Investigations on Risk Factors for Malaria in Rufiji District, Tanzania

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Abstract: *Rufiji District is an area with endemic and perennial malaria. The aim of this study was to assess the factors contributing to increased malaria risk in the study area. The factors investigated included; mode of house construction, protection against mosquito bites and human behaviour. Parameters recorded for evaluating the mode of house construction were; type of wall, roofing materials, presence of open eaves between wall and roof and the type of window. Structured questionnaires were used to assess household mosquito avoidance behaviour and utilization of bed nets. Medium scale behavioural surveys were carried out to determine time spent by individuals outdoors during the night. This was then plotted against mean hourly mosquito catches. Generally, house constructed using mud, grass, palm walls, and roofs made of grass/palm thatch, houses with no or open windows and without mosquito gauze and houses with open eaves and low utilization of bed nets (treated and untreated) were common over the entire study area. Of the 2,423 houses walls examined; 90% were constructed using mud, 61% were roofed using grass, 98% had eaves between wall and roof, and 49% had no windows while 45% of windows had no mosquito gauzes. There were highly significant differences ($p < 0.001$) within all the above variables investigated. Only 21% of the households used bed nets of which only 7.5% were insecticides treated. There were highly significant differences ($p < 0.0001$) within variables investigated on mosquito avoidance behaviour. Most individuals, both children and adults, remained outdoors up to 22.00 hrs. Environmental factors, poorly constructed houses, low rate of utilization of bed nets and other protective measures, and poverty were identified as risk determinants for malaria in the study area. Intervention measures relevant to the study area are discussed.*

Key words: malaria, risk, mosquitoes, Rufiji, Tanzania

INTRODUCTION

Malaria and poverty are intimately connected; the disease is most intractable in Africa (Malaney *et al.,* 2004). The only parts of Africa free of malaria are the northern and southern extremes, which have the richest countries on the continent. Malaria risk has always been geographically specific, and intensive malaria transmission is confined to the tropical and subtropical zone. Poor countries predominate in the same regions as malaria (Gallup and Sachs, 2001).

Malaria is a significant impediment to social and economic development of the world's poorest people who suffer more than 300 million episodes of acute malaria illness each year (Sachs and Malaney, 2002). Malaria kills at least a million people each year, most of them children (WHO, 2005). In addition to the direct cost of treating and preventing malaria illness and loss in productivity, malaria has been shown to slow economic growth in African countries by up to 1.3% each year, increasing the gap in prosperity between malaria endemic and malaria free countries (Sachs and Malaney, 2002). At present, malaria-free countries have an average GDP of three times higher than malaria endemic countries, even after adjusting other factors, which might explain the difference (Gallup and Sachs, 2001).

In Tanzania, malaria is still a major public health problem, and the leading cause of outpatient and inpatient health service attendance and death in both children and adults. Of the 31 million people at risk for malaria in Tanzania, five million are children under the age of five. The disease accounts for about one quarter of all child deaths, in the country (WHO, 2005). Over 1% of the national GDP is devoted to the control and treatment of the disease, representing about US $ 2.2 per capita, and 39% of the total health budget. Private expenditure, primarily on drugs, coils, and bed-nets, represent 71% of total individual household's expenditure (Jowett and Miller, 2005).

The intensity of malaria transmission in Rufiji District is high. Two biological factors have been implicated for the high malaria transmission in the district. These are: the mosquito vector *An. gambiae* s.s. (the most efficient vector) and *Plasmodium falciparum,* (the most pathogenic species) are prevalent in the area (Kigadye, 2006). Furthermore, environmental changes, including modified land use and poor housing may have considerably affected vector distribution and the dynamics of malaria transmission, and hence, malaria risk in the study area. Climate, ecology and personal behaviour such as the use of bed-nets and house design/construction may influence high transmission of malaria (Weiss, 2002).

The objective of the present study was to assess the factors influencing the risk and vulnerability to malaria that could arise from local environmental factors, particularly house construction, behavioural factors such as mosquito avoidance behaviour and socio-economic factors of the people of Rufiji district.

MATERIALS AND METHODS

Study location

The study area forms part of the Rufiji district, in south eastern Tanzania. The district covers an area of approximately 14,500 square kilometres. The present study was carried out in the area under the Rufiji Demographic Surveillance System (RDSS) (7.47° 8'S, 38 39°.17'E), that covers six contiguous wards with 31 villages (about 60 x 30 km wide) (Figure 1).

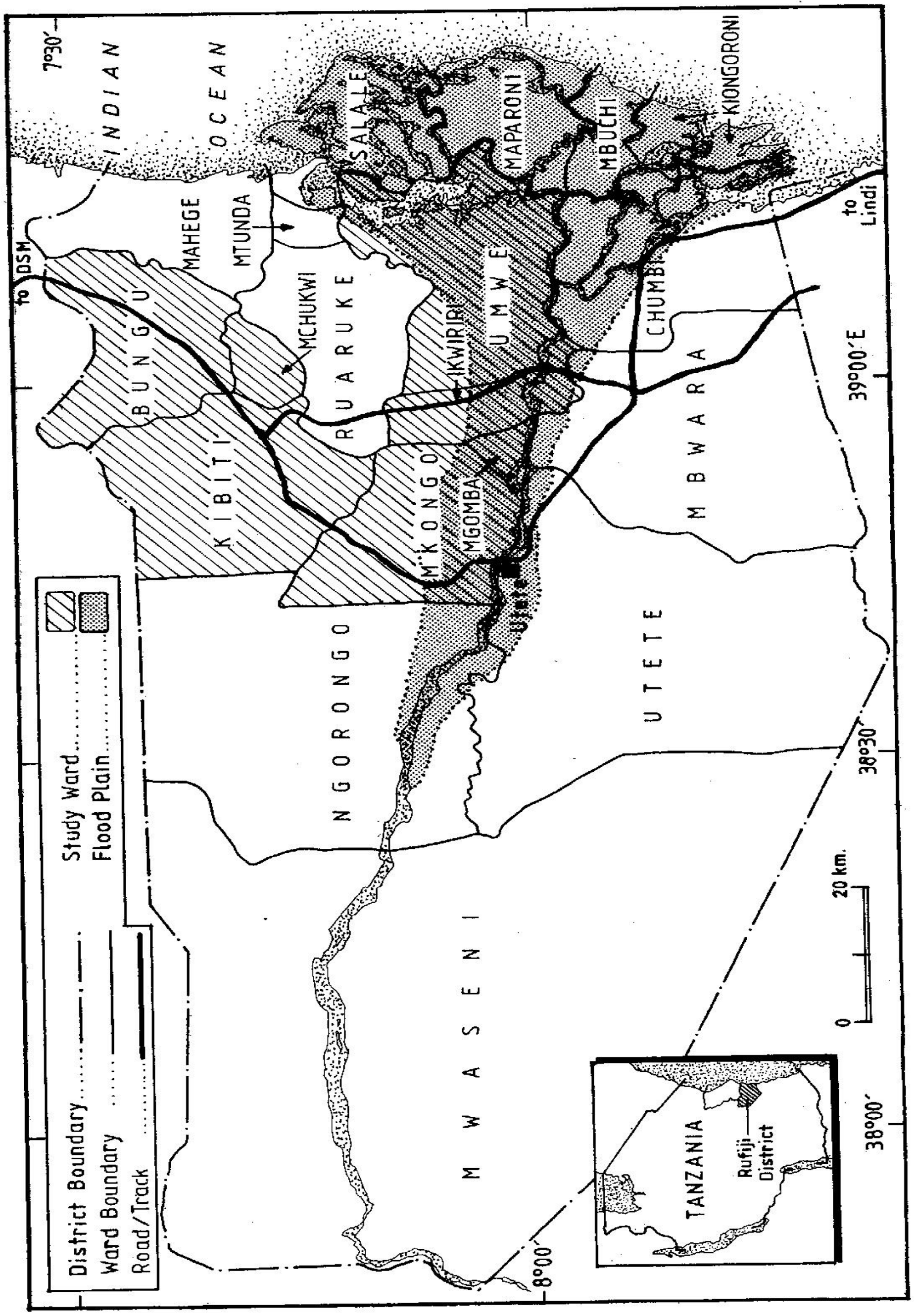

Figure 1: Rufiji District: Location and study sites. Shaded area represents the flood plain and the un-shaded area represents the plateau

The climate of Rufiji district is characterized by a hot and humid season (January to February) followed by a cool period (June-July), and a hot, dry season (August to November). The rainy season consists of two parts, with an average rainfall of 800-1000 mm per year (Richmond *et al.,* 2002). There is usually a short rainy period (October to December), followed by long rains (March-May).

Ethical clearance and informed consent
The study received ethical approval from the Medical Research Coordination Committee of the National Institute for Medical Research, Tanzania (Certificate No. NIMR/HQ/R.Sa/Vol. IX/192). Informed consent was obtained from Local Health Authorities and Village Committees as well as individual house occupants.

Sample and sampling procedures
A cross-sectional study was carried out from October 2002 to September 2003 to assess the factors contributing to increased malaria risk in the study area. A total of 23,423 households were selected from six wards in the Rufiji District (Ikwiriri, Kibiti, Mgomba, Umwe, Bungu and Mchukwi) (Figure 1). The households were classified into geographical clusters of 100 people (i.e. people living in the same area), using data from the Rufiji Demographic Surveillance System (RDSS). The houses were selected by simple random sampling in each cluster (from the data base).

Mode of house construction
For each house in which mosquito collection was carried out the following parameters were recorded: Village/ward, type of wall (mud, bricks or others), roofing material (grass/palm, corrugated iron or others). Presence of open eaves between the wall and the roof and type of windows, i.e. none, with mosquito gauze and without mosquito gauze.

Houses that had incomplete and /or mud, grass, palm walls, and roofs made of grass/palm thatch, houses with no or open windows and without mosquito gauze and houses with open eaves were classified as poorly constructed. While houses with mud/cement/brick walls, closed windows with mosquito gauze, no eaves, and roofs made of corrugated iron sheets as being of good construction.

Type of protection against mosquito bites
For each house in which mosquito collection was carried out, the occupants were asked if they used any kind of mosquito protection besides bed nets such as: mosquito coils, repellents, burning of herbs and if they slept under traditional sleeping bags. In addition, the index person (head of the household) was asked if he/she has a net, if it was treated with insecticide and when it was last treated.

Human behaviour
To account for the effect of human behaviour on the level of malaria transmission, medium-scale behavioural surveys were carried out to determine how much time is spent out-doors during the night. A field assistant sat in a selected index person compound and recorded the number of people and their age at hourly intervals from 12.00 p.m. until all retired to bed. A similar procedure was carried from 4.00 a.m. to

6.00 am on the following morning. The data obtained from the behavioural surveys were plotted against mean hourly mosquitoes caught biting humans.

Data analysis

Analysis was performed using SPSSâ software version 10 (SPSS, Inc., Chicago, IL). Chi-square analysis was carried out to test for association within variables. For mode of house construction the test was used to see if there are significant differences among house walls constructed using mud, bricks or grass/palm; roofs constructed using grass/palm, tin or other materials; open eaves or closed eaves; if the houses have windows, no windows; if the windows have mosquito gauze or without mosquito gauze. In addition, Chi-square test carried out to test for significant differences among households using bed nets; if the bed nets were treated, not treated or not using bed nets at all. Households using other means of protection rather than bed nets were also compared statistically. These included those using insecticide sprays, coils, traditional sleeping bags, burning of herbs and those not using any means.

RESULTS

Mode of house construction

Table 1 summarizes household statistics as regards mode of house construction. The results indicate that there were very significant differences ($p < 0.001$) within all variables investigated. Houses whose walls were constructed using mud and poles constituted 90%, houses roofed using grass/or palm (61%), with open eaves between wall and roof (98%), using windows without mosquito gauze (45 %).

Table 1: Summary of Household Statistics Regarding Housing Construction in Rufiji District

Variable	Number (%)	Chi-square analysis within variables	
Wall	**n = 2423**		
Mud	2169 (90.0)	10.0	
Brick	110 (4.5)	95.5	p < 0.001
Grass/palm	144 (5.5)	94.5	
Roof	**n = 2423**		
Grass/palm	1478 (61.0)	39.0	
Tin	900 (37.0)	63.0	p < 0.001
Others	45 (2.0)	98.0	
Open eaves between wall and roof	**n = 2423**		
Open	2374 (98.0)	2.0	p < 0.001
Closed	49 (2.0)	98.0	
Windows	**n = 2423**		
No windows	1186 (49.0)	51.0	
Without mosquito gauze	1101 (45.0)	55.0	p < 0.001
With mosquito gauze	136 (9.0)	91.0	

Protection from Mosquito bites

Table 2 summarizes the proportion of households engaged in multiple mosquito avoidance practices. The results show that there were highly significant differences ($p < 0.0001$) within variables. Only 21% of the households used bed nets, of which 7.5% were insecticide treated. Only 221 (11%) households were using other means of personal protection against mosquito bites.

Table 2: Proportion of Households Practicing Multiple mosquito Avoidance Behaviour in the Study Area

Variable	Number (%)	Chi-square analysis within variables	
Bed nets	**n = 2423**		
Treated	181 (7.5)	92.5	
Not treated	320 (13.2)	86.8	p < 0.0001
Not using	1922 (79.3)	20.7	
Other means	**n = 1922**		
Spray	11 (0.6)	99.4	
Coils	71 (3.7)	96.3	
Traditional sleeping bags	188 (9.8)	90.2	p < 0.0001
Burning herbs	5 (0.3)	99.7	
Not using	1647 (86)	(4.0)	

Human behaviour

Figure 2 illustrates the biting cycle of female *Anopheles* mosquitoes in relation to time spent by people (adults and children) outdoors and indoors during the night. Results show that some adults retire indoors at 23.00 hours and start going out at 04.00 hours in the morning. The biting cycle of *Anopheles* starts at or around 19.00 hours in the evening with peaks between 24.00 and 03.00 in the night. These results suggest that a large proportion of adults are still outside when *Anopheles* are already biting at 19.00 hours, and start going out at 04.00 o'clock when the mosquitoes are still biting. Most children retire indoors by 21.00 hours and start going out at 04.00 hours in the morning.

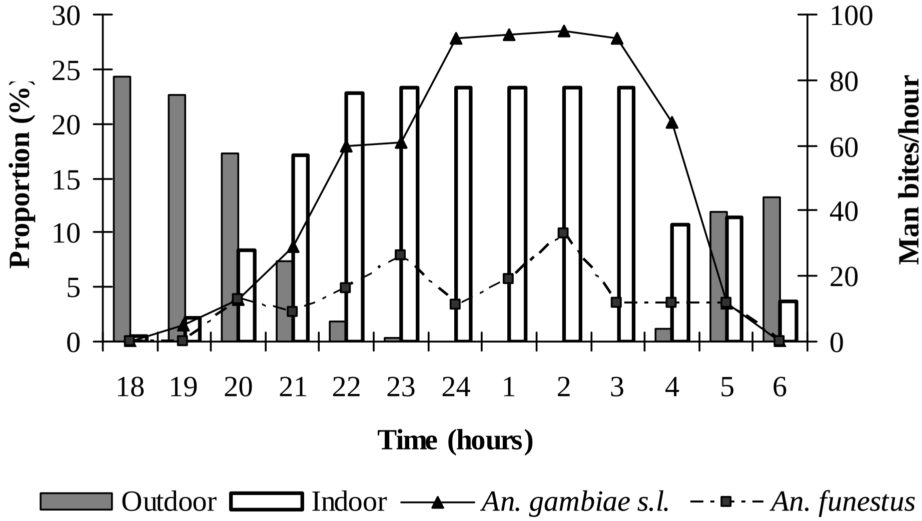

Figure 2: The Biting Cycle of Female *Anopheles* Mosquitoes and Time spent by both Adults and Children Outdoors and Indoors during the Night

About 25% of children are still outside when *Anopheles* start biting at 19.00 hours and start going out at 04.00 o'clock near the end of the biting cycle. There was no significant difference between adults and children in respect of the time of retiring at night and going out in the morning.

DISCUSSION

One of the difficulties associated with achieving a reduction in the malaria incidence is that a combination of diverse factors contributes to the maintenance of malaria transmission (Ezzati *et al.,* 2005). This includes environmental and geographical features of the area such as climatic factors, land use patterns, water development projects, the movement and habits of people, and creation of new human settlements in relation to development schemes (Gunawardena *et al*., 1998). These call for re-examination of the principles of transmission on a micro-epidemiological scale to identify risk factors and formulate interventions that may have to be applied in a more focused manner. This study analysed whether housing, behaviour and social factors influence the transmission of malaria and increase the risk and vulnerability to malaria in the study area.

Type of house construction is known to influence the abundance of mosquitoes in households, and poorly constructed houses do not impede mosquito entry (Charlwood *et al.,* 2003). Most of the houses surveyed in the present study, were poorly constructed thus posing a higher risk for harbouring malaria vectors than those that were of good construction classification. Generally, the findings from this study support the significance of housing construction in relation to the presence of indoor-resting anophelines as reported elsewhere (Lindsay *et al.*, 2003).

In the present study it was observed that a small proportion of house occupants used neither bed nets (treated or not treated) nor other means of personal protection such as mosquito coils, repellents, etc. The low rate of using both impregnated and un-impregnated bed nets points to increased malaria risk in the study area. Mboera (2004) observed that inadequate use of personal preventive measures (insecticides and bed nets) was one of the factors for the increased malaria risk in the northern highlands of Tanzania. Kigadye (2006) observed that seasonal peaks of malaria transmission coincide with peaks in mosquito density in the study area. This implies that malaria transmission in Rufiji district may be reduced drastically by wide scale utilization of Insecticide Treated Nets (ITNs). It has been reported that treated bed nets profoundly reduce the abundance of mosquito population in a household and thus a reduction in malaria transmission (Lengeler, 2004).

The results of the present study show that 21% of adults and 5% of children were still outdoors by 21.00 hours when *Anopheles* mosquitoes biting cycle had already started to peak, and 5% of both adults and children went out at 5.00 hours in the morning when the mosquitoes were still biting. This implies that a moderate proportion of the Rufiji people received infective bites early in the night and during the morning. Most houses in the study area did not appear to impede entry of malaria vectors and, given the generally late biting cycle of *Anopheles* mosquitoes in the study area (Kigadye, 2006). Even those who sleep early and wake up late were still vulnerable to mosquito bites. Therefore, the great majority of transmission took place indoors (Harris *et al.*, 2006), and the low use rate of bed nets in the district further exacerbates the situation. Nevertheless, the Tanzania National Voucher Scheme (TNVS) aiming to provide a bed net to every pregnant woman and infant and the current strategy being carried out by National Malaria Control Programme of having every Tanzanian sleeping under a net by 2011 is expected greatly reduce the burden of the malaria in the study area.

Most people interviewed, mentioned traditional dances, alcohol drinking at village pubs, weddings and funerals as major reasons for the late sleeping behaviour. While, most people woke up early to tend farms and attend school (children). Perhaps, efforts should be carried out through health education to influence the Rufiji community to change some of the behaviour which makes them vulnerable to increased malaria risk. However, Panter-Brick *et al.*, (2006) observed that, behaviour change is difficult to initiate and sustain. To be successful, interventions should be culturally compelling, not merely culturally appropriate; they must engage local communities, and nestle within social and ecological landscape.

The socio-economic status of the Rufiji population based on educational level and family wealth is another factor that may contribute to increased malaria risk. MacIntyre *et al.* (2002) reported similar results in Kenya. According to The National Bureau of Statistics (2002) given the low education level in the study area, the poverty level is relatively high. This may imply that, most people do not understand how to avoid or prevent mosquito bites. In addition, most people cannot afford the cost of a mosquito net, or can afford to construct good houses, which could prevent mosquito entry. There is a positive correlation between economic resources and access to health care or the ability to purchase medicines, as more efficient use of prophylactics or prevention measures is associated with higher education level (Macintyre *et al.*, 2002). For instance, Butraporn *et al.* (1986) observed that people with low education level do not re-treat their bed-nets with insecticides regularly as recommended.

The impact of vector control on the transmission potential (reproduction rate and vectorial capacity) has been reported to be directly proportional to the reduction of vector density (Najera and Zaim, 2002). Significant reduction in vector density is, therefore, required to achieve effective control in the study area. This could be achieved by large-scale introduction of community-wide use of insecticide treated bed nets, improvement in house construction, environmental management, larviciding and indoor residual spraying.

The results of the present study demonstrate the importance of examining the relationship between human-mosquito interaction and increased malaria risk in terms of housing, behavioural and social-economic factors. The significant differences shown among variables investigated in the present study indicates that many families in Rufiji district live in poorly constructed houses and practice very little mosquito avoidance behaviour. This implies that the majority of the population is at great risk to malaria infection. People living in the study area are advised to construct houses which impede mosquito entry. Moreover, Rufiji residents are advised to reduce outdoor activities at peak biting hours of anopheline mosquitoes and to use protective means against mosquito bites such as bed-nets and other forms. In addition, more support is needed from local authority, community based organizations and the National Malaria Control Programme (NMCP) for a wide scale provision of ITNs and other protective methods subsidized by local and national government or by the international donor community.

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