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Malaria trend and effect of rainfall and temperature within Regions 7 and 8, Guyana

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Abstract
The objective of this research was to identify relationships between climatic conditions and malaria incidence within Regions 7 and 8. An association between malarial cases and climatic conditions were done by collecting data from Ministry of Health, Ministry of Agriculture and Malaria clinic & tropical disease laboratory during the period 2006-2013. Statistical analyses were done using ANOVA, T-tests, Chi Square tests and correlations. Mean rainfall (mm) and temperature recorded in region 7 were 73.4±9.0 mm (r=0.83; 95% CI 0.29-0.97) and 26.9±1.6 ^{O}C (r=0.21; 95% CI -0.58-0.80) respectively. Mean rainfall and temperature recorded in region 8 were 91.6±45.5 mm (r=(-0.71; 95% CI -0.9-0.0) and 23.9±2.0 ^{O}C (r=0.03; 95% CI -0.7-0.7) respectively. Mean ± SD for *Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae* and mixed infections in region 7 throughout the study period were 1230.75±712.2, 1222.3±637.3, 24.1±36.3, 112±116.4 respectively. The mean ± SD of *P. falciparum, P. vivax, P. malariae* and mixed infections in region 8 were 1029.6±383.1, 935.8±583.1, 22.4±27.5, 85.4±54.3 respectively. Ethnicity, age group and gender showed a significant increase in malarial cases (p≤005). Climate change showed an effect on malarial incidence along with other demographic conditions like gender, ethnicity and age group.

Keywords: Malaria, Rainfall, Temperature, Climate Change, Guyana

1. Introduction

Malaria, a vector transmitted disease, has long plagued many nations across the world. Even with many efforts for prevention of the disease, malaria continues to be a major cause of death among people living in the tropics. This disease is geographically specific, and is often found in the tropical part of the globe. In these countries ecological factors and climatic factors control the spread of the disease and also the life cycles of both vector and parasite [1]. According to the latest estimates from World Health Organization (WHO), there were 214 million new cases of malaria worldwide in 2015 (range 149–303 million) [2].

The plasmodium parasite development relies heavily on ambient temperature, whilst mosquito breeding depends on stagnant water accumulation around an area, usually due to precipitation [1]. Malaria is establishing a trend as it relates to climatic factors within an endemic environment which would lead to forecasting preventative measures for the community [3]. Vector availability, biting rates and parasite development are all influenced by climatic conditions, especially as it relates to the various Plasmodium species [4]. Factors such as temperature, humidity and rainfall directly impact the lifecycles of both vector and parasite; rainfall aids in accumulation of stagnant water, hence making the environment ideal for mosquito breeding sites, whereas, higher temperatures accelerate parasitic plasmodium growth within mosquitoes [5]. For a successful parasitic growth, the *Anopheles* mosquito must be able to survive a crucial 10 to 18 day period for the parasite development, at this point, temperatures usually above 20°C (68°F) is vital for the development of the parasite, specifically *Plasmodium falciparum* [6].

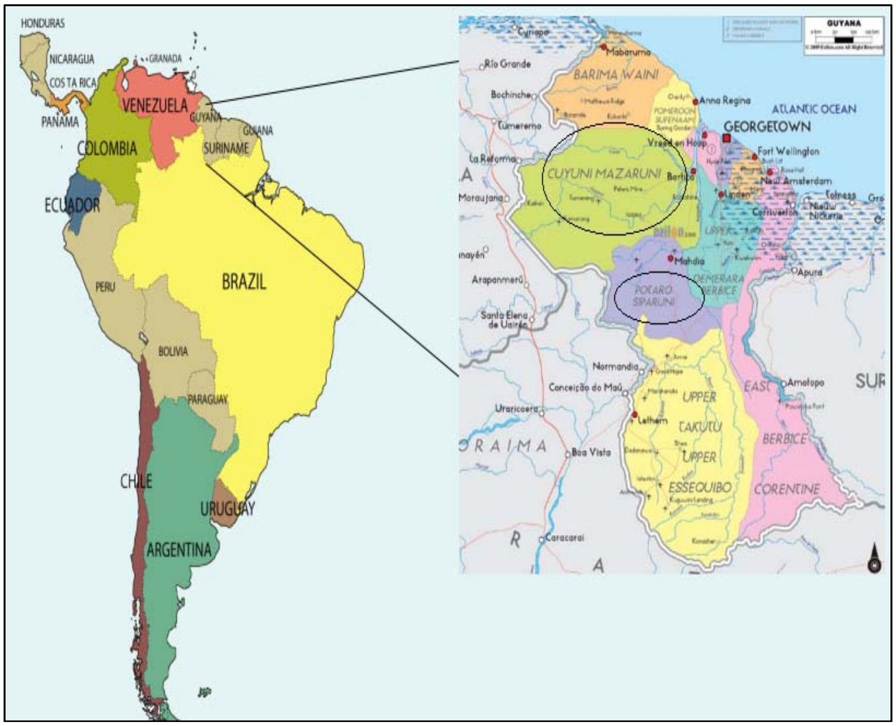
Malaria also creates a significant economic burden on families and the nation as a whole targeting the most vulnerable groups [7-8]. Climate change exacerbated makes the entire situation more challenging to control the transmission. Studies have shown a strong relationship between climate change and incidence of malaria especially in South America, Africa [3-6] and in other parts of the world [7-10]. Although there are studies showing effect of temperature on spread of malaria but the role of temperature, humidity and rainfall in malaria

transmission is very important as climate change has a significant role in vector transmission and distribution. In coming years climate change is widely expected to affect the global spread, intensity, and distribution of malaria.

This study therefore provides an insight between climate variables and malaria cases in two different regions in Guyana to better understand the effects of climate variability on malaria incidence and strategy a better control measure.

2. Materials and Methods

Guyana, being in the Neotropical Zone experiences its fair share of rainfall and temperature fluctuations over the years. In region 7 and 8, rainfall and temperature fluctuates at a somewhat similar level as they are both bordering regions, located in the North-Western district of Guyana, with Cuyuni-Mazaruni having an area of 47,213km^2 with coordinates 6.45^{0}N, 60.21^{0}W and Potaro-Siparuni having an area of 20,051km^2 with coordinates 4.76^{0}N, 59.26^{0}W.



Map of Guyana highlighting the study regions

Data for the study was collected from Ministry of Health on malaria incidence within regions 7 and 8 for the period 2006-2013. Hydrometric data on temperature and rainfall for region 7 and 8 were collected from Ministry of Agriculture. Plasmodium species infectivity cases along with age, sex and ethnicity of the infected cases were collected from malaria clinic and tropical diseases laboratory for the period 2006-2013. Statistical analysis was done in SPSS and JMP for ANOVA, T-tests, Chi Square tests and regression. Data was analyzed to establish trend between climatic factors and malaria incidence within region 7 and 8.

3. Results

Rainfall and temperature throughout the study period 2006-2013 showed a diverse correlation. Rainfall throughout the year in region 8 showed a strong negative correlation (r=-0.71; 95% CI -0.94- -0.1 and for rainfall a weak negative correlation (r=-0.02; 95% CI -0.69-0.72). However in region 7, the correlation throughout the study period for rainfall and temperature were r=0.83; 95% CI 0.29-0.97 and r=0.21; 95% CI -0.58-0.80). In Regions 8 when compared to region 7, readings were taken from a single weather station within the Kaieteur vicinity, from this data there were noticeable fluctuations in rainfall, however, temperatures reaches to 17^{o}C (Fig 1 & Fig 2).

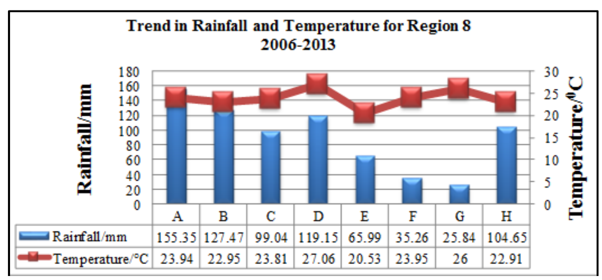


Fig 1: Trend in Rainfall and Temperature in Region 8 (A-H indicates for 2006-2013)

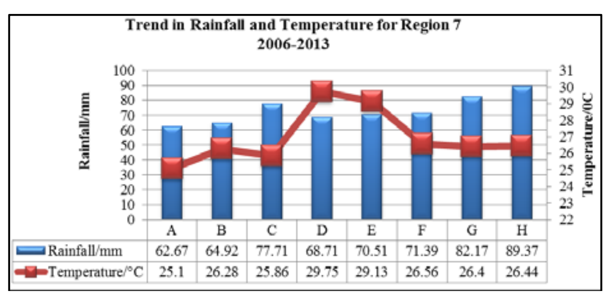


Fig 2: showing Trend in Rainfall and Temperature in Region 7 (A-H indicates for 2006-2013)

The data showed common prevalent *Plasmodium* infections within the regions, being *Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae* and mixed infections -combination of any two parasites. Figure 3 shows the prevalence of total malaria cases in both regions and prevalence of most predominant parasites within the regions. Most prevalent parasites were *P. falciparum* and *P. vivax* in both regions (45%-50%), with 1% - 4% of cases being caused by *P. malariae* and mixed infections respectively (Fig 4).

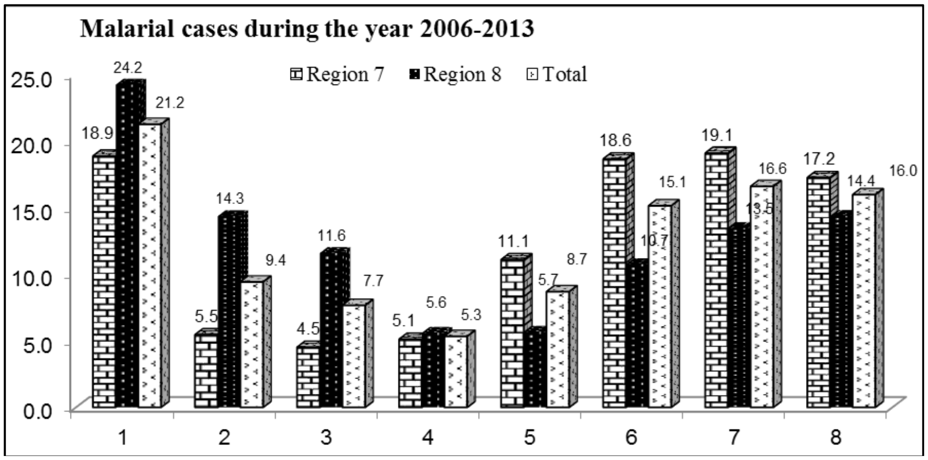


Fig 3: Comparison of total malarial cases in region 7 and region 8.

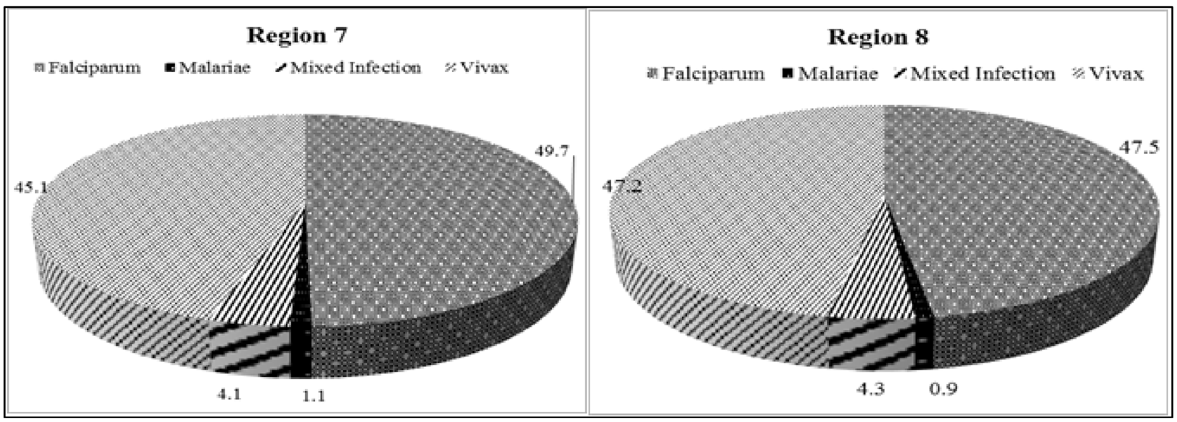


Fig 4: Percentage of individual parasite species in region 7 and region 8.

Total malaria cases in Region 7 during the study period were recorded to be 16,586 with *P. falciparum* and *P. vivax* being responsible for 15, 724 of those cases. Correlation of *P. falciparum, P. vivax, P. malariae* and mixed infection during the study period were r=-0.18; 95% CI -0.78-0.60, r=-0.53; 95% CI -0.90-0.28, r=-0.87; 95% CI -0.98—0.41 & r=0.61; 95% CI -0.17-0.92 respectively. In Region 8, the number of malaria cases over the years were 20, 714, with *P. falciparum* and *P. vivax* being responsible for 19,624 cases. Correlation of parasite during the study period were r=0.41; 95% CI -0.42-0.86, r=0.45; 95% CI -0.37-0.88, r=-0.78; 95% CI -0.96--0.17 & r=0.77; 95% CI 0.14-0.96 for *P. falciparum, P. vivax, P. malariae* and mixed infections respectively. Mean rainfall and temperature during the study period is shown (Table 1 & 2).

Table 1: Comparison of Malaria Incidence and Weather Parameters in Region 7 (2006-2013)

Year	Falciparum	Vivax	Total	Average Temperature (°C)	Average Rainfall (mm)
2006	1,723	2,134	3,857	25.81 ± 1.64	62.67 ± 17.45
2007	1,003	1,303	2,306	26.28 ± 2.18	64.92 ± 45.41
2008	984	838	1822	25.86 ± 2.53	77.71 ± 39.41
2009	550	330	880	29.75 ± 0.89	68.71 ± 37.80
2010	568	339	907	29.13 ± 0.31	70.51 ± 15.88
2011	926	681	1607	26.56 ± 1.89	71.39 ± 18.08
2012	1,234	852	2,086	26.40 ± 2.38	82.17 ± 13.24
2013	1,249	1,010	2,259	26.44 ± 2.29	89.37 ± 13.94
Mean ±SD	1,030 ± 383.09	936 ± 583.18	1,966 ± 944.32	27.02± 1.52	73.43±9.03

Table 2: Comparison of Malaria Incidence and Weather Parameters in Region 8 (2006-2013)

Year	Falciparum	Vivax	Total	Average Temperature (°C)	Average Rainfall (mm)
2006	1,856	1,909	3,765	23.94 ± 2.44	155.35 ± 51.90
2007	555	525	1080	22.95 ± 2.50	127.47 ± 56.99
2008	457	451	908	23.81 ± 0.96	99.04 ± 54.30
2009	483	528	1011	27.06 ± 1.88	119.15 ± 46.05
2010	923	1,277	2200	20.53 ± 0.55	65.99 ± 56.35
2011	2,065	1,512	3,577	23.95 ± 2.39	35.26 ± 23.60
2012	2,076	1,586	3,662	26.00 ± 3.36	25.84 ± 17.60
2013	1,431	1,990	3,421	22.91 ± 1.90	104.65 ± 36.52
Mean ±SD	1,231± 712.20	1,222± 637.327	2,453± 1298.29	23.89 ± 1.98	91. 59 ± 45.49

Correlation between the parasite species with rainfall and temperature showed significant findings in both regions. Mean (±SD) rainfall in region 7 was recorded as 73.4±9.0. Region 7 recorded a weak positive correlation between rainfall and *P. falciparum* (r=0.07; 95% CI -0.67-0.74) and strong negative correlation between temperature and *P. falciparum* (r=-0.86; 95% CI -0.97- -0.40); indicating an increase in *P. falciparum* cases with an increase in rainfall and with increase in temperature there was a decrease in *P. falciparum* cases. However in region 8 a moderate negative correlation was recorded between with *P. falciparum* and rainfall (r=-0.5; 95% CI -0.9-0.4)) and a weak positive correlation with temperature and *P. falciparum* (r= 0.1; 95% CI -0.65-0.75); this can be interpreted as with the increase in rainfall there was actually an increase in *P. falciparum* cases but with an increase in temperature there was a similar decrease in *P. falciparum* cases. Similar was the case in region 8 with all other malarial cases (Fig 5, Fig 6 & Fig 7).

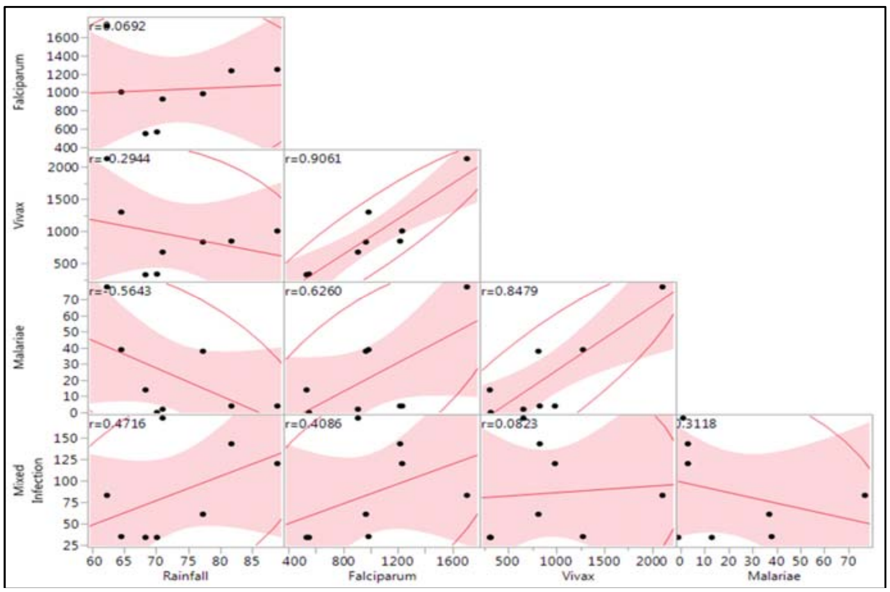


Fig 5: Graph showing correlation between rainfall and plasmodium species in region 7

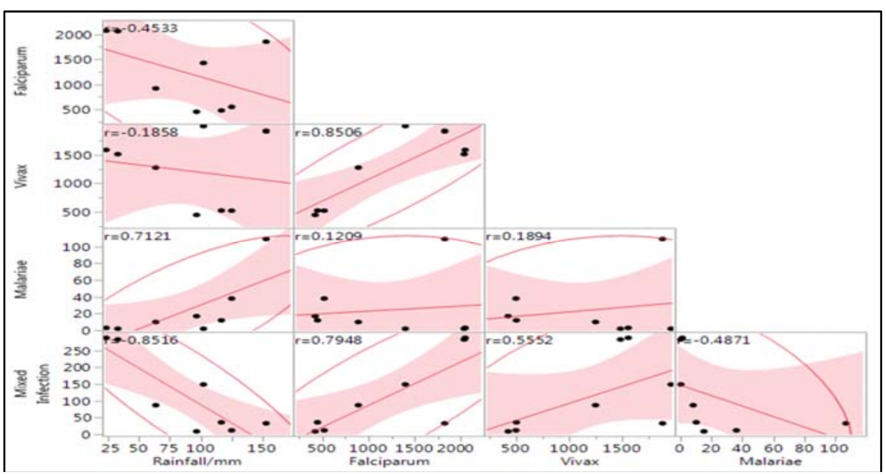


Fig 6: Graph showing correlation between rainfall and plasmodium species in region 8

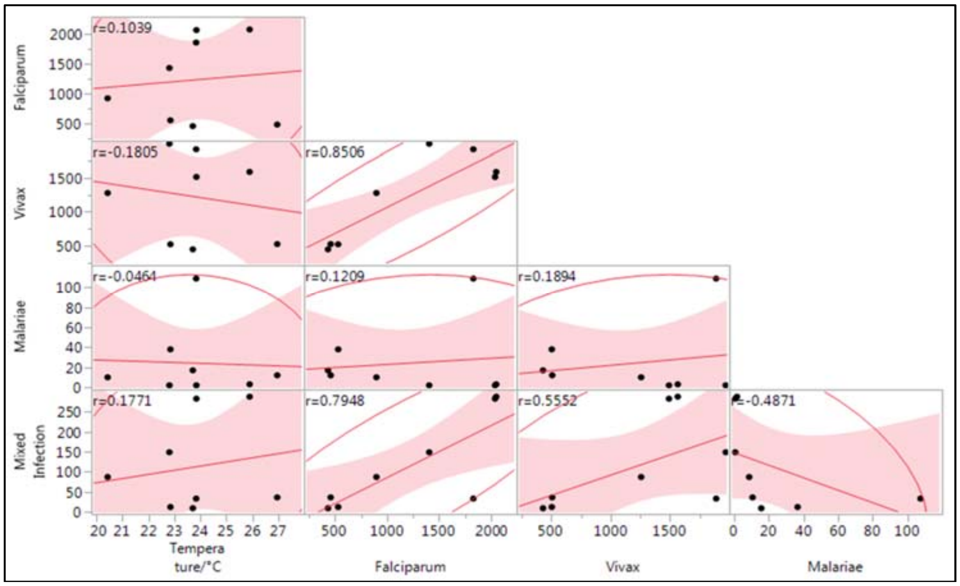


Fig 7: Graph showing correlation between rainfall and plasmodium species in region 8

3.1 Demographic trend among malaria cases

In Region 7 and in Region 8 majority of the cases were caused by *P. falciparum* and *P. vivax* ($p \geq 0.05$). Region 7 recorded 16,586 cases of *P. falciparum* and 15, 724 cases of *P. vivax*. On the other hand, Region 8 had 20,714 cases of *P. falciparum* and 19,624 cases of *P. vivax*. No significant rates of infections were recorded over the years for both *P. falciparum* and *P. vivax*, however there was a significant difference in the rates of infections amongst age groups ($p \leq 0.05$). In both regions majority of infections occurred in patients that were between 15-49 age groups (Fig 8). Ethnicity was also another factor which recorded a significant difference in infection rates for both *P. falciparum* and *P. vivax* ($p \leq 0.05$) (Fig 9). Both regions recorded Amerindian decent with most cases of malaria followed by the mixed and Afro Guyanese groups. Among gender in both regions, women were more infected than men significantly ($p \leq 0.05$) (Fig 10).

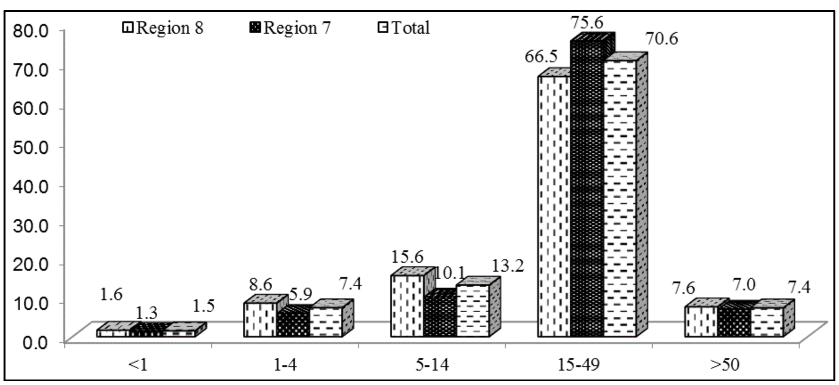


Fig 8: Percentage of malarial cases among different age groups

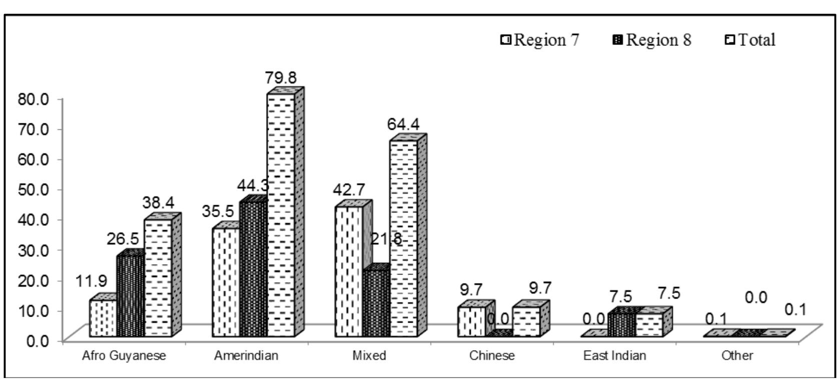


Fig 9: Prevalence of malarial parasite among different ethnic groups

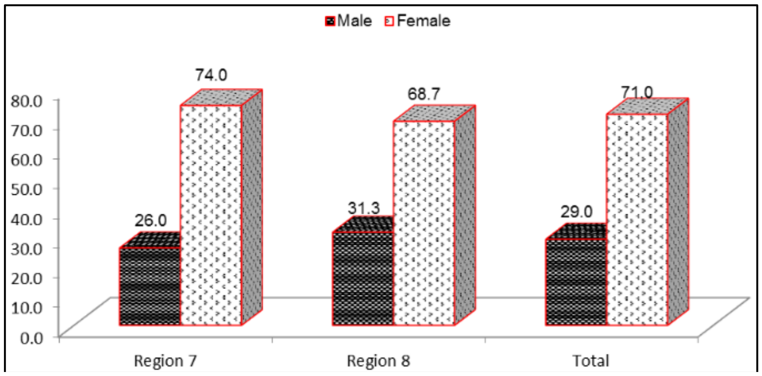


Fig 10: Prevalence of malarial cases distributed among male and female populations

4. Discussion

Climate change is expected to increase vector borne diseases globally. With climatic warming and seasonal changes there will be a critical effect on malaria rates. However, every organism has a specific range of temperature and other environmental factors in which they can thrive successfully and *Plasmodium* is no different. Ambient temperatures are required for parasite growth within the *Anopheles* mosquito; optimum temperatures for mosquitoes are between 25ºC and 30ºC, hence their abundance in the Tropical and Neotropical zones. Temperature affects the extrinsic or sporogonic stages of the parasite within the mosquito, hence temperature can affect transmission rates of malaria [17].

During 2006 -2007, malaria cases for both parasitic types were high (3,857) with a significant drop in cases in 2007 (2,306), with an increase in rainfall and temperature. During 2008-2011 there was a decrease in cases of malaria followed by an increase in malaria cases from 2011. In the "*Annoted Checklist of the Anopheles of Guyana, South America*" by Rambajan, it was confirmed that there are twenty two (22) species of *Anopheles* in Guyana. In the Cuyuni-Mazaruni (Region 7) and Potaro Siparuni (Region 8), there were five (5) species of *Anopheles* found, namely, *A. neivai*, *A. triannulatus*, *A. darlingi*, *A. oswaldi* and *A. aquasalis*. A special interest was placed in *A. darlingi* as Rambajan labeled this species the most important in Guyana as it not only carries *Wucheria bancrofti*, which causes filariasis but is almost always found in areas where indigenous malaria occurs. In 1951, this species was eradicated along the coast of Guyana, hence, the coast being hardly affected by malaria unless there is transmission through travelling to endemic regions and also since *A. aquasalis* (the only species of *Anopheles* that can tolerate saline conditions) thrives within these regions, but has not been deemed an important malaria vector [18].

Anopheles darlingi is very important in transmission of malaria within the Amazon region. *A. darlingi* breed easily and more prone to carry malarial parasites in endemic areas [19]. Since Regions 7 and 8 are heavily forested and have many black water rivers, creates suitable breeding sites for *A. darlingi*. Even though the statistical evidence varied between the regions, with some parasitic infections being correlated directly to rainfall and temperature e.g. *P. falciparum* cases in Region 7 increased with rainfall and decreased with temperature; it could be because rainfall and temperature act as catalysts for infections and cannot be solely responsible for malaria infections.

There are other contributing factors such as drug resistance and also environmental factors which are major issues in malaria transmission along with prevention factors such as the use of impregnated bed nets (to prevent mosquito biting and also to isolate malaria patients), fogging and of course education and awareness of the disease.

In a 2013 study, conducted by the World Health Organization, a conclusion of suspected artemisinin resistance was drawn as it relates to regions within Guyana and Suriname; this factor is also amplified when malaria patients do not complete their recommended dosages [20]. The environmental factor is also another contributing factor; after rainfall once there is water accumulation in buckets, old tires, or containers, there is a likelihood of creating suitable breeding sights for mosquitoes. Weeds, overgrown grasses and bushes can also contribute to breeding sites hence increasing malaria possibilities. Malarial drug resistance is a major issue in Guyana [21-22].

Globally, children are mostly affected by malaria especially in endemic regions of Africa, where in poverty stricken areas impregnated bed nets are not provided nor can lifesaving treatment be afforded or even accessed; millions of children succumb to this disease globally. This disease also causes severe infections in pregnant women resulting in anemia leading to increased rates of infant mortality [23]. With focus on the most affected age group being 15-49, it is evident that this age group consists of persons that are more active within the regions as it relates to school, travelling from various villages and the working class of people especially in the mining camps, which increases the transmission of the disease as these persons are not only more exposed to the environment but also to other persons that may be carrying different stages of malaria. Amerindians are mostly infected since they populate the highland regions of Guyana, in Region 7 there are many Akawaio and Arecuna settlements and in Region 8, Akawaio and Patamona tribes.

5. Conclusion

These weather parameters combined with environmental factors, drug resistance, preventative factors and even geographical locations, create opportune environments for mosquito breeding, parasite development and infection rates, thus, increasing the likelihood of contracting malaria. Age, Gender and Ethnicity can also be deemed significant factors in parasite infection within populations of both Regions 7 and 8, however, like weather parameters, they are not sole factors responsible for infection.

6. References

1. Gallup JL, Sachs JD. The Economic Burden of Malaria. Am J Trop Med Hyg. 2001; 64:85-96.
2. WHO. 2016. http://www.who.int/malaria/media/world-malaria-report-2015/en/
3. Abeku AT, Hay SI, Ochola S, Langi P, Beard B, De Vlas SJ *et al*. Malaria Epidemic Early Warning and Detection in African Highlands. Trends Parasitol. 2004; 20:400-405.
4. Wardrop N, Barnett A, Atkinson J, Clements A. *Plasmodium vivax* Malaria Incidence over Time and its Association with Temperature and Rainfall in Four Counties of Yunnan Province, China. Malar J. 2013; 12:452.
5. Centers for Disease Control and Prevention. 2012. Global Health- Division of Parasitic Diseases and Malaria- Malaria Parasite. http://www.cdc.gov/malaria/about/biology/parasites.html
6. Centers for Disease Control and Prevention 2012. Global Health- Division of Parasitic Diseases and Malaria - The History of Malaria, an Ancient Disease. http://www.cdc.gov/malaria/about/history/
7. WHO. WHO Global Malaria Programme, World Malaria Report. WHO Press, World Health Organization, Geneva, 2013.
8. Sachs J, Malaney P. The Economic and Social Burden of Malaria. Nature, 2012; 415:680-685. http://dx.doi.org/10.1038/415680a
9. Van Lieshout M, Kovats RS, Livermore MTJ, Martens P. Climate Change and Malaria: Analysis of the SRES Climate and Socioeconomic Scenarios. Glob Environ Chang. 2004; 14:87-99. http://dx.doi.org/10.1016/j.gloenvcha.2003.10.009
10. Tanser FC, Sharp BL, Le Sueur D. Potential Effect of Climate Change on Malaria Transmission in Africa. The Lancet. 2003; 362:1792-1798. http://dx.doi.org/10.1016/S0140-6736 (03)14898-2
11. Thomas CJ, Davies G, Dunn CE. Mixed Picture for Changes in Stable Malaria Distribution with Future Climate in Africa. Trends Parasitol. 2004; 20:216-220. http://dx.doi.org/10.1016/j.pt.2004.03.001
12. Ebi KL, Hartman J, Chan N, McConnell KJ, Schlesinger M, Weyant J. Climate Suitability for Stable Malaria Transmission in Zimbabwe under Different Climate Change Scenarios. Clim Change. 2005; 73:375-393. http://dx.doi.org/10.1007/s10584-005-6875-2
13. Bhattarai A, Abdullah S, Kachur P, Martensson A, Abbas A, Khatib R *et al*. Impact of Artemisinin-Based Combination Therapy and Insecticide-Treated Nets on Malaria Burden in Zanzibar. PLoS Med. 2007; 4:e309. http://dx.doi.org/10.1371/journal.pmed.0040309
14. Teklehaimanot HD, Schwatrz J, Teklehaimanot A, Lipsitch M. Alert Threshold Algorithms and Malaria Epidemic Detection. Emerg Infect Diseases. 2004; 10:1220-1226. http://dx.doi.org/10.3201/eid1007.030722
15. Gupta R. Correlation of Rainfall with Upsurge of Malaria in Rajasthan. J Assoc Physicians India. 1996; 44:385-389.
16. Bouma MJ, Dye C, van der Kaay HJ. Falciparum Malaria and Climate Change in the Northwest Frontier Province of Pakistan. Am J Trop Med Hyg. 1996; 55:131-137.
17. Centers for Disease Control and Prevention. 2012. Global Health- Division of Parasitic Diseases and Malaria- Anopheles Mosquitoes. http://www.cdc.gov/malaria/about/biology/mosquitoes/index.html
18. Rambajan I. Annoted Checklist of the Anopheles of Guyana, South America. Mosquito Systematics. 1987; 1:146-150. http://www.mosquitocatalog.org/files/pdfs/MS19N02P146.pdf
19. Hiwat H, Bretas G. Ecology of *Anopheles darlingi* Root with respect to vector importance: a review. Parasit Vectors. 2011; 4:177. http://www.parasitesandvectors.com/content/4/1/177
20. World Health Organization. Global Malaria Report: Artemisinin-based combination therapy (ACT) efficacy in Guyana and Suriname, 2013. http://www.who.int/malaria/mpac/drug_resistance_guyana_suriname_presentation.pdf
21. Musoke B, Musoke D, Nsubuga W. Factors associated with prevention of malaria and other diseases transmitted by mosquitoes at household level in Wakiso district, Uganda. J Environ Health Res. 2013; 13:59-67. http://www.cieh.org/assets/0/72/948/129834/b5d91d2c-d2c1-48c1-bd27-cc750f04860c.pdf
22. Kurup R, Kumar H. Self-treatment of Malaria and its management in communities of Guyana. Nat Sci. 2014; 12(1):87-92. (ISSN: 1545-0740). http://www.sciencepub.net/nature. 13
23. United Nations Children's Fund. Malaria, 2013. http://www.unicef.org/health/index_malaria.html