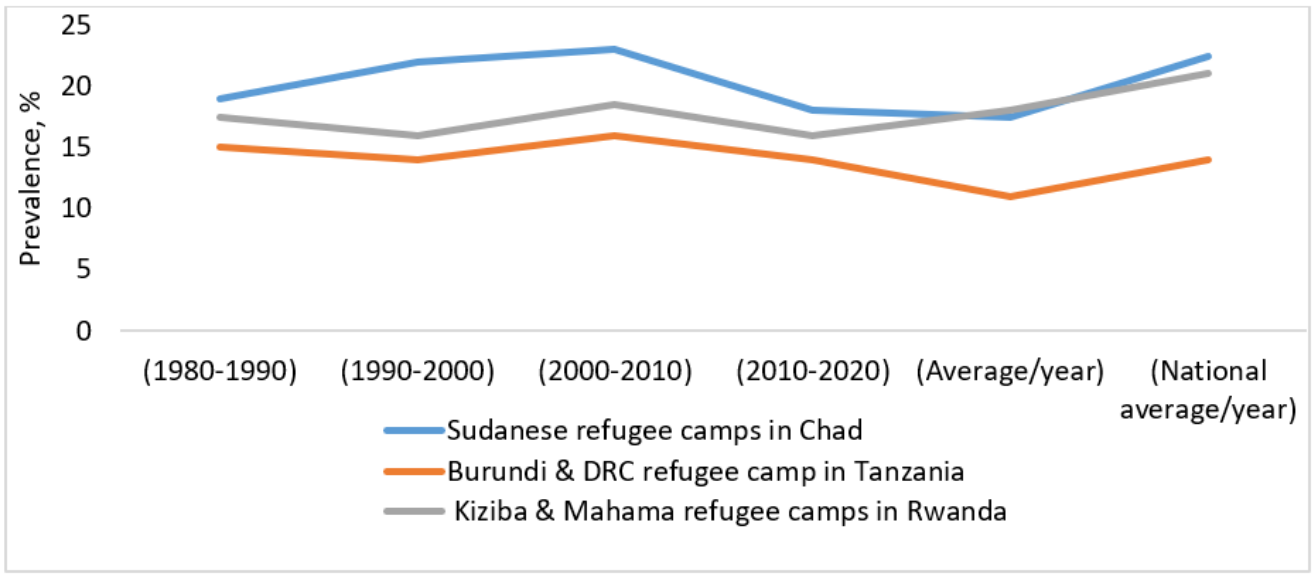

Figure 2: Malaria incidence in the key refugee camps in Africa during 1980-2020 (Reconstructed from Rowland, et al. [1-5,20,37]).

For instance, in the Kiziba, Rwanda, malaria prevalence account of 7.77% was significantly higher compare with similar settings in other parts of Africa (Molnarova, et al. [24]). This was consistent with Coldiron, et al. [5] that in 2015 estimated malaria as one of the major health concerns in Ayilo 1 and Ayilo 2- two refugee camps in Northern Uganda. Apart from, the conflict ridden refugee settings usually get aggravated with the onset of infectious and communicable diseases that warding off the potential threats of the latter in any border lined area turns very difficult.

To add, malaria elimination efforts turns worse from uncontrolled population migration and/or displacement in the targeted area. The complications from this unchecked migration or population shifts vis- a- vis the refugees affect the ecology of the community of the frontiers. As a result, both pre and post conflict transmission of a communicable disease- here the malaria tends to push up the graph of disease morbidity and mortality in malaria transmission. There appears some backdrops then, like linguistic and cultural barriers, and difficulties in getting access to a new population on a new place, mostly on border areas in the pathway to meeting the targets and goals for eliminating malaria (Shoklo Malaria Research Unit, [27]). In most instances, leaving malaria unexplored and unmanaged among a displaced new population in any endemic zone will be a major threat to visiting or travelling people and the local people there. Accordingly, proper malaria surveillance on the transmission dynamics of the disease in migrant and host populations under humanitarian crisis situation is highly advocated (SMRU, [27]). This is inevitable for fighting the disease and checking its potential outbreak among any population at risk under the malaria elimination programme.

unlike most of the peace time settings, malaria screening in refugee camps seems to be constrained by the emergencies in the camp areas, Weak and fragile health service facilities with unhygienic living standards in shabby public health status prevails in most refugee camps in malaria endemic areas that worsen malaria situation compared with that in normal peace time areas where malaria resources are easily transferrable and accessible. In one study, some refugee type immigrants in Canada from Africa were tested malaria positive (Sullivan [28]). Their refugee life in Africa experienced rudimentary laboratory facilities too little to get proper malaria tests. A Canadian doctor in the study tested 240 refugees hailing from the refugee camps in Burundi for malaria upon their complaints of fever. Malaria test positivity in the screening appeared 5%. Poor in camp living conditions in conjunction with hard to avail normal health service in complex humanitarian situation makes screening and treating malaria in a refugee camp difficult and complicated. This also works at facilitating various routs of malaria transmission and further complicates malaria burden in refugee camps. To add, abundance of unreported malaria incidence turns as a common follow up issue among the refugees. In a partial comparative picture of the two regions, malaria case positivity in refugee camps in Burundi and the Central Congo was higher than that of many south-east Asian countries including Cambodia, Vietnam, and Laos. Missing effective in country malaria screening the refugees of these countries were tested malaria positive in Canada upon their arrival in early 1980.

In either instances, malaria treatment sought higher cost mostly for diagnosis segment beyond for drugs that seemingly became an important factor for making malaria screening somewhat scarce in the extra ordinary condition in the refugee camps. In addition to this, malaria risks emerged elevated in occupational groups in poverty ridden areas under poor economy (Galagan, et al. [29]). According to (Khan, et al. [20]) the traditional Jhum (slash and burn) cultivators in the Rohingya refugee camps in Bangladesh were the regular forest travelers who showed extra ordinarily enhanced malaria case morbidity. This goes consistent with (Ahmed, et al. [30]), National Malaria Elimination Programme, (NMEP [31], Rowland, et al. [2,32]) to implicate among others the existence of diverse infected and/or infective mosquito bites for a persisting malaria incidence in and around refugee settings in endemic areas. Understanding malaria situation among the Khmers, Karen, Afghan, and, many African refugees unequivocally ask for controlling malaria in the humanitarian emergencies with prompt and properly design programme as one of the most challenging public health issue. Remembering that malaria epidemics relies on its vector management to a vast extent both preventive and curative measures must come together on the surveillance design package in a given setting. In the refugee settings in endemic areas, the disease needs to be dealt against a rapidly transforming and struggling health service system that develops also to deal with the threats of many other infectious diseases in a peculiarly existing setting demographics and new ecology. This latter usually offers unhygienic environmental conditions that suit best for an enduring vector bionomics.

Then in such settings, inquiries for more answers, better solutions, and new avenues need to be conducted through multifaceted research on malaria and other vector borne infectious disease. Apparently, the dynamics of malaria transmission in humanitarian emergencies evolves through acute, unstable to chronic, post crisis stable phase before turning into an epidemic and devastating form if proper interventions are not taken for fighting the disease.

The immediate unstable settings usually help guide the change to malaria dynamics with the shifting socio-political conditions. This causes to adopt the primary protective and preventive measures to undo rapid deterioration of the infections. A proper case diagnosis and treatment, assessment of the source of infection, and resolving the status of the transmission should be considered the most effective interventions in the areas of interest- peacetime or emergency. Moreover, the initiatives for combating malarial will need to be translated into operational research paradigm in association with regular control efforts. Study findings in this review also argue for operating research on malaria in emergencies promptly in a way to simulating better case management in other settings within post emergencies. Despite difficulty with operational perspectives in the extra ordinary crisis settings, proper understanding of real case definition, plasmodial species identity, and demographics of the infections must be resolved. Additionally, in any case study, malariometry should be able to discern better answers to the queries in disease transmission. Constructing malaria epidemiology in any setting then would be meaningful and practically answerable to the questions stated. It is also important to track malaria and its transmission dynamics in the refugee dominating areas for a successful programme of eliminating the disease. This is because, such humanitarian emergencies pass through various changes not in ecological context only but demographically also that makes malaria surveillance somewhat more difficult and complicated. Therefore, an effectively functioning malaria surveillance there must integrate and craft experimental evidence based elimination efforts, make the best use of malaria resources, deal the population at risk under a regular monitoring follow-up approach in proper time and space.

Malaria Surveillance During Humanitarian Emergencies in Refugee Camps

Malaria surveillance has developed through passing across various experiences in peace time areas and emergency situation laden refugee camps on planet. The refugee settings in this review show a basic common picture to include Test, Treat, and Track (3T) strategy in malaria surveillance in light with the suggestions of WHO Global Malaria Program that was launched in 2012. This aimed for defeating malaria by identifying every malaria case, treating, and tracking the incidences in a malaria risk area (Oteng, et al. [33]). Also, the vulnerable segments of a population at risk are spotted before selecting proper malaria resources to be deployed in focused and target oriented fashion. All this is maintained under a strong and effective monitoring system so that the associations in malaria transmission in the settings

are declined and removed finally. Moreover, the surveillance in such emergencies weighs high on proper case management and case reporting ensuring that all malaria incidences are set on track towards reduction and elimination on local, regional, and global scales regardless of the prevailing situations- emergencies or peace time.

Preventing Malaria in Humanitarian Emergencies at Refugee Areas Conforms that in Peace Time

Malaria programme in refugee dominating areas find use of ITNs, bed nets, IRS, coils, and spray with pyrethroids, organochlorine, carbamates, and organophosphate to be of major effective vector deterring measures under prevention aspect in eliminating the disease in any situation (WHO [34]). Despite some instances of resistance to pyrethroids are documented, ITNs apparently remain the most effective tool for preventing malaria. In another words, vector control success leads the instances of combating malaria on this planet. Then an advocacy for enhanced coverage of ITN usage in a malaria prone area in any situation fits best to be accepted and understood by the malaria workers and experts. This intervention measure seemingly comes first in the prompt response regiment of fighting the disease preferably in the areas and settings dominated by refugees, internally displaced and/or forcibly migrated human populations on earth (WHO [34-36]). For example, quick distribution of ITNs has been the highest intervention tool in the refugee camps in Europe, Asia, and Africa orchestrated by the NGOs and the respective governments of the territories. This was done especially during the initial acute and unstable emergencies followed by extended coverage during stable post emergencies there. In line with this, the age old nomadic refugees who used to migrate from winter camps in the Punjab to high-altitude camps in tribal areas of the North West frontier province of Pakistan each spring experience their tents being sprayed as effective deterrent to withheld malaria transmission and malaria outbreak there (Nafo Traoré, et al. [3]).

Noticeably, being under protected by the traditional indoor house spray with residual insecticides, the nomadic populations carry malaria infections to unaffected areas taking the benefit of a hard to follow-up issue in the local disease surveillance. This obviously stands by the logic for using adhesive formulations of insecticides, like the pyrethroids, permethrin or deltamethrin in treating their tents as an effective vector repellent. To repeat, in war or conflict driven settings of the refugees on trans-borders ITNs offer an excellent solution to fighting malaria. Accordingly, sleeping under bed nets and/or ITNs as daily practice by the residents of the refugee camps malaria epidemic or outbreak in humanitarian emergency settings. To do this some ethno populations unwilling to use bed nets might be needed to undergo motivation and awareness building campaigns on some occasions. This will help them resort to the practice. With this end, distribution of ITNs in the refugee camps should be made cost effective in the economic and cultural aspects of the population at risk. The problems towards ensuring cent percent proper use the ITNs should also be resolved practically. While charging no cost for the ITNs woks good in many instances, imposing a portion of the cost of the nets on the users could promote their own awareness and concerns for using the tools. If the ambient emergencies are managed with ensuring better livelihood and socio-political prospects for the strangled camp residents this will definitely work better (Rowland, et al. [2]).

Overall Implications of Eliminating Malaria in Refugee Areas

It is now apparent that malaria elimination in refugee settings in endemic areas rests on the management strategies of the social, demographical, cultural, political, and economic factors, vector mosquitoes, case identification from plasmodial species context, and the living experiences of the new community involving both refugees and their host people regardless of the situations- peace time or humanitarian emergencies. The transmission dynamics of the disease is arguably driven by the joint command of these factors. This is added with peculiarities, if any in the diverse vectorial nature of the anopheline mosquitoes, infection roles of the plasmodial parasites, resistance to insecticides and drugs, and the treatment and other interventional issues in dealing with the disease burden. Proper case diagnosis, estimation, spotting the reservoir of infections, and treatment in all respects are integral to building an effective barrier against disease spread and complications in malaria programme. It is encouraging that malaria control and/or elimination in any situation is organized and operated since 2015 under the guidance and support of World Health Organization through its technical framework for all malaria endemic countries (WHO, 2016). This formulates four targets to be reached by 2030 against the corresponding base line malaria data-2010: reducing the case incidence and the mortality rate by 90% apiece, eliminating malaria at least in 35 countries adding Bangladesh and Myanmar, preventing malaria resurgence in the territories declared malaria free. Following-up the framework (WHO [34]) found 10 sub-Saharan countries and India to bear 70% of the world malaria case morbidity and mortality burden in 2017.

In addition, in 2016, the Roll Back Malaria (RBM) and WHO programme identified four pillars to win 2020, 2025, and 2030 in proper malaria response: strengthening political (both national and global) attention to reduce malaria mortality, well planned sharing and usage of information for driving impact in a setting; Deciding on best international policies, strategies, and guidance for all malaria endemic countries in all situations, and ensuring a coordinated response to malaria epidemics at country level. This helped unroll 'high burden to high impact'- a country driven effort for the high burden malaria territories. Mozambique launched this programme in 2018 (WHO [36]). Considering its high toll of drug resistance in *Plasmodium falciparum* strains, Cambodia (a GMSR country) deployed many containment efforts in 4/5 years back and showed significant success in reducing case mortality (WHO [36]).

In WHO south-east Asian region, on some occasions, malaria transmission in humanitarian emergencies showed association with malaria burden in peace time areas. Considering a significant volume of malaria incidences on the Myanmar-Thailand border areas, health posts with malaria diagnosis facilities are found to be installed in villages of the two countries. In 2013, significant number of asymptomatic parasitaemia was found in the villages of Western Cambodia- the findings affirmed by a malaria research team in Pailin (a village where artisunate resistance was noticed first) referral hospital in the country. Vietnam- another GMSR country, has long been fighting against malaria. Malaria in the Binh Phuoc province of the country started to be aligned with a gradual increase in the degree of artemisinin-resistance following substantial decline in the case incidences until 2010. Interestingly, malaria situation in several endemic south-east Asian countries stood disproportionate by 2017 while children under 5 year incurred significant increase in case morbidity (WHO [36]). Until 2018, most of the region's case morbidity were contributed by India, 58%, Indonesia, 30%, and Myanmar, 10%. Bangladesh potentially appeared to be offering suitable corridor for malaria outbreak in its remote and hard to reach border areas with India and Myanmar in the region. This postulates seems to be logical whilst the country's malaria surveillance is implicated with a rather poor and inadequate data driven interventions.

Anyway, the account of progress in declining malaria incidences in south-east Asia has been similar since 2014. In 2014, API in the area was 57/1000 and in 2010, 71/1000. By 2021 it has been roaming round 57/1000 maintaining similar accounts since 2014 (Daily Star, December 8, 2019) (WHO [7]). By the by, in recent years, across many countries in south-east Asia and Africa, the country-driven approach- High burden to high impact has got momentum aimed at driving back the global malaria response back on track for achieving the GTS goals by 2030. Winning the aforesaid four founding pillars of nationwide malaria elimination programme in any endemic country rests on proper catalytic roles of the WHO. Besides, inter agency partnership for Roll Back Malaria could further facilitate the efforts to end malaria. Upon considering the progress patterns in combating malaria across 2015-2018, the attainments of the targets in reducing global malaria morbidity and mortality by 2025 compared with the 2015 baseline data could potentially be missed (WHO [36]).

Nevertheless, malaria elimination at any level- local, regional, and global evidently relies on both individual and integrated success in fighting malaria. This fighting keeps transcending the peculiarities of various settings in terms of geography, demographics, political setups, resources, and legal framework linked in malaria elimination programme. The human migration, trans-border activities, free flight of vector mosquitoes, and the under-reporting of the real infection scenario in proper epidemiological contexts still remain as the key challenges of defeating malaria. This leads to drum up awareness among the malaria experts and workers for understanding the basic epidemiology in any setting first at any point of dealing with malaria incidence to succeed into an ongoing malaria elimination program in a territory afflicted with population displacement, migrant or refugee crises. To rejoice, many border sharing countries laden with humanitarian emergencies in malaria endemic regions are struggling with remarkable progress in responding to malaria outbreak and its devastating consequence in the new situation.

Conclusion and Recommendations

This overview of malaria incidences and elimination implications in refugee dominated humanitarian emergencies evidentially finds some answers to many questions of the trends, patterns, demographics, and the associations or risks in a wide range of complex extra ordinary settings in Africa and south-east Asia. This has also been an attempt to investigate the demographical, biological, environmental, and interventional factors with implications in fighting malaria in the two regions. Besides, ways towards achieving malaria control and elimination goals and targets in respective territories inflicted with refugee crisis are explored. Any refugee led emergency situations in malaria endemic region with diverse range of geography, topography, economy, culture, and political crisis claim for some basic strategic and technical measures for combatting the mosquito borne infection. The key interventions in common include quick mobilization of malaria resources in the conflict driven settings, proper test diagnosis with RDTs and Microscopy in line with operating prompt test, treat, and track in the new environment. For treatment, chloroquine and ACT appear the best choice while ITNs/Bed nets still work very well to repel the infected/infective mosquito bites. Then understanding the demographics and risks in malaria transmission in the targeted population obviously helps a malaria risk country to avoid deterioration of overall malaria burden from the onset of potentially new concerns with displacement or migration or population movement-the emergence of refugees. Since the 1970s, both Africa and south-east-Asia have suffered from refugee crises on many occasions time to time in different areas near international borders between two countries that progress in the fight against malaria during peace time situation in the regions got complicated, cumbersome, uncertain, and disturbed. It is obvious that designing and executing effective response to potential malaria attack in various forms in the two endemic regions should aim for eliminating malaria in either situation-peace time or conflict led emergency. This should also be developed against a rapidly changing and/or transforming local, regional and global order. Higher average peace time malaria burden, chances of repeated conflicts, degrees of population shift, relative poverty, and grade of ethno-cultural peculiarities in the African refugee settings could have slowed both individual and collective malaria incidences compared with that in Asian region.

In all respects, an endemic country afflicted with refugee crisis must consider their peacetime experiences of combating malaria before responding to possible outbreak of malaria in the new occa-

sion- the refugee camps. This will definitely help provide better management in malaria surveillance and lessen the case morbidity and mortality accounts as expected. The surveillance outcomes, nevertheless are relative of the ambient political, social issues, demographical, cultural, and economic conditions whilst both peace and emergency time experiences meet together. Again, malaria risks and their implicating factors at trans-border refugee camps in malaria endemic areas largely depend on the relative status of malaria endemicity of the places across the continuum of source – sink. This is added with the climatic, demographic and spatiotemporal status, and the movement and life style episodes of the targeted population.

Eventually, a cascade of new challenges from shifting towards a potentially aggravating malaria situation with the overlapping and amalgamation of different trans-border populations in a malaria endemic region needs to be identified and assessed to the beginning of operating one or more surveillance of infectious and vector borne disease. [37-44] It is claimed that understanding malaria risk factors either emerged anew or existed already in a new community should be one of the key breakthroughs into eliminating the disease. Bolstering effective deployment of malaria investment could also pivotal to meet the conditions in malaria elimination plan based on required research and development segment in the disease surveillance. This will definitely promote smooth operation of the surveillance and interventions that the pathways in malaria transmission in the humanitarian crisis situation be cut off. Malaria screening, treating, and monitoring must be aligned with prompt malaria response regardless of the type of humanitarian emergencies and the politics of the onset of refugee crisis. This fits also better in the perspective of concerned demographics, geography, and the interventions in understanding and constituting malaria epidemiology in similar settings on our planet.

In light of all this ideas and implications in malaria situation in refugee settings here are some recommendations that the individuals, parties and agencies should follow for a total success in attenuating malaria threats and tolls followed by elimination, particularly in humanitarian emergency situation in refugee camp areas vis-à-vis in the peace time situations in malaria endemic regions:

1. Operating regular monitoring and tracking of malaria incidences among the displaced or migrated populations- refugees or immigrants fleeing humanitarian crises. Conducting prompt and early malaria surveillance, detecting or identifying new infections, and managing both symptomatic and asymptomatic infections
2. Checking for any dominant strains, their potential resistance to antimalarial drugs that chances for recurrence of infections could be reduced
3. Taking institutional preparation for mobilizing malaria resources in crisis ridden human settlements in remote and hard to reach area, especially in and around trans-border areas
4. Promoting effective community engagement campaigns including education and awareness building programme on using ITNs/or bed nets and mosquito repellents in proper time and settings round the year
5. Strengthening entomological control for the vector, *Anopheles* mosquitoes especially during its breeding season. All levels of local government agencies assigned with mosquito control can then resort to effective repellents and insecticides and thus become an important partner in local malaria surveillance
6. Better tailoring of malaria interventions must be possible by striking proper investment in research and development. This will guide innovations towards better findings drug resistance patterns, case detection, and mosquito bionomics and habitat preferences. Funding cutting-edge technologies in malaria issues, like the genetic mutations of mosquitoes in transmissions pathways of the disease will help better vector control. Promoting enhanced citizen services by constructing more roads, industries, schools, clinics, and other infrastructure in under developed malaria prone areas and thus facilitating prompt mobilization of malaria resources to targeted populations at risk
7. Conducting local and regional surveillance on collaboration until malaria elimination goals are achieved. The target of declining malaria transmission to zero in trans-border areas of two or more neighboring countries as stipulated by the Global Strategic Techniques for Malaria (2016-2030) could be reached only through surveillance collaboration among the parties involved. Success to this end will also be meant for destroying reconstruction of new transmission routs or human reservoir from population migration or refugee influx crises.

We find malaria incidences in the refugee camps and/or other humanitarian emergencies to be benefitted from a peculiar environment, new vector bionomics, and host experiences on the back of newly evolved socio-cultural and political implications in managing the health issues of the displaced population. Considering a rapidly changing regional and world order much efforts yet to be deployed not being complacent with a rather stellar progress in controlling malaria in the recent but remaining vigilant for the total malaria elimination globally by 2050. To win an overall struggle for combatting malaria inclusively needs addressing the intermittent up-surging of malaria incidence in refugee camps. Stray malaria outbreaks in clustered spots of high lands and forested areas are not uncommon. The proper appreciation of the incidences, risks, implications, and the recommendations here will definitely help deal malaria elimination issues in all settings comprising both peacetime and humanitarian emergencies in the endemic regions on a greater comprehensive table of actions to eradicate the disease.

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ISSN: 2574-1241

DOI: 10.26717/BJSTR.2025.62.009701

Md. Ariful Anwar Khan. Biomed J Sci & Tech Res

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