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Nine Years of Malaria Cases in Bangladesh: A Time Series Analysis

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Abstract

Aims

Bangladesh, a malaria endemic country in South East Asia Region, has been successfully decreased malaria over the years through adoption of different strategies. Still this is un-notified and no systematic malaria trend analysis has been done. Hence this study assesses the malaria trend through different dimension with consideration of various anti-malarial programme.

Study Design and Methodology

A secondary data from NMEP and BRAC were used to analysis the trend of malaria cases. A time series of the data were done to complement the analysis. A comparison of different regions through spatial distribution wasalsofitted out to determine the present scenario in Bangladesh.

Result

The annual malaria incidence declined from 7.77 per 1000 population in 2008 to 1.58 per 1000 population in 2016 [R^2=.712, P=.004 95% CI= -1.039- (-0.286)]. Both *P. falciparum and P. vivax* is decreased by 75% and 77% respectively since 2008 though *P. vivax*is slightly increased after major shuffling in 2014. For severe malaria, it is gradually decreased over the year [R^2=.779, P=.002, 95% CI =(-480.879- (-170.654)] which is 78% lower in 2016 in relation to 2008.A different scenario was found through stratification as malaria infection is steadily decreased in both low [R^2=0.826, P=0.000, 95% CI=(-5.98-(-4.87)] and medium endemic districts [R^2=0.293, P=0.000 ,95% CI=(-5.82-(-2.817)], but the same rate does not happened in Chittagong Hill Tracts. The study unveiled that malaria prevalence was higher in males(57.86%) than females(42.13%) while in age group, malaria was higher in 15 plus group (59.3%) followed by 5-14 years (28.6%) and then 1-14 years (11%) and < l years (1%).

Conclusion

Though malaria infection is sharply decline in all endemic districts except Chittagong Hill Tracts, it needs a sustained intensified strategy to be employed in all endemic districts to embarking malaria elimination in 2030.

Keywords: Chittagong Hill Tracts, malaria, elimination

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ABBREVIATIONS

ACT	Artemisinin-based Combination Therapy
API	Annual Parasitic Incidence
CHT	Chittagong Hill Tract
GFATM	Global Fund to Fight AIDS TB and Malaria
icdrr'b	International Centre for Diarrhoeal Disease Research, Bangladesh
LLIN	Long-lasting insecticidal net
M & E	Monitoring and Evaluation
MIS	Management Information System
NMEP	National Malaria Elimination Programme
PR	Principal Recipient
PSM	Procurement and Supply Management
RDT	Rapid Diagnostic Test
Pf	Plasmodium Falciparum
Pv	Plasmodium Vivax
SOP	Standard Operating Procedure
SR	Sub-Recipient
UHC	Upazila Health Complex
UH & FPO	Upazila Health and Family Planning Officer
UNDP	United Nations Development Programme
UNOPS	United Nations Office for Project Services
WHO	World Health Organization

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1. Introduction

Malaria is a protozoan disease caused by parasites of the genus *Plasmodium*. It is one of the leading causes of illness and death in the world. In 2015, there were an estimated 212 million malaria cases and 429 000 malaria deaths worldwide, with 90% of deaths occurred in Sub-Saharan African countries, followed by the WHO South – East Asian Regions (7%) and then the WHO Eastern Mediterranean Region (2%) [1]. Malaria is concentrated in world poor countries mostly Africa and South East Asia, where pregnant women and under 5 years of age are at greater risk of malaria infection [2].

Bangladesh, a malaria endemic country in South –East Asian Region, where malaria is endemic in thirteen districts out of sixty four districts under North –East and South –Eastern region that bordering with India and Myanmar. Since 2008, Malaria Control Programme in Bangladesh got a momentum after securing funding from The Global Fund and goal of the Round -6 Proposal was “to reduce malaria specific morbidity and mortality by 50% in 2012 from the baseline year 2005”. This project has shifted its strategy from control to elimination of malaria after nine years of widespread systematic implementation in three stratified regions—high: CHT; medium: Cox’s Bazaar and other low endemic areas underdifferent Round of proposals. During the days, malaria positivity decreased from 84,690 in 2008 to 27,737 in 2016 resulting malaria infection mostly occur in rural areas which is close proximity to hard to reach areas and/or to fringe or deep forest under CHT (Chittagong Hill Tracts), Cox’s Bazar and other low endemic areas. This reduction of malaria encourages National Malaria Programme to develop a far-reaching National Malaria Strategic Plan (2017-2021)[3]in view of Global Technical Strategy for Malaria (2016-2030)[4]. The three CHT districts--Khagrachari, Rangamati, Bandarban--the high endemic districts still remains major causes of malaria morbidity and mortality in Bangladesh.

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In 2007, the overall malaria prevalence rate was 3.1% with Khagrachari district (15.5%) was most prevalence area followed by Bandarban (10.7%) and then Rangamatidistrict(6.5%) [Malaria Baseline Socio-economic and Prevalence survey, 2007, BRAC and icdrr'b, unpublished data] .Among the nine low endemic areas, the prevalence rate was high in Hobiganjdistrict(1.74%).In 2013, the prevalence of malaria reduced to 0.9 per 1000 population with Bandarbanwas the highest prevalence district (6.7 per 1000 population)[Follow up Malaria Prevalence survey, 2013,WHO,BRAC,icdrr'b,unpublished data]. Then Bangladesh got an unusual experienceonmalaria case infection in 2014 which was more than double than that of 2013 malaria cases. This familiarities is also find in Northeastern districts of India where the three Indian states (Meghalaya, Mizoram and Tripura) close to Bangladesh had more than double malaria cases in 2014 than that of 2013[5].

The epidemiology of malaria in Bangladesh is highly complex. All four species of human plasmodium are present but the vast majority of malaria cases are caused by *Plasmodium falciparum*. Most of the rest are caused by *Plasmodium vivax*. The epidemiology of the disease varies from location to location and from one population to another population. Intense malaria transmission is largely restricted to hilly, forested and forest fringe areas of the Chittagong Hill Tracts.The most efficient vectors is *Anopheles dirus then Anopheles minimus where the former can survive in high* dense forest in CHT and the latter, this species is also primarily forest-based but can survive in less densely shaded forest, forest fringes and part of bamboo thickets.However, this improvement in reducing of malaria in Bangladesh is largely overlooked and thus a trend analysis of malaria cases had hardly been studied. This study was undertaken whether there was any significant effect in malaria endemic areas considering the strategies taken over the years that open a new window in Bangladesh towards malaria elimination.

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2. Methods and Materials

A secondary data from NMEP and BRAC were used to analysis the trend of malaria cases from 2008-2016 with consideration of various anti-malarial activities. A district wise monthly surveillance data (2008- 2016) obtained from BRAC to get the effectiveness of programme at region base. The blood examination rate which is based on blood slide examination per 100 population, collected through programmatic data reporting system. Annual Parasite Index (API), a unique measurement of malaria severity, also calculated from confirmed malaria per 1000 population. The mid- year district population were used to computing these rates derived from the national census (2005 & 2011) andalsoconsidering the growth of population. A time series of the data were done to analysis the trend using centered moving average. Data was entered and analyzedbySPSS v 16.

3. Result

During the study period (2008–2016), a total of 33,76,333blood films and 16,73808 RDT were done for malaria diagnosis of which 15,6627 (4.63%) microscopically and 2,80,949 (16.7%) RDT were positive withmean malaria cases of 48,619 in Bangladesh. During the year (2008-2016), malaria positivity were decreased by 32% (R^2=.507, *P*=.031) (Fig1)while annual blood examination rate remains almost unchanged from 3.087 in 2008 to 3.274 in 2016 (Table 1) (Fig 2).Annual Parasite Index (API)isalsodeclinedfrom7.77 in 2008 to 1.58 in 2016 [R^2=.712, *P*=.004, 95% CI= -1.039- (-0.286)] (Table 1)

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Table 1 :Malaria cases from 2008-2016

Year	Blood slide Examination	RDT Testing	Total Test	Blood slide positive	RDT Positive	Total Positive	Pf	Pv	Mixed	Severe malaria	Population	API	Annual Blood Examination rate (%)
2008	336505	106001	442506	50004	34686	84690	69606	14409	675	3042	10900000	7.770	3.087
2009	397148	156639	553787	25203	38670	63873	56912	6853	108	3287	11118000	5.745	3.572
2010	308326	152936	461262	20519	35354	55873	52012	3824	37	2726	11340360	4.927	2.719
2011	270253	120172	390425	20231	31564	51795	49105	2580	110	3095	16286155	3.180	1.659
2012	253887	118919	372806	9901	19617	29518	27644	1699	175	1457	16525561	1.786	1.536
2013	290496	128259	418755	7303	19588	26891	25815	983	93	1155	16768487	1.604	1.732
2014	418519	211662	630181	13628	43852	57480	41261	3348	12871	2063	17014984	3.378	2.460
2015	527659	259171	786830	6621	33098	39719	26525	4011	9183	1023	17265104	2.301	3.056
2016	573540	420049	993589	3217	24520	27737	17318	3306	7113	670	17518901	1.583	3.274
	3376333	**1673808**	**5E+06**	**156627**	**280949**	**437576**	**4E+05**	**41013**	**30365**	**18518**	**134737552**		

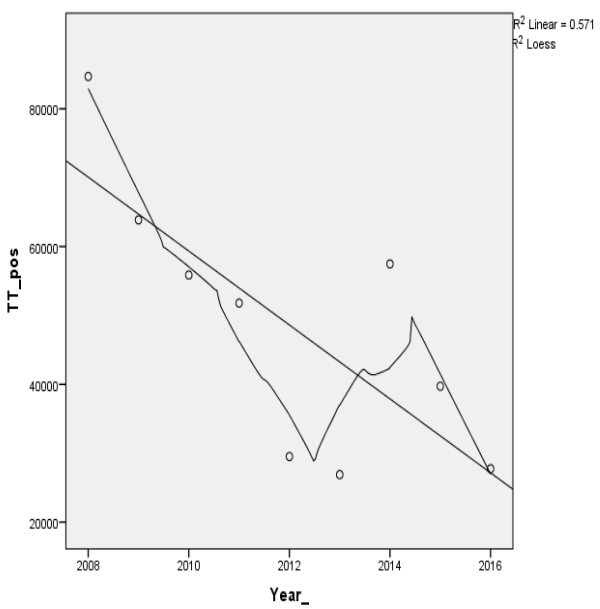

Fig 1: Malaria positive (2008-2016)

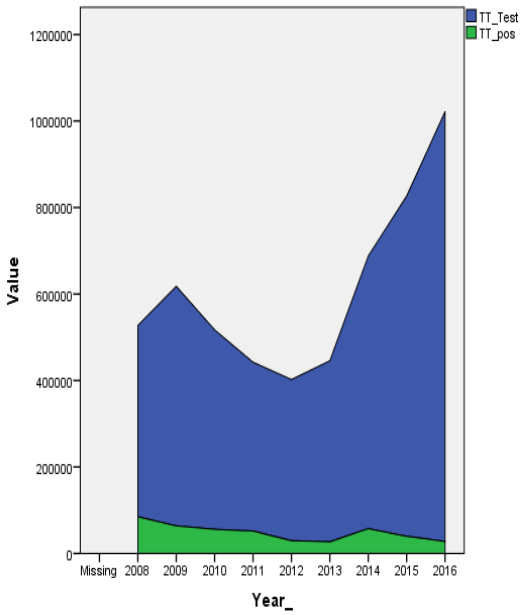

Fig 2 :Malaria blood examination and positivity

There is significant annual decline in the malaria incidence over the years, though there was high peak in 2014. The figure (Fig 3) revealed malaria incidence continue to fall till 2013 (32% as of 2008) and then it was sudden increase in 2014 before it was further down in next two years (2015-2016).

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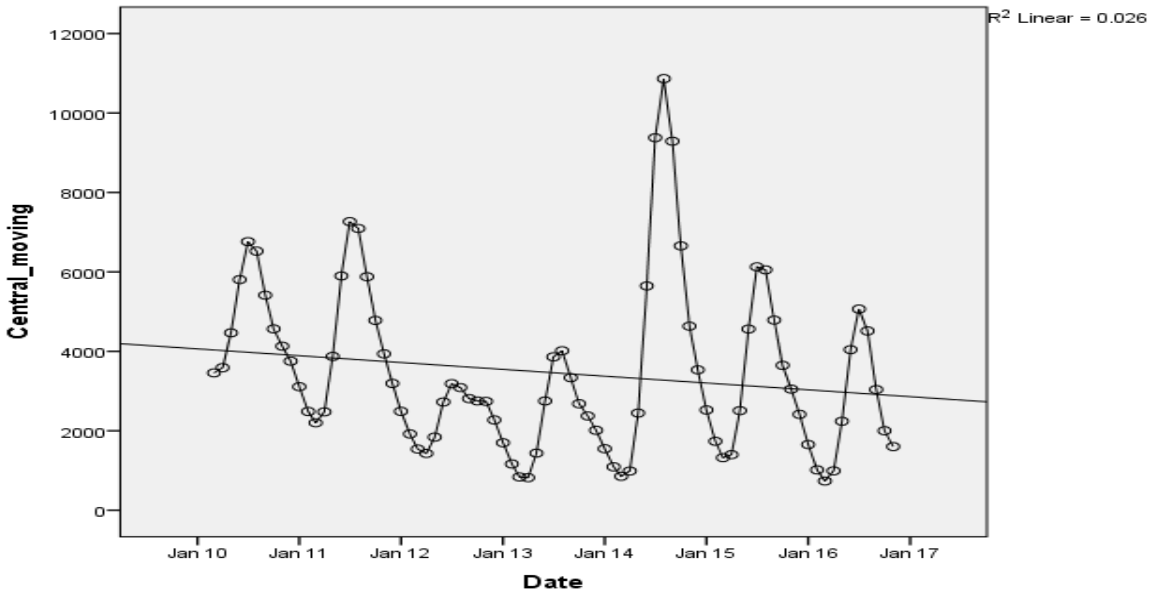

Fig 3: Monthly malaria incidence with moving average (2008-2016)

The result of the study shows that malaria prevalence is higher in males than females. From the infected patients (57.8%) were male and (42.13%) were female (Fig 4). In age group, malaria was higher in 15+group (59.3%) followed by 5-14 years (28.6%) and then 1-14 years (11%) and < I years (1%) (Fig 5). In all aspects, malaria has been decreased over the year with a peak in 2014. .

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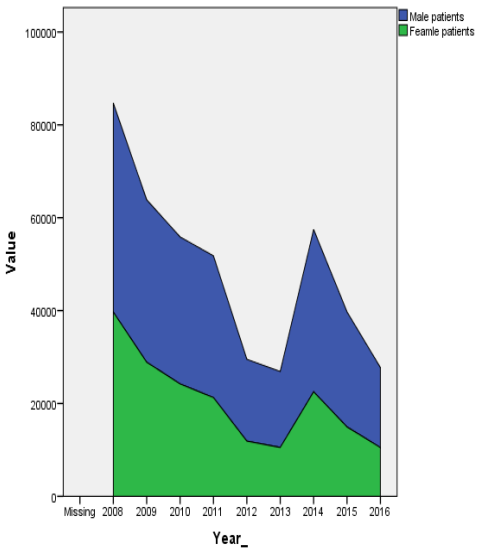

Fig 4 : Analysis of sex group (2008-2016)

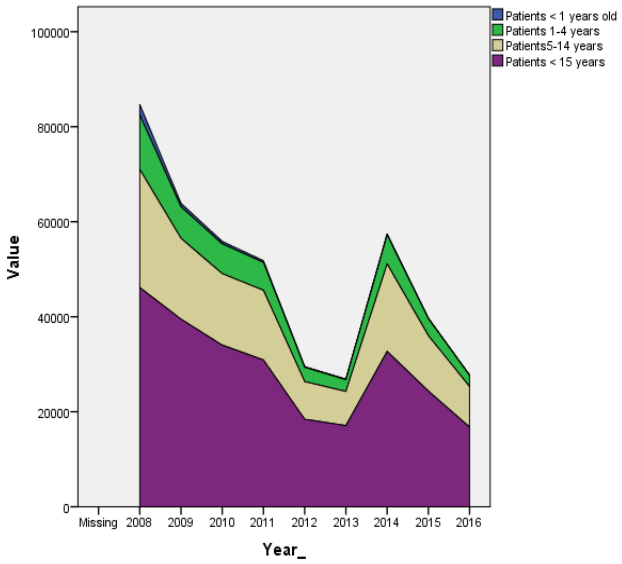

Fig 5 : Analysis of age group (2008-2016)

Malaria is caused by Plasmodium parasites and*Plasmodiumfalciparum*is the dominating species in Bangladesh. More than (80%) of malaria cases are of *Plasmodium falciparum*and it is decreased till the year 2013, after that a sharp rise in 2014 (160%) and then it is back to decreasing pointin following year 2015, which is continue to 2016 (Fig 6) [R^2=.860, *P*=.003,Fig :7] . *Plasmodium vivax*, a more harmful species and frequent cause of malaria, increased in successive years 2014- 2015 (340% in 2014 and 120 % in 2015)(Table 1) after 2013,though there is steady decline since 2008 (But it is not significant) (Fig 7). Both *P. falciparum and P. vivax* is decreased by 75% and 77% respectively in regard to 2008 (Table 1).

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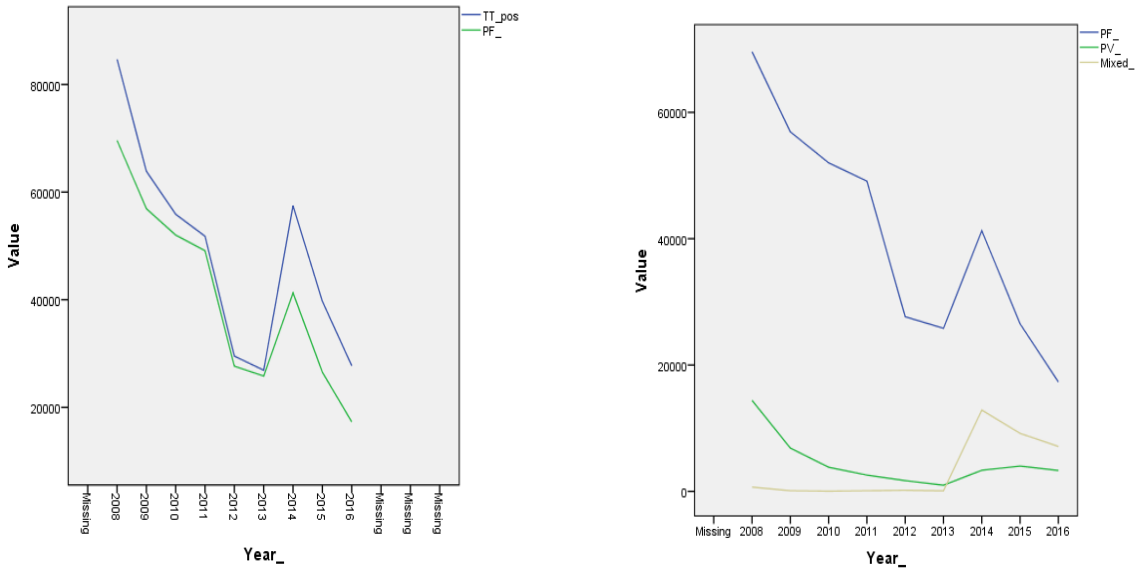

Fig 6 :Trend of malaria cases with Pf and trend of Pf Pv and mixed (2008-16)

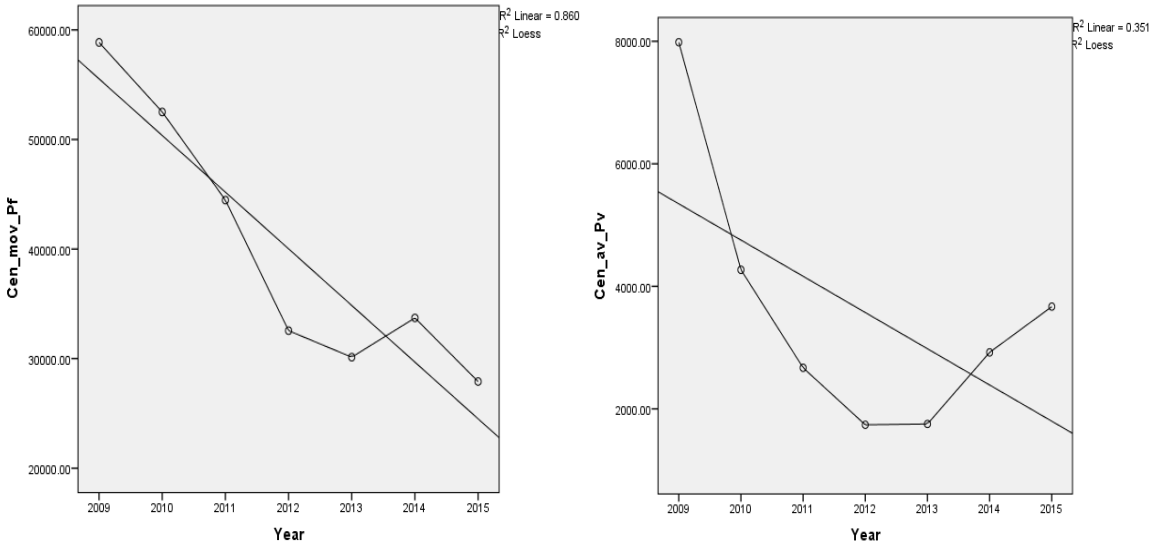

Fig 7 : Trend of *P. falciparum*and*P. Vivax*malariawith moving average

For the severe malaria, it is gradually decreased over the year[R ²=.779,*P*=.002, 95% CI =(-480.879- (-170.654)] which is 78% lower in 2016 in relation to 2008(Fig 8) (Fig 9).

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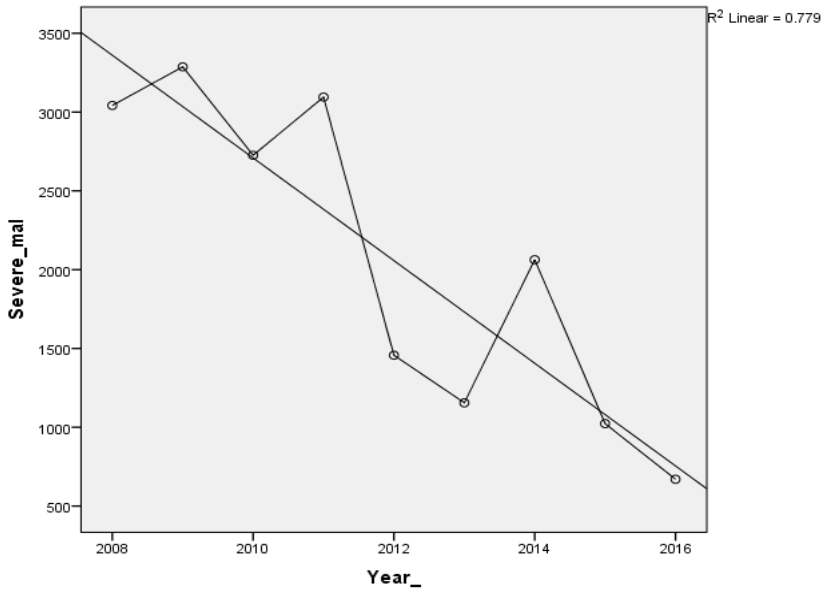

Fig 8 : Trend of severe malaria with moving average (2008-2016)

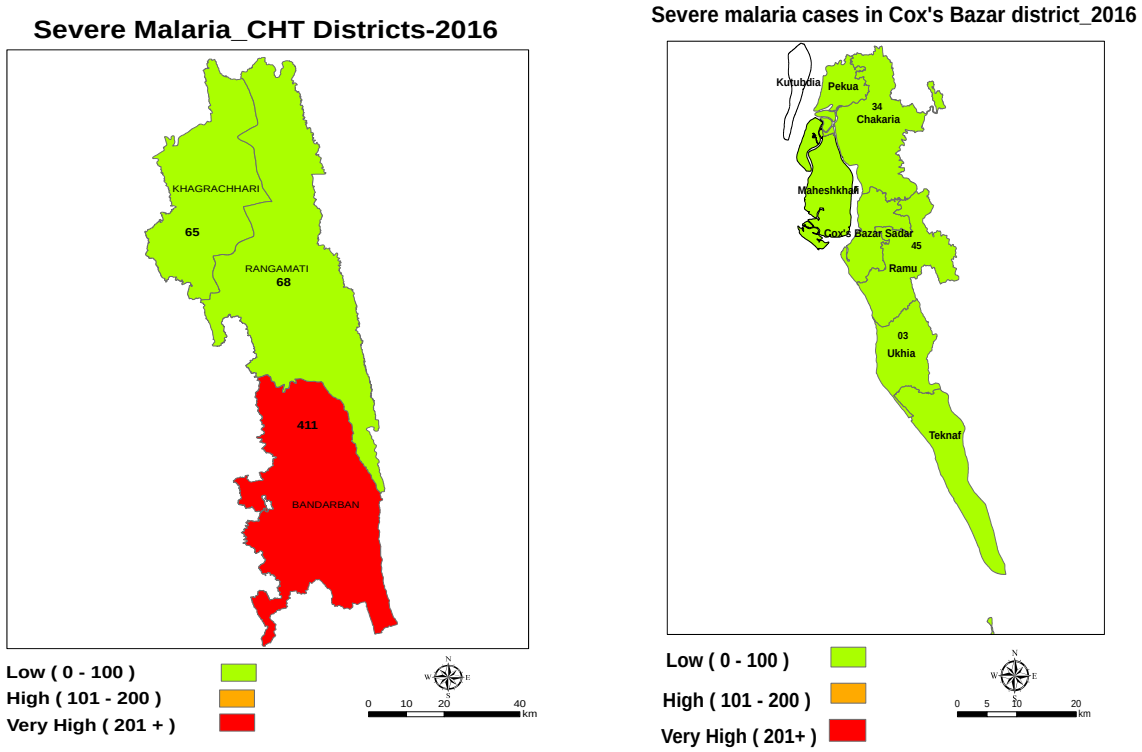

Fig 9: Severe malaria cases in CHT and Cox's bazar Districts in 2016

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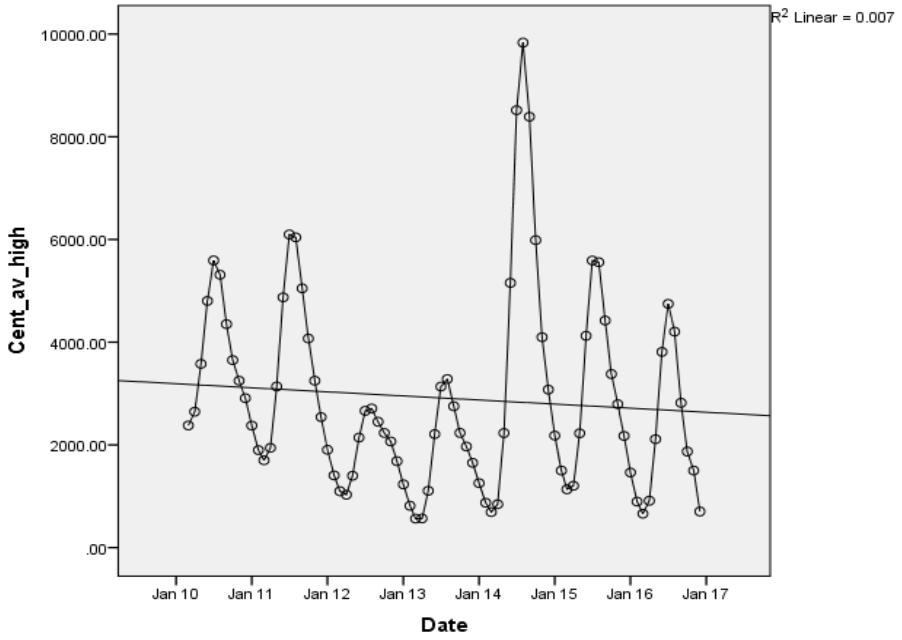
Malaria case fatality rate also fell by 38% from 1.8 per 1,000 casesin 2008 to 0.69 per 1000 cases in 2016, which reflecting a major improvements in access to early diagnosis and appropriate treatment in Bangladesh. However, there was steeprise in 2014 to 0.78 per 1000 cases from 0.56 per 1000 cases in 2013 for malaria upsurge in Bangladesh.

3.1 Malaria atdifferent region base

If we stratified the endemic area and strategically analysis through region base for the period 2010-2016, we found that there is more relative decline in malaria incidence [R^2=.826, *P*=.000, 95% CI=(-5.98-(-4.87)] in low endemic districts where it ismoderatelydecreased [R^2=.293, *P*=.000 ,95% CI=(-5.82-(-2.817)] in medium endemic district like Cox' Bazar, but the decreasing rate in CHT areas is not fairly straight line (Fig 10). For the low and medium endemic districts, malaria incidence had been decreased at similar fashion in first fiveyears(2008- 2013) but the latter part this decreasing is only continue in low endemic districts (Fig 10).That is, malaria still more prominent disease in CHT districts (API: 12.56) and lot of preventable measures in terms of both epidemiological and entomological activities is needed to mitigate it.



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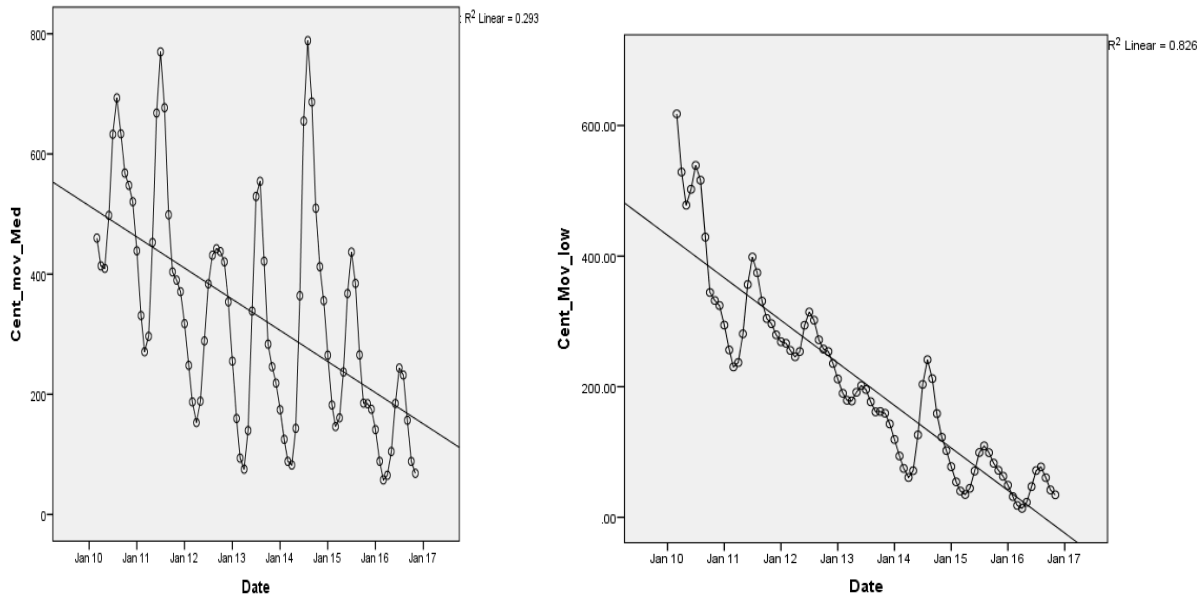

Fig 10: Malaria trend in CHT, Cox'BazarandMymenshing region with moving average

3.2 Spatial distribution at region base

The Fig 11-14 shows that malaria incidence at different geographical base –CHT (High), Sylhet, Mymenshing(Low endemic region)and Cox's Bazar(medium endemic)--has been decreasing and CHT is high prevalent area in Bangladesh.

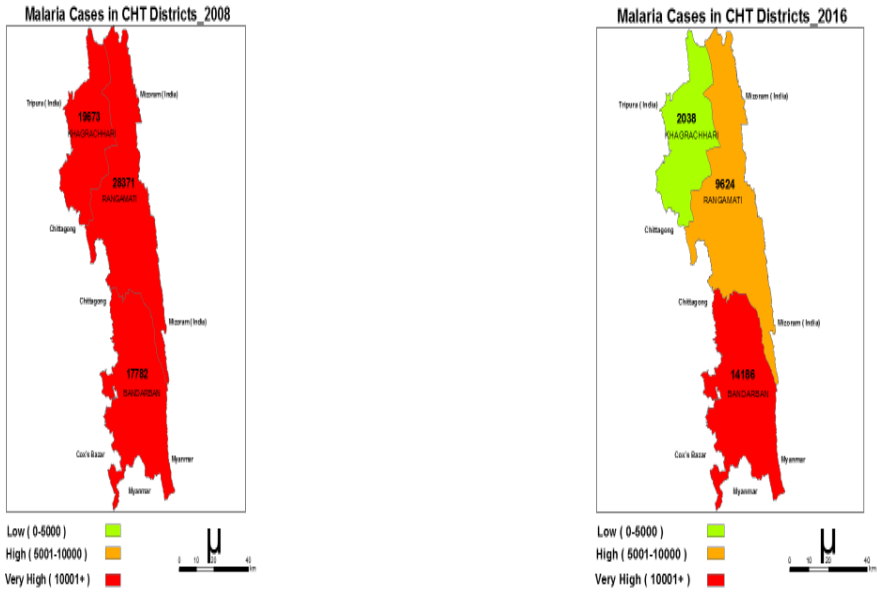

Fig 11: Malaria cases in CHT districts in 2008 and in 2016

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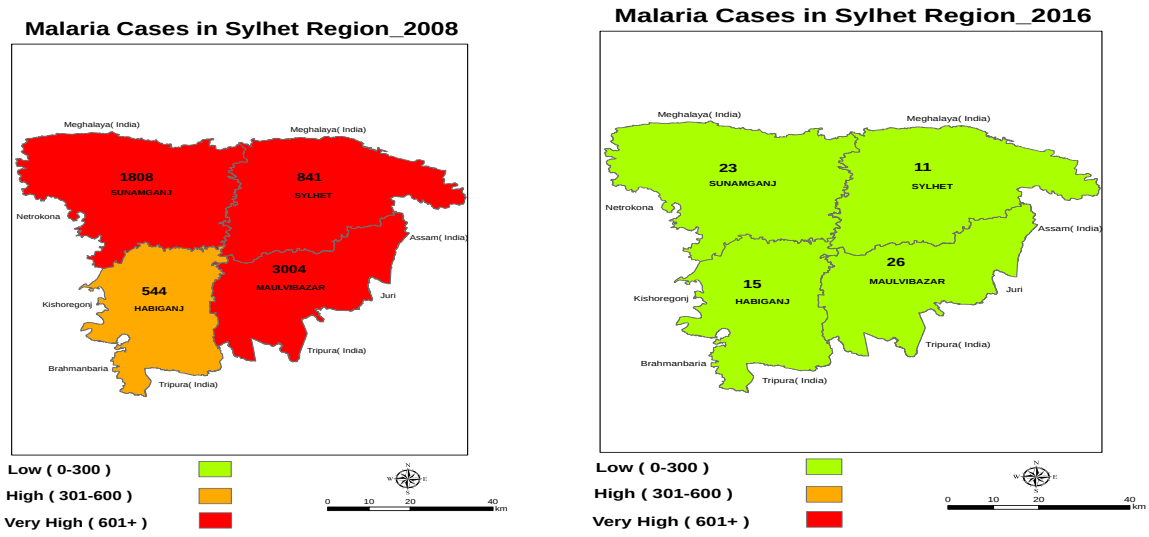

Fig 12: Malaria cases in Sylhetdivision in 2008 and in 2016

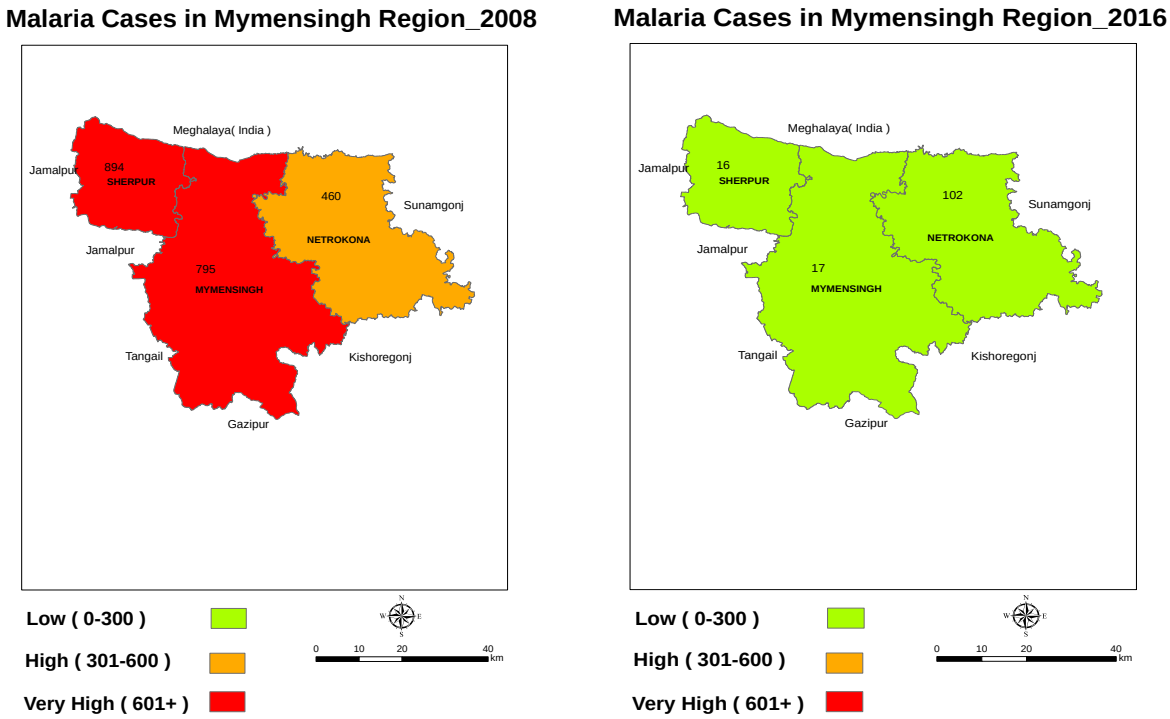

Fig 13: Malaria cases in MymenshingRegion in 2008 and in 2016

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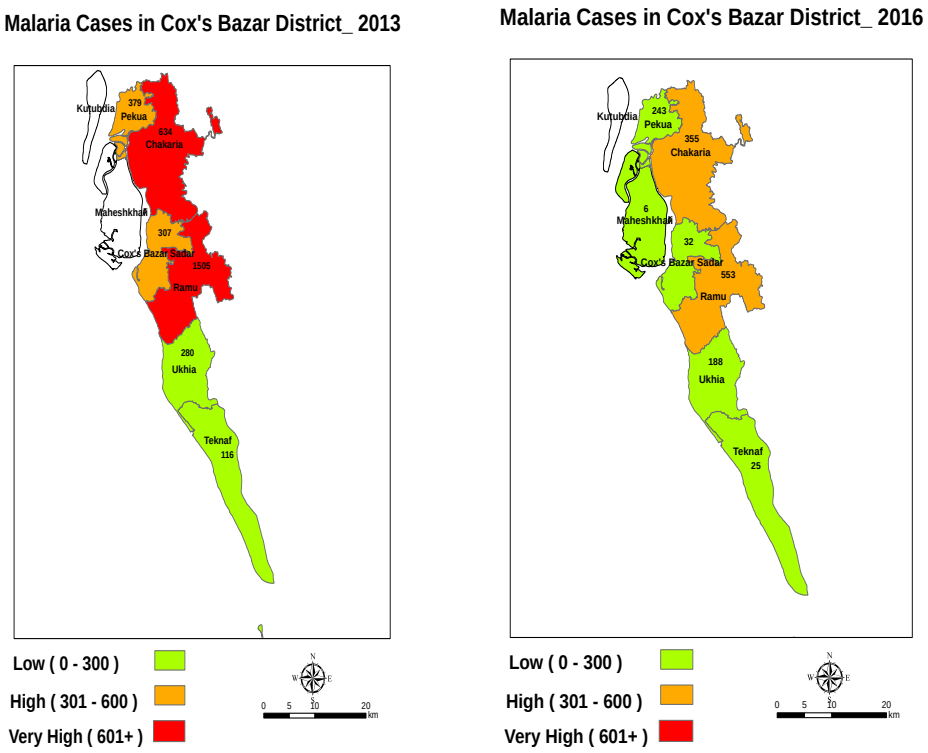

Fig 14: Malaria cases in Cox's Bazar district in 2013 and in 2016

3.4 Seasonal variability

A seasonal variability of malaria infection is observed in Bangladesh. The highest peak of this seasonal disease along the years was observed during June- July, showing almost 200% increase in the incidence as compared to the annual mean. The minimum malaria incidence was observed during February- March, which was 40% less than the mean annual incidence (Fig 15)

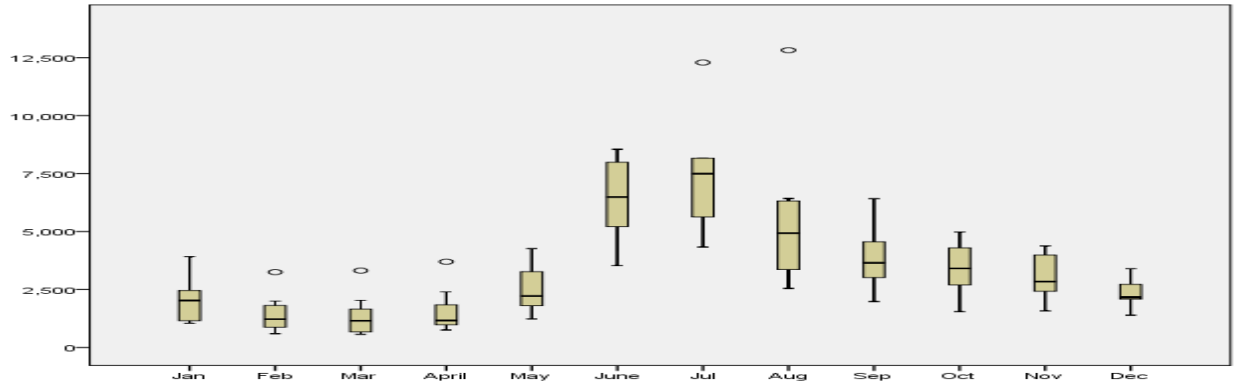

Fig 15 : Seasonal variability of malaria cases (2008-2016)

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4. Discussion

Malaria is a major public health problem in terms of morbidity and mortality in Bangladesh. Since 2008, burden of malaria cases has been dissipated over the years after availability of grant from the Global Fund. The result of our study revealed that during the last nine years, a fluctuating trend of malaria cases was observed in malaria endemic areas especially in high and medium endemic districts(Fig 10) with a minimum number of malaria cases reported in 2013indicating that these endemic districts bear 84% of total malaria cases and is full of dense and fringe hill and deep forest areas which may be influence in vector breeding during the rainy season in Bangladesh. However, there is steepincrease of malaria cases from 2013 to 2014 which is also visible in both CHT and Cox's Bazar districts. The primary cause of this outbreak is likely prolonged intermittent rainfall with insufficient heavy downpours to flush out vector-breeding sites in CHT and Cox'sBazar districts.Rainfall plays an important role in malaria epidemiology because water not only provides themedium for the aquatic stages of the mosquito's life but also increases the relative humidity and thereby the longevity of the adult mosquitoes [6]. The impact of rainfall on the transmission of malaria is very complicated, varying with the circumstances of a particular geographic region and depending on the local habits of mosquitoes. Rains may prove beneficial to mosquito breeding if it is moderate, but may destroy breeding sites and flush out the mosquitolarvae when it is excessive [6].This finding is consistent as we find that the same thing occurred in Mpumalanga Province, South Africa, in 2005-06 where a 30% more malaria cases were recorded than average malaria incidence [7,8]. This is also happened in Northern Indian States that close to Bangladesh where malaria cases were more than double than that of 2013 [5].

The study uncovered that burden of malaria is decreased with deceasing rate of *Plasmodium falciparum*(Fig 6) where *Plasmodium falciparum* and *Plasmodium vivax* occurring in the country

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about 84 % and 9% respectively with mixed cases 7% (Table 1) which is relatively higher from African Country like Ethiopia [8,9]. However, this is contrasting to the findings in Jimma town, South East Ethiopia, where *P. vivax* and *P. falciparum* accounted for (71.4%) and (26.4%) respectively with mixed infection accounted for (2.4%) [10]. This is because of nature study as this study was conducted in urban areas like small and medium sized town, Jimma town, in Ethiopia while in Bangladesh, malaria infection is mostly occurred in the close vicinity of the hard to reach areas and of fringe forest or deep forest areas under rural areas. As we got in the study that *Plasmodium vivax* is initially decline steadily but it is slightly increasing after 2014 which indicates a paradigm shift (Fig 7). This shift is similar to other study report in Ethiopia [8].This may be happened as *P. vivax* parasites can remain dormant in the liver for several months and even up to a year or more. When these dormant parasites reactivate they can cause relapses of febrile illness [11]. This relapse cases is also experiencing in Bangladesh especially in low endemic areas. A study in Papua New Guine found that relapses cause approximately four of every five *P*. *vivax* infection [12]. The more promising fact is severe malaria (Fig 8) is decreasing continuously along the regression line (R^2=.779) which is only appeared n CHT and Cox' Bazar areas (Fig 9). This reduction of malaria cases from 2008 coincides with the increased availability of the new effective drug regimen ACT for the treatment of *P. falciparum* malaria at national and sub-national levels. Other possible reasons for malaria reduction during this period (2008-2016) might be due to the increased LLIN distribution at community level with a view to 100% population coverage in line with 1.8 population @ LLIN in CHT and Cox's Bazar districts and hotspot based LLIN distribution in other low endemic areas. Though there is aggressive LLIN distribution in CHT and Cox's Bazar distribution, still malaria infection is highin CHT areas (API more than 10)which require a more comprehensive malaria strategy to neutralize malaria infection in CHT districts.

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According to the report, malaria is more prevalent among male (57.8%) than females (42.13%) (Fig 5) which is perceived to attributed to the fact that male members are more likely engaged in outdoor activities than females [13,14]. However, this scenario is not universal like in Chittagong Hill Tracts where both male and female tribal people are working together in agriculture product especially in *Jhum*cultivation [15],but it is not case for forest goers and bamboo cutters. As the population in CHT is quite low (11.7%) in respect to thirteen endemic districts, it does not influence in sex wise malaria distribution. Regarding the age groups, 15–44 years (57.8%)is highly affected age groups followed by 5–14 years old(28.6%) and then 1–4 years old (11.5%) who have less association in parasite infection(Fig 4). The findings is consistent with the studies in Ethiopia[8,13]. But a different scenario is recorded in Wolaita zone, Southern Ethiopia,with blood slide examination, the slide positivity is higher in 5-14 years group (40.60%) followed by 1-4 years (35.50%) and then 15 plus group (31.30%) while < I years is also critical (29.20%) [9].The pre dominance by the adult population could be normally related to the relative proportion of the adult population and the growing younger generation shift in Bangladesh .The current findings is an important implication that these age groups need due attention with regard to malaria intervention, particularly prevention and control measures taken by malaria programme in Bangladesh.

The low case infection in low endemic areas including Chittagong districts is the result of pre-elimination strategy taken by National Malaria Programme in 2012. The programmehas extended this strategy in North Eastern Sylhet division (Fig 12) which is also broughta fruitful result in Bangladesh. But Chittagong, though not experiencing with high burden of cases, always hit with some fatal cases till 2016 as there is ecological and epidemiological similarities with Cox's Bazar and CHT districts.That seems, Bangladesh need a community based surveillance network which will bring down malaria mortality at least at expected level towards malaria elimination in 2030.

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In this study, annual malaria occurrence was observed to have a seasonal variability with one peakseason June- July (Fig 15), where cases ismore than double than mean malaria infection. Subsequently, Feb- March is the lowest malaria infection period which is 40% less than mean malaria infection. The report is coincide with the study in India where malaria peakseasonwasobserved during June –September [16]andslightly varied from the pattern in Sudan, where malaria cases are higher during July – November, strongly influenced by average monthly rainfall in the rainy season [17]. Seasonal variation was also observed in Wolaita zone in Southern Ethiopia where two peak seasons occurred: the first one occurred between September to November and the second one ranges from April to June [9].

In this study, malaria occurrence might be under estimated as we use secondary data from NMEP and BRAC MIS unit but at least we believe a credible evidence we have got after series of trend analysis that would provide a future reference, and more detail entomological and epidemiological analysis would give a complete scenario that will enable country to boarding towards malaria elimination in 2030..

5. Conclusion

To conclude the study, we found, after scaling up and rolling out of various strategies along the nine years, malaria has been substantially decreased in thirteen endemic districts especially in medium and low endemic districts which indicate the effectiveness of this intensification of various strategies. Still we have a lot of concern regarding CHT districts where infection of malaria is a great agony of the living people especially in peak season, and the effectiveness of program in neighboring Indian States cannot be ruled out. However, management of *Plasmodium vivax* is also a matter of apprehension for National Malaria Elimination Programme. Therefore the strategy the countryhave taken need to be sustained and intensified in CHT districts to embarking the country towards malaria elimination in 2030.

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9. Ethical Approval

The data used in our analysis were center base -aggregate programmatic data of NMEP and BRAC. These were routinely collected data from 2008 to 2016 by MIS department. No intervention done under this study. Thus, the ethical consideration was deemed to be inapplicable to the quantitative data.

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