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Research Article

Meteorological Influence in Pattern of Malaria Cases in North-Eastern Tanzania: Five Years Analysis of Malaria Incidence and Climate Condition

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Abstract

Background: Climatic conditions have been suggested to influence malaria transmission in tropical regions. Understanding the extent to which climatic conditions correlates with malaria incidence in local communities is necessary to inform policies and interventions for prevention strategies.

Method: This was a cross sectional study, which included patients of all age group confirmed to be malaria positive in dispensaries, health centers and Hospitals. Information on climatic data recorded monthly were obtained from Tanzania meteorological department, Northern -eastern Tanzania. Spearman correlation coefficient was estimated as a measure of the correlation.

Results: Malaria in individuals with <5 years was significant higher in 2010 and 2014 (p=0.03). Malaria incidence in individuals with <5 years were positively correlated with mean minimum temperature at p=0.05, with relative humidity at 0600 GMT at p<0.01 and with relative humidity at 1200 GMT at p<0.01.

Conclusion: In Northern-eastern Tanzania, most of the climate factors are correlated with malaria incidence.

Background

Malaria stills a public health problem in tropical countries, in spite of recent gains in the fight against the disease. Malaria accounts for over 30% of disease burden in Tanzania, with over 95% of the 45 million people in the country are at risk of malaria infection [1]. It is known that malaria is declining in different parts of the world; this is including northern-eastern Tanzania. It is not known whether climate change has direct effect to decline of malaria or because of whether massive scale-up of insecticides treated nets, indoor residual spraying, community-based management of fevers, and environmental management of mosquito breeding sites all contributed to these results. However, in other parts of the world studies suggest that the incidence of malaria was already declining at the beginning before these interventions were introduced [2]. There is contradictory information concerning whether climate factors increases or decreases malaria incidences.

Meteorological factors are important drivers of malaria transmission and they have been associated with the dynamics of malaria vector population [3]. Studies in different parts of the world have associated malaria incidence and meteorological factors such as rainfall, temperature and humidity [4,5]. In Africa, rainfall, temperature [6,7] and humidity [8] have been explained to influence malaria. Despite consistently reported evidence that meteorological factors affect malaria transmission, conflicting findings about their importance. In a study conducted in South Africa it was found that malaria cases increase with increasing temperature, rainfall that led to emergence of a lot of new cases of malaria [9]. Although climatic condition influences malaria epidemiology [6-9], the relationship between climatic variability and malaria case intensity in Tanzania is poorly understood and scarcely documented. The transmission pattern of malaria with climatic variables is less studied and few studies have predicted climate variability with malaria epidemics or prevalence [10,11]. Therefore, this study assessed and compared trends of malaria for three sites which have different malaria transmission pattern [12-14]. The study included climatic variables (temperature, rainfall and humidity) to see whether these variables play a role in the pattern of malaria incidence in those sites.

Methods

Study area

This study was conducted in three districts (Hai, Moshi rural and Handeni) in northern Tanzania. Hai district is located in Kilimanjaro between 2°50' and 37°10' south of equator and between longitudes 30°30' and 37°10' east of Greenwich. Hai is experiencing low malaria transmission rates. Handeni is located in Tanga region and is experiencing high malaria transmission rates. Handeni lies between 40°55' and 60°04'S and between longitudes 37°07' and 38°46'E. Moshi rural is district located in Kilimanjaro region and is found between 37°15'-37°21' east longitude and 3°03'-3°20' south latitude. Moshi rural malaria transmission is moderate.

Study design and data collection

This was a cross sectional study, which included patients of all age group diagnosed to be malaria cases in dispensary, health centers and Hospital. Monthly Malaria cases were obtained from DMO office and Climate data was obtained from Meteorological office in Northern Tanzania.

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Table 1: Total malaria incidence in five-year trend in northern-eastern tanzania.

Variable	Year	Mean	Std. Deviation	95% CI		p-value
				Lower	Upper	
Malaria in <5 years	2010	237.6	343.5	121.4	353.9	
	2011	220.1	336.0	106.4	333.8	0.03
	2012	175.5	251.9	90.2	260.7	
	2013	195.9	302.2	93.6	298.1	
	2014	442.5	621.4	232.3	652.8	
Malaria in ≥ 5 years	2010	446.8	644.8	228.6	665.0	
	2011	322.5	464.4	165.4	479.7	0.1
	2012	312.0	463.2	155.2	468.7	
	2013	389.8	465.9	232.1	547.4	
	2014	666.6	980.9	334.7	998.6	
Total Malaria Cases	2010	684.5	972.2	355.5	1013.4	
	2011	542.7	782.6	277.9	807.5	
	2012	489.0	698.2	252.7	725.2	0.06
	2013	585.7	732.9	337.7	833.7	
	2014	1109.2	1544.1	586.8	1631.7	

Analysis was conducted by comparing Malaria means between years using ANOVA

Table 2: Malaria incidence in three sites.

		Mean	Std. Deviation	95% CI		p-value
				Lower	Upper	
Malaria in <5 years	Hai	38.3	45.3	26.6	50	<0.001
	Handeni	697.7	428.9	586.9	808.5	
	Moshi Rural	27	19.7	21.9	32.1	
	Total	254.3	400.3	195.4	313.2	
Malaria in ≥ 5 years	Hai	83.2	132.1	49	117.3	<0.001
	Handeni	1142.6	672	968.9	1316.2	
	Moshi Rural	56.9	55.8	42.5	71.4	
	Total	427.5	642.5	333	522.1	
Total Malaria Cases	Hai	122.4	174.3	77.3	167.4	<0.001
	Handeni	1840.3	1007.9	1579.9	2100.6	
	Moshi Rural	84	71	65.6	102.3	
	Total	682.2	1010.4	533.6	830.8	

Analysis was conducted by comparing Malaria means between districts using ANOVA

Epidemiological data: Epidemiological data of malarial cases in North-eastern Tanzania from the years 2010 to 2014 were obtained from the DMO (Handeni, Hai and Moshi rural districts). Information on malaria positivity, age and year was recorded. Malaria data was categorized as less than five years (<5 years) and five years and above (≥5 years).

Meteorological data: Climate data extraction form was used. Information on weather data recorded monthly wise on mean maximum temperature, mean minimum temperature (°C), total rainfall (mm) in the month and mean relative humidity (0600 GMT and 1200 GMT) was obtained from Tanzania meteorological department, Northern -eastern Tanzania. These meteorological details were used to understand the effect of climatic factors on malaria incidence.

Data Analysis

Data analysis was conducted using SPSS version 16.

Analysis of Variance (ANOVA)

Mean of malaria cases each month or / and year was calculated by using the ANOVA in order to determine the mean variation in each month or /and in each year.

Correlation/Association analysis

Pearson Correlation analysis was performed on the available data to check for statistical dependence of climatic factors to each other and also to monthly mean malaria incidences. Correlation coefficient (p) of less than 0.05 was considered significant.

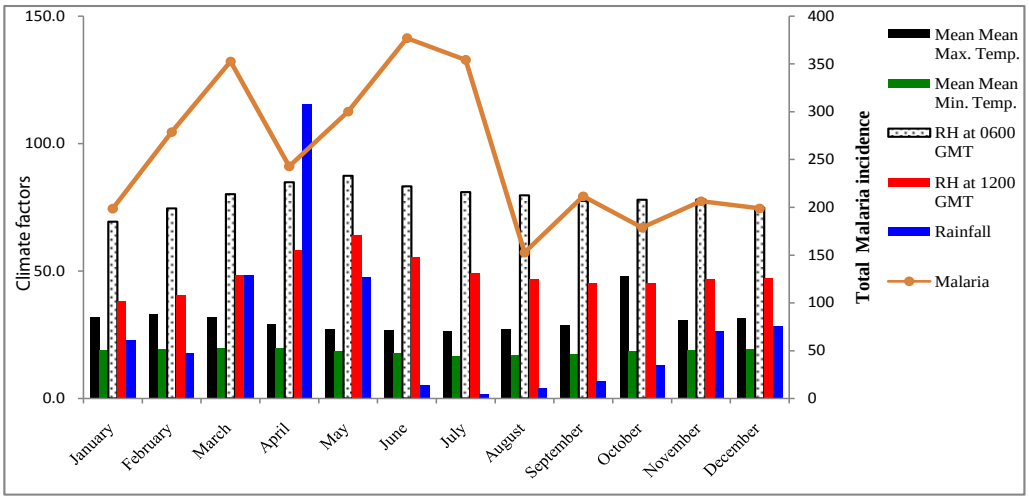

Figure 1: Average Climate factors and malaria incidence in under-fives in Northern-eastern Tanzania.

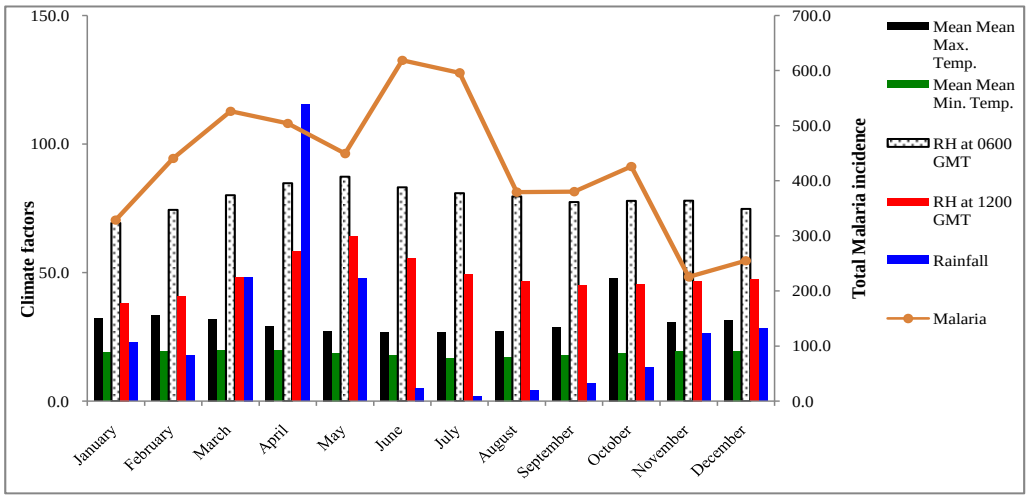

Figure 2: Average Climate factors and malaria incidence in individual with 5 years and above in Northern-eastern Tanzania.

Ethical consideration

KCMU College Research and Ethics Review Committee approved this study. Permission to gather climate data was sought from the head of department of meteorological office in northern zone. Also permission to access malaria data was sought from DMO in offices.

Results

Total malaria incidence in five years trend (2010-2014)

In the analysis of malaria incidence for five years in northern-eastern Tanzania, results shows that total malaria cases was higher in 2010 and declined in 2012, and raised again in 2014. Malaria in individuals with <5 years was significant higher in 2010, declined in 2012 and raised in 2014 ($p=0.03$), likewise in individual with ≥5 years, malaria was higher in 2010, declined in 2012 and raised in 2014, though this was not statistically significant (Table 1).

Malaria incidence in three sites

Results show that malaria incidences were significantly higher in Handeni district as compare to Hai and Moshi rural district ($p<0.001$) (Table 2).

Climate factors and Malaria incidence

Climate factors and malaria incidence was descriptively analyzed, and result shows that, in all age group malaria incidences were higher in June and July. Relative humidity at 0600GMT was comparable through the year in all five years. Relative humidity was slightly higher in March, April, May and June. Rainfall was higher in March, April, May, November and December. Mean minimum temperature was comparable throughout the years for all five years. Mean maximum temperature was higher in October (Figure 1 and 2).

Correlation analysis of malaria with climate factors

Data analysis was performed to study the correlation existing among climate variables and malaria incidence. Results show that most of the climate conditions were correlated to each other at $p<0.01$. Mean Maximum Temperature were positively correlated with Mean Minimum Temperature, and negatively correlated with

Table 3: Pearson Correlation Matrix (** p<0.01).

Climatic variable	Mean Maximum Temperature	Mean Minimum Temperature	RH at 0600 GMT	RH at 1200 GMT	Rainfall in mm
Mean Maximum Temperature	1	0.439**	-0.536**	-0.495**	0.093
Mean Minimum Temperature	0.439**	1	0.099	0.066	0.256**
RH at 0600 GMT	-0.536**	0.099	1	0.784**	0.097
RH at 1200 GMT	-0.495**	0.066	0.784**	1	0.063
Rainfall in mm	0.093	0.256**	0.097	0.063	1

**Correlation is significant at the 0.000 level (2-tailed)

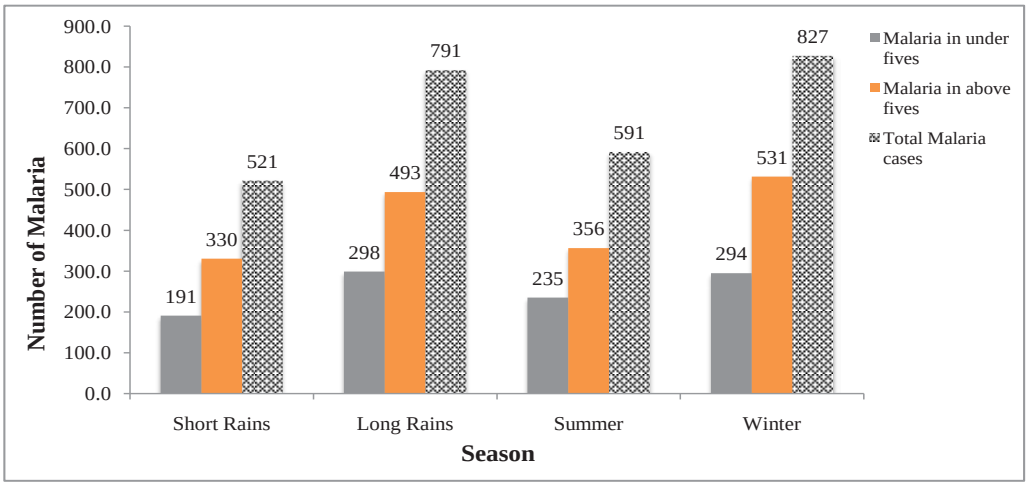

Figure 3: Season wise average malaria incidence for five years.

relative humidity at 0600 GMT and at 1200 GMT (p<0.01). Mean Minimum Temperature was positively correlated with rainfall (p<0.01). Relative humidity at 0600 GMT was positively correlated with relative humidity at 1200 GMT (p<0.01) (Table 3).

In a separate analysis of different climatic conditions with respect to total monthly malaria incidence, results show that malaria incidence in <5 years was negatively correlated with mean maximum temperature at p=0.03. Malaria incidence in <5 years were positively correlated with mean minimum temperature at p=0.05, with relative humidity at 0600 GMT at p<0.01 and with relative humidity at 1200 GMT at p<0.01. No correlation of malaria incidence in <5 years with rainfall. In analysis of climate factors with individual with ages of ≥ 5 years, results show that malaria incidence was negatively correlated with mean maximum temperature at p<0.01. Malaria incidence was positively correlated with relative humidity at 0600 GMT at p<0.01 and with relative humidity at 1200 GMT at p<0.01. No correlations of malaria incidence with rain fall and mean minimum temperature.

Season wise average malaria incidence for five years

Results show that malaria occurred at least in every month of the year; however the malaria incidences varied between months and also between seasons. In this study results show that average malaria incidence in <5 years was found to be 298 during long rains and 294 during winter season. For individuals with ≥ 5 years, higher average malaria incidence was 531 during winter and 493 during long rains season. Surprisingly winter season was found to be prone to malaria incidences (Figure 3).

Discussion

Malaria is still a major public health problem in Tanzania. Recently there is a report of malaria decline in northern Tanzania [15]. The observed change in epidemiology can be due to several factors, including improved to access of effective malaria treatment, increased access of insecticides treated nets and improved indoor residue spray. In the present study climate conditions and malaria incidence were studied, and correlation between these two variables has been observed.

In the present study, average monthly malaria incidence was calculated for every year, and results shows that malaria declined in 2012, which corresponds with other studies, which reported decline of malaria in the same year [15]. The observed decline of malaria incidence is in agreement with report from Health Management Information System, which reported decline of number of malaria cases in both under-fives and individuals with 5 years and above. Though this should be interpreted with constant because, our study only included three districts in Northern-eastern Tanzania. We reported significant higher malaria in Handeni district as compared to Hai and Moshi rural, this is true because these areas have different malaria endemicity. Handeni having high malaria transmission, while Moshi Rural having moderate malaria transmission and Hai is having low moderate transmission.

Mean maximum temperature were positively correlated with mean minimum temperature, this is in agreement with another study, which was conducted in China [16] and Ethiopia [17]. Like-wise,

mean minimum temperature was positively correlated with rainfall. Also relative humidity at 0600GMT and at 1200GMT was positively correlated to each other. Correlation of these climatic conditions with malaria incidence reveled that, in <5 years, malaria incidences were positively correlated with mean minimum temperature, relative humidity at 0600GMT and relative humidity at 1200GMT.

Surprisingly, no correlation of malaria incidence in under-fives with rainfall, this also has been reported by [18]. In individuals with ≥ 5 years, the study did not find correlation between malaria incidences with rainfall and mean minimum temperature the same phenomenon have been reported elsewhere [19]. Positive correlations have been observed between malaria in individuals with five years and above with relative humidity 1200GMT.This is in line with study by [16].

Malaria incidence in <5 years is fewer than ≥5 years in all season wise in 5 years. The incidence is too high in winter season compare to other seasons. The peak of malaria incidence occurs during the long rainfall and winter season, which harbors mosquitoes breeding sites that enhance malaria incidence to be higher in Northern-eastern Tanzania. In summer where there is a drier than normal from rainfall deficits malaria incidence drop down, and if long rains are normal and start in on time (March-May) the rangeland continue to facilitate mosquitoes breeding site that cause malaria infection due to the weather conditions. The Mosquitoes breeding sites are too low in dry season due to the low relative humidity in the weather whereby the vectors were flushed out in summer. The rate of deaths occurred after the long and short rainfall seasons.

Conclusion

In Northern-eastern Tanzania, most of the climate conditions are correlated with malaria incidence. The five-year trend indicates that malaria incidence was declined in 2012. Malaria incidence is significant higher in Handeni district for all five years.

Recommendations

Additional studies are needed in order to fully understand the effect of climate condition and its relationship to malaria epidemiology. Due to weather variations in different regions, it is sometimes hard to find consistent evidence that there is a relevant correlation between increased malaria and climate conditions and as well as climate changes. Therefore, countrywide studies will be of paramount in order to establish the correlation between climate conditions and malaria in all areas, which may have different climatic pattern.

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