

Socio-Ecologic Factors Responsible for Increased Malaria Vulnerability in Six Most Affected Counties in Kenya

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Abstract: This paper intends to understand the socio-ecologic factors responsible for increased vulnerability to malaria in six counties of Kenya. Available official information indicates that over the years the six counties of Busia, Siaya, Tharaka Nithi, Homa Bay, Kisumu and Migori had the highest number of malaria cases – double the national average. It is therefore necessary to have a quick collection of preliminary information to understand this occurrence. Using desk top research, this paper assembles information that may shed light on this phenomenon.

Keywords: Counties; Kenya; Malaria; Responsible; Socio-ecologic factors; Vulnerability.

I. INTRODUCTION

Malaria is caused by five parasites – *Plasmodium falciparum*, *Plasmodium knowlesi*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium vivax*. The most dangerous of these parasites is *Plasmodium falciparum*. All the human malaria parasites are spread by the female *anopheles* mosquito through its bites. Therefore, malaria is a vector-borne disease. Globally, between 124 and 283 million people are affected by malaria each year mainly in Africa, Asia and South America (International Association of Medical Assistance to Travellers, 2015).

Recent complete, reliable and available data on malaria cases in Kenya indicate that there were approximately 9.3 million malaria cases in Kenya for the year 2012. Table 1 indicates that out of all counties in Kenya, Busia, Siaya, Tharaka Nithi, Homa Bay, Kisumu and Migori had the highest number of malaria cases – double the national average (Government of Kenya: Ministry of Health, 2015). This paper seeks to understand the social and ecological factors that may be making the six counties more susceptible to malaria transmission in comparison to the rest of the counties in Kenya.

II. ECOLOGICAL FACTORS

A closer look at the six counties reveals that other than Tharaka Nithi all the others (Busia, Siaya, Homa Bay, Kisumu and Migori) are located in the Lake Victoria basin. Indeed the five counties have Lake Victoria as one of their boundaries (Soft Kenya, 2012). Thus, the five counties are both in the basin as well as are part of the wetlands of Lake Victoria.

The geography of the basin may be a factor contributing to the high incidence of malaria cases in the counties. In total it covers an area of 194,200km² of which 22% (i.e. 42,724km²) is in Kenya. The drainage pattern of the basin comprises of rivers, stream and wetlands. In Kenya the main rivers and streams draining into the lake are Nzoia, Sio, Mara, Yala, Awach, Gucha, Migori and Sondu. The major wetlands include the Yala swamp (17,500 ha), Nyando swamp (which is 15 km long and 6 km wide), Sondu-Miriu wetland (10,000 ha), Saiwa swamp (20km long) and Kimandi River wetland (4,800ha) (East African Community, Lake Victoria Basin Commission, YNI; Okeyo-Owuor et.al 2012). The climate is

classified as equatorial hot and humid with a bi-annual rainfall pattern of long rains occurring between March and May and the short rains falling between October and December. The coolest month is July and the warmest month fluctuates between October and February. Annual rainfall amounts ranges between 1300 to 2400mm while temperature ranges between 14^o and 29^oC. It should also be noted that there has been an increase of 1^oC in the region since the beginning of data collection on temperature in 1950 (East African Community *op. cit.*). Soil type in the basin is mainly dark-coloured clays which expand and contract depending on their moisture contents.

Table 1: Ranked county malaria cases per 100,000 persons for the year 2012

Rank	County	Cases	Rank	County	Cases	Rank	County	Cases	Rank	County	Cases
1	Busia	77,510	13	Kitui	30,126	25	Kajiado	20,442	37	Laikipia	12,164
2	Siaya	57,462	14	Isiolo	29,850	26	Kilifi	20,297	38	Marsabit	8,952
3	Tharaka Nithi	52,833	15	Kericho	29,122	27	Bomet	19,962	39	Kirinyaga	6,723
4	Homa Bay	44,668	16	Baringo	28,051	28	Turkana	18,923	40	Nyandarua	5,281
5	Kisumu	41,752	17	Elgeyo-Marakwet	25,528	29	Samburu	18,461	41	Wajir	5,125
6	Migori	40,440	18	West Pokot	24,880	30	Trans-Nzoia	18,053	41	Garissa	4,769
7	Kakamega	37,295	19	Bungoma	24,506	31	Nyamira	17,722	43	Nairobi	4,601
8	Vihiga	36,704	20	Lamu	24,403	32	Taita Taveta	17,098	44	Kiambu	4,457
9	Embu	34,122	21	Kisii	23,205	33	Mombasa	16,609	45	Muranga	2,824
10	Meru	32,549	22	Uasin Gishu	23,028	34	Machakos	16,459	46	Mandera	2,495
11	Nandi	31,012	23	Makueni	22,042	35	Tana River	15,243	47	Nyeri	543
12	Kwale	30,166	24	Nakuru	20,639	36	Narok	12,230		Kenya	21,945

Derived from Government of Kenya, Ministry of Health County Health Fact Sheets, 2015

The geographical conditions of the Lake Victoria Basin provide optimum conditions for the thriving of the malaria vector (*Anopheles* mosquito) as well as malaria causing parasite (plasmodium). Climatic factors of temperature, rainfall and humidity influence the pattern and level of malaria transmission. Specifically, the ranges of minimum and maximum temperature greatly affect the development of plasmodium and anopheles mosquito. On average the parasite requires ten days to fully develop within the body of the anopheles mosquito. When it is cold the duration lengthens and when temperatures rise the duration shortens. The optimum temperature required for the full development of plasmodium in the body of the anopheles mosquito is 27^oC. From 21^oC up to this optimum the development period greatly shortens. On its part, the anopheles mosquito larvae require higher temperature to develop more quickly. Higher temperature also increases the number of blood meals required by the anopheles mosquito as well as the number of eggs laid by it. This means with high temperatures there will be more mosquito bites and more mosquitoes (The Open University Health Education and Training Programme, 2015). Average temperatures in the five counties with high incidence of malaria cases (Busia 22^oC; Homa Bay 26^oC; Kisumu 23^oC; Migori 28^oC; and Siaya 23^oC) favour both faster development of the parasite as well as increasing the number of blood meals required by mosquitoes and number of eggs laid. High county temperature also hastens the development of anopheles mosquito larvae. The fact that the five counties exist astride the equator further makes the situation more complex as temperatures remain constantly high throughout the year. This then explains the high incidence of malaria cases in the five counties found in the Lake Victoria basin.

Rainfall is another important climatic factor that influences the transmission of malaria. The right amount of rainfall is necessary for breeding of the anopheles mosquitoes. Different species of anopheles mosquitoes prefer different bodies of water as suitable breeding places. In general, fresh clean and unpolluted stagnant water is preferred for the completion of the full cycle of development. The five counties of Busia, Homa Bay, Kisumu, Migori and Siaya each has a bi-annual pattern of rainfall comprising of long rains which occurs between March and May and short rains which start in October and end in December. On average the counties receive between 1300 and 2400mm of rainfall annually (East Africa

Community *op. cit.*). In the drier parts of the counties, the rains encourage the growth of lush vegetation which also is a preferred breeding condition for some species of the anopheles mosquitoes. In the periods with no rain, the flow of water in the streams and rivers is slowed and mainly stops thereby creating additional sites for mosquitoes to breed (Odhiambo, 2013; Open University *op. cit.*). Therefore the abundant precipitation as well as the rain breaks increases the number of breeding sites for the anopheles mosquito and hence exacerbating the risk of populations resident in the five counties.

The third climatic factor influencing transmission patterns of malaria is relative humidity – the amount of water in the air. Humidity influences the activity and survival and thus longevity of the anopheles mosquito. The longer it lives the more havoc it will cause by transmitting the malaria parasite to many people. To be able to transmit malaria, anopheles mosquito must live for 8 to 10 days as this is the length of time it takes the malaria parasite to be fully developed in the belly of the mosquito. Mosquitoes prefer relatively high humidity as this enhances their activity. This explains why they are active at night as relative humidity is high at night. Average relative humidity of 60% shortens the life of mosquitoes and as a result will reduce its ability to transmit the malaria parasite. The swamps, rivers, wetlands and proximity to Lake Victoria increases relative humidity of Busia, Homa Bay, Kisumu, Migori and Siaya to an average of 70-90% (Okeyo-Owuor *op.cit.*). This level of relative humidity heightens their risk of malaria compared to other counties in the Kenya.

The impact of climate change on the rate of malaria transmission in the five counties is yet to be determined. However, it has already been confirmed that there has been a change in climate in the Lake Victoria Basin at least as far as temperature is concerned. Temperature recordings from the 1950s indicate that there has been an increase of temperature in this region by 1⁰C (East African Community, *op. cit.*). This implies the area and conditions under which anopheles mosquitoes and the malaria parasites can thrive has expanded. Specifically, this has affected areas of high altitudes with cooler conditions which initially inhibited the survival of both the malarial vector and parasite. In Busia County this includes the high regions of Samia, North Teso and Funyula Hills which are more than 1500m above sea level. In Homa Bay County the highest and coolest regions include the hills of Gwasssi, Wire, Ngorome, Ruri, Gembe, Homa and Asego. In Kisumu County the regions of cooler temperatures include areas surrounding the Hills of Fort Tenan and Songoh. Migori County seems to have much hilly and therefore cooler areas including the highest hills of Nyakune (4625m), Ogengo (4300m), Maeta (1733m) and Renjoka (1592m). Other high grounds include areas around Got Kwer, Kwach, Nyabisawa, Sibwoche and Mukuro (Republic of Kenya, Ministry of Agriculture ASDSP, 2014). In Siaya County high altitude and therefore cooler regions includes areas surrounding a number of hills in the county including Mbagaa, Odiado, Akala, Regea, Nyambare, Usenge, Ramogi, Rambugu as well as Abiero, Siratuongo and Naya (Republic of Kenya, County Government of Siaya, 2015). An increase in temperature may have turned some of these cooler areas to be suitable for the survival and existence of the malaria vector – anopheles mosquito - and parasite (plasmodium) thereby increasing cases of malaria in the region. .

Three other ecological but non-climatic factors may also be contributing to the high incidence of malaria cases in the five counties – type of soil, land topography and malaria vector adaptations. Information on the soil types in the Lake Victoria Basin indicates that ferrosols, vertisols, acrisols, nitosols and cambisols are common (East Africa Community *op. cit.*). One quality of these soils is their tendency to be impervious and inability to allow seepage through them due to their small particle sizes. This quality makes soils in the keep water for longer periods of time. Coupled with high humidity prevalent in the basin means that rates of evaporation are low and thus water is able to stand and collect over longer periods enabling the mosquito to effectively breed and increase in numbers.

Closely linked to the type of soils is the non-climatic ecologic factor of land topography. The Lake Victoria Basin is generally characterised by plains with minimal differences in heights. The basin is therefore generally flat. When precipitation occurs water remains stagnant as there is no gradient to allow it to flow. This phenomenon further creates an ideal condition for the breeding of the malarial vector – anopheles mosquito. Conducive breeding grounds increase the number of mosquitoes in the region thereby increasing incidences of malaria in the five counties within the Lake Victoria Basin.

Not all mosquitoes transmit malaria parasites. In Kenya just like in other parts of Africa, the female anopheles mosquito – *Anopheles gambiae* group (only found in Africa) is responsible for over 95% of all malaria transmissions as it feeds on human blood only in order to develop and reproduce (Lindsay and Martens, 1998). The other feature of this vector which is causing worries is its ability to adapt to previously hostile environments. Previously, it was thought that mosquitoes

only able to breed in clean, fresh and stagnant pools of water. However, it has been found out that *Anopheles gambiae* has adapted itself and can breed in polluted water (even that mixed with petrol), water in domestic containers in houses, slow moving water and even on small amounts of water that collects on human foot prints. It has also adapted to breeding in irrigated fields (De Silva *op. cit.*). This capability introduces another dimension to the malaria phenomenon which further complicates transmission rates. Although not yet confirmed in the five counties, this phenomenon is highly likely to be partially responsible for the high malaria cases in the five counties. Although malaria vector adaptation is a biological factor, it deserves to be mentioned in this paper.

III. SOCIAL FACTORS

Besides the identified ecologic factors that may be responsible for high incidence of malaria in the five counties of the lake region, there are also numerous human factors that may partially explain the high rates. Other than Kisumu County, the other four counties are predominantly categorised as rural. However, even in them are numerous urban centres. Busia County has Busia town, Nambale, Budalangi, Funyula and Matayos urban centres. Homa bay has major urban centres such as Mbita, Homa Bay itself, Oyugis, Kendu Bay, Suba and Rachuonyo while Kisumu County has Kisumu city, Muhoroni, Nyando and Nyakach. Migori County has major urban centres such as Awendo, Rongo, Kihancha, Isebania and Migori itself. These urban environments create artificial vector breeding sites such as urban agriculture, drains and gutters, ditches, water pipes, vehicle tyre tracks, water tanks, construction sites and swimming pools (De Silva *op.cit.*). Urban agriculture creates trenches, ditches and furrows between seedbeds which further create optimal conditions for vector breeding. To provide water for urban agriculture, most urban dwellers dig out irrigation wells which are not cemented and are left open. Furthermore, human foot prints are constantly created as people work on the urban farms or when harvesting products. Most hotels and lodges construct swimming pools as a recreational facility but most remain unused for long periods of time. Artificial water storage mechanisms such as plastic water tanks at residential, official and at car washing sites provide ideal breeding sites for mosquitoes. It is common for water pipes to burst and remain unrepaired for long creating suitable breeding sites for mosquitoes. Drain ditches as well as gutters for collecting water on roofs of buildings are also common in these urban areas. Silt collects on the drains and other debris collects on gutters blocking them. Once there is precipitation, water collects on the blocked drains and gutters creating further breeding sites for malaria vectors. Thus, by creating artificial vector breeding sites, urban centres contributes numerous numbers of vectors which further lead to more cases of malaria cases.

There is an association between socio-economic status and malaria transmission. Those that are affluent afford better refuse collection in their homes, are highly exposed to information about malaria prevention through TVs, radio and print media. Moreover they can also afford to attain higher levels of education and mostly are connected to piped water systems and have the ability to actively to pursue a variety of malaria preventive and effective treatment methods . The converse is also true. A close examination of levels of poverty in the six counties with high malaria cases in Kenya indicates that they are high (Commission on Revenue Allocation, 2013). This situation is further demonstrated by the percentage of person with at least secondary school education (Republic of Kenya, Population and Housing Census, Vol. II. 2010).

Related to socio-economic status are household factors. This relates to the quality of housing. Better-quality housing decreases the risk of malaria as it minimizes entry points for mosquitoes at night. Houses with mud walls, open cleavages, absent ceilings, earthen floors increase the risk of malaria. Being mostly rural counties, the quality of housing is low and this further increases the possibility of increasing incidences of malaria cases. Related to the quality housing is the phenomenon of hygiene, waste collection and disposal. Being rural counties coupled with high levels of poverty, most homes in the six counties are surrounded by bushes, garbage and stagnant pools of water which increases their vulnerability to malaria transmission.

The population growth rates are also high in the six counties. This forces residents to utilise existing spaces for habitation and production of food. The existing forests and wetlands have increasingly be put under pressure as residents encroach onto them for purposes of creating settlements and create other investment ventures. Deforestation and encroachment onto wetlands and other marginal lands in the six counties creates open spaces for malaria vectors to breed (Terazzas et al. 2015). This also partially explains the high malaria cases in the six worse counties in Kenya.

There are few health facilities in the counties indicating that there are large distances between them and the residents of the counties. This factor coupled with limited mobility due to difficult roads presents challenges for the adequate and effective implementation of public health services including malaria campaigns. This phenomenon makes a larger proportion of the population to be less informed on malaria thereby increasing their risk to malaria transmission (Terezzas *op.cit.*).

Movement of people from one region of the county to the other for a variety of reasons has the potential of introducing or re-introducing malaria to a region. There are common resources within the counties frequented by vast numbers of people. One such resource is Lake Victoria where many of the residents frequent in order to carry out fishing. The various forests and hilltops are other places not forgetting the urban centres within the counties. This factor is potentially responsible for the increase in the number of malaria cases within these counties.

There are other minor factors such as ownership and use of insecticide treated nets and attitudes towards their use (many people say they are too hot). There are also various barriers that hinder the effective prevention and treatment of malaria cases in the counties. For example, many residents do not understand how malaria is transmitted, belief that malaria cannot be prevented and use of alternative treatment mechanisms including traditional medicine. These human factors to an extent make the counties to experience high incidences of malaria cases.

IV. CONCLUSION

This paper has identified that malaria cases are high in Busia, Homa Bay, Kisumu, Migori, Tharaka Nithi and Siaya Counties of Kenya. Five of the worst hit counties are located in the Lake Victoria Basin lending credence to the role played by ecologic factors of climate, topography and soil type in increasing the regions vulnerability to malaria. Tharaka Nithi County seem to be accounted mostly by human than ecologic factors. It is worth remembering that these are just speculative general propositions of making sense of the observation. There is need to undertake empirical studies to actually ascertain the situation in the counties in order to address the problem amicably.

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