Characteristics of malaria among children living in lowlands and highlands of Muheza District, north-east Tanzania

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Abstract: Cross-sectional surveys were conducted to determine the characteristics of malaria among communities living in lowlands and highlands in Muheza district in north-east Tanzania. A total of 5425 children (mean age= 6±3.5 years) participated in the surveys. Clinical examination was performed and body temperature measured. Parents or guardians of children were interviewed on their practices in relation to the utilisation of antimalarial drugs. Blood samples for detection of malaria parasites and for estimation of haemoglobin were taken from a finger prick. A total of 1940 (76.3%) blood slides collected from lowlands and 1589 (55%) from the highlands were found to be positive for *Plasmodium falciparum* malaria parasites. The overall geometric mean parasite density (GMPD) was 77.4 parasites/μl of blood and median parasite density was 200 parasites/μl. Significantly higher GMPD and parasite prevalence were found in the lowlands than in the highlands. Children in highland areas had significantly higher level haemoglobin of 0.23 g/dl ($P<0.001$). Eight per cent of the blood samples had a haemoglobin level below the cut-off point of 7g/dl. The distribution of anaemic children by area showed that 7.7% and 8.1% were found in the highlands and lowlands, respectively. Of the total number of children screened, 415 (8.0%) had a body temperature ≥ 37.5°C. A total of 1066 guardians (caretakers) were interviewed. Of these, 459 (15.2%) reported to have dispensed anti-malarial drugs and analgesics to their children when they suspected that they had malaria. A statistically significant higher proportion of home treatment practice was observed among residents of the highland than those from the lowlands ($P<0.01$). Malaria and anaemia were more prevalent on the lowlands than on the highland areas. The distribution patterns of malaria transmission seem to be similar in both highlands and lowlands. However, a significant difference was observed between the areas in-terms of parasite density.

Key words: *Plasmodium falciparum,* malaria, lowlands, highlands, Muheza, Tanzania

Introduction

Malaria is the leading cause of mortality and morbidity in Tanzania, and is responsible for the majority of hospital attendances, admissions and deaths. Children under five years of age and pregnant women in endemic areas are categorised as high risk groups because they are adversely affected by malaria. The world malaria incidence is estimated at 300 to 500 million clinical cases with 1.5 to 2.7 million deaths each year. Over 90% of the total malaria incidences occur in Sub-Saharan Africa. Malaria kills 3000 children aged below five years of age per day (WHO, 1998).

Malaria is endemic in most parts of Tanzania. In decreasing order of prevalence, the species of *Plasmodium* affecting man in Tanzania are *P. falciparum, P. malariae, P. ovale* and *P. vivax* (Clyde, 1967). The distribution of malaria endemicity in Tanzania is not homogenous. There are holoendemic areas where malaria transmission is stable and occurs for more than 6 months per year, hyperendemic areas with transmission between 3 and 6 months, and hypoendemic ones with transmission occurring for less than 3 months. In a few areas malaria occurs as outbreaks and only in some years (Mboera & Kitua, 2001). Such a distribution is determined in part by both climatic and topographic factors as well as by the distribution patterns of the vectors (Mnzava, 1991). In holoendemic areas, including the coastal regions of Tanzania, over 80% of the children carry malaria parasites in their blood without showing any clinical symptoms. Although Clyde (1967) described the levels of endemicity of malaria in various areas of Tanzania, data on the current pattern of malaria morbidity in different ecological settings in the country are not available.

Malaria is the number one cause of morbidity and mortality in Muheza District. The district is probably the worst hit malaria endemic area in north-eastern Tanzania having areas with highest transmission (over 400 infective bites per person per year) (Ellman *et al.,* 1998). There are very few areas in the district where transmission is very low or absent. The cross-sectional surveys described in this paper were conducted to determine the characteristics of malaria

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among communities living in lowlands and highlands in Muheza district in north-east Tanzania.

Materials and Methods

Study area

Muheza district lies between 4°45'S and 39°00'E. Topographically, the district lies between 200 and 1200m above sea level. It has a tropical climate with two main rainy seasons (long rains between March and May, and short rains between October and November). The annual rainfall averages 1800 mm in the highland and 1000 mm in the lowlands, and is spread over a greater number of days. The temperature ranges from 20-32°C and the relative humidity 65-100%. The district has a population of approximately 270,000, of whom 20% are children aged less than 10 years. Most of the inhabitants are subsistence farmers.

The district was divided into two zones, i.e., lowlands (<900m) and highlands (>900m). From the highlands and lowlands 11 and 8 villages were randomly selected. At the beginning of the study a census of the study population was carried out and personal details were recorded. The villages involved were mapped, each house was allocated a project number and children aged from 1 to 14 years were recruited and given a unique identification number after individual oral consent had been obtained from their parents or guardians.

Study design

The data for this study was a subset from a larger study on malaria carried out in the district in 1998 (Kamugisha, 2005). A monthly cross-sectional survey was conducted in all the selected 19 villages. For each survey a random sample of 50 children drawn from the census list was requested to attend and for each child, date of birth history of fever for the previous week, and intake of antimalarial drugs were recorded. Axillary body temperature was measured, and spleen size estimated. Finger prick blood samples were obtained for preparation of thick films for malaria diagnosis. Parasite count was made against 200 white blood cells. Haemoglobin levels were measured using a HemoCue machine, capillary blood being collected directly into the cuvettes and measured in the field.

The core body temperature was measured using Thermoscan thermometers. For each child the reading of the body temperature was taken and recorded twice from one ear and once from the other. The arithmetic mean temperature was calculated in order to obtain the average body temperature for each child.

Data analysis

Data from all surveys were combined together because episodes were being used for observation, rather than as a subject. The data were analysed using the STATA statistical package version 5 (Statistic Corporation, Texas, United States).

Results

A total of 5425 children participated in the cross sectional survey. Of these, 47% were from the lowlands and 53% from the highlands. There was no significant difference between sex ratios in the two areas of residence (P=0.1). The overall mean age of the children was a 6±3.5 year old. There was a significant difference between the age distributions in the two areas (P=0.02). Age was classified into four groups: 0–11 months; 12-23 months; 24-50 months; 60-107 months and 108+ above. Age distribution relative to area showed a greater number of children aged >2 years in each area, 2176 (85%) in the lowland area and 2427 (84%) in the highland area compared to children <2 years of age. A Chi-square test showed no significant difference (χ^2= 2.1 and P = 0.1).

Of the blood slides collected 76.3% from the lowlands and 55.1% from the highlands were laboratory diagnosed as having malaria parasites. Of the children, 11.5% in the lowlands and 4.8% in the highlands had fever with temperatures >37.5°C. The difference was significant at P <0.001 (Table 1).

Haemoglobin level was measured on the 4894 blood samples collected during the survey. The mean average haemoglobin level was estimated as 9.7 g/dl for the children examined in the two study areas. Children in highlands had a significantly higher mean haemoglobin level (P<0.001) than those from the lowlands. Stratification of haemoglobin level between the two areas in age groups (Table 2) showed that, the haemoglobin level in infants between the two areas was not significantly different. However, for the two age groups (4.9 years and ≥5 years) there was a significant difference in mean haemoglobin levels between the two areas. It was also observed that for both areas, the value for the haemoglobin levels increased significantly with age.

Eight percent (387/4894) of the blood samples had a haemoglobin level below the cut-off point of 7g/dl which classified children below that level as being anaemic. The distribution of anaemic children by area showed that 174 (8.1%) and 213 (7.7%) were found in the lowlands and highlands respectively. The difference was not statistically significant (χ^2_1= 0.3; P =0.6).

The results obtained from the regression analysis on the relationship between parasite density for the positive blood slides showed a significant relationship in each area (P<0.001). In both areas an inverse relationship between parasite density and haemoglobin level was observed.

The overall geometric mean of parasite density (GMPD) was 77.4 parasites/μl ranging from 0-124244 parasites/μl and with a median of 200 parasites/μl (N= 5425). However, the GMPD for lowland was 183 parasites/μl and that for the highland was 36 parasites/μl. The differences between the two areas were significant (P<0.01).

The mean temperature of the children from lowlands was 0.3°C higher (36.9°C) than that of the children from highland areas (36.6°C). The age groups of children and the distribution of body temperature taken during the survey are shown in the Table 3. Those children with body temperature of ≥ 37.5°C were considered to have fever which was most likely due to malaria. This was 0.6°C higher in the lowland and 0.9°C in the highlands. In both areas the mean body temperature of children with malaria parasite was higher in the under fives.

Prevalence of parasites was lower among children from the highlands than those from the lowlands (Table 4). The overall prevalence of parasites among

Table 1: Fever episodes, parasitaemia, haemoglobin levels and drug usage among children from highland and lowland areas in Muheza district

Variable		Lowlands No (%)	Highlands No (%)	Test statistic *(P-value)*
Febrile (>37.5°C)	Yes	284 (11.5)	131 (4.8)	χ^2 =77.32 (P< 0.001)
	No	219 (88.5)	2579 (95.2)	
Parasitaemia	Yes	1940 (76.3)	1589 (55.1)	χ^2 = 267 (P < 0.001)
	No	602 (23.7	1294 (44.9)	
Haemoglobin level (g/dl)	<7g/dl	1964 (91.9)	2543 (95.3)	χ^2 = 0.28 (P = 0.60)
	>7g/dl	174 (8.1)	213 (7.7)	
Drug usage	Antimalarials	529 (34.9)	537 (35.8)	χ^2 = 37.9 (P< 0.001)
	Other drugs	290 (19.1)	169 (11.3)	
	None	699 (46.1)	794. (52.9)	

Table 2: The distribution of haemoglobin level by areas and age

Age group	Lowland Mean (g/dl)	Test statistic*	Highlands Mean (g/dl)	Test statistic*
< 1 year	8.0	P<0.01	8.0	P<0.01
1-4.9 years	8.9		9.5	
5+ years	10.2		10.3	
Total	9.6		9.9	

*Test for between age groups mean performed using ANOVA test

Table 3: The means body temperature of the febrile cases by area and age

Age groups	Lowlands Febrile cases (Temp ≥37.7°C)	Highlands Febrile cases (Temp ≥37.7°C)
0 –11 months	10 (38.1)	4 (39.0)
12-23 months	23 (38.0)	14 (38.3)
24-59 months	87 (37.8)	34 (38.1)
60-107 months	96 (37.8)	54 (37.7)
108 months+ above	68 (37.7)	25 (37.7)

the febrile children and afebrile children was 76.3% and 64.5%, respectively. Prevalence among febrile children was higher (81.7%) than among afebrile children (76.0%). A similar situation (febrile= 64.6%; afebrile= 54.7%) was observed among children from the highlands.

In both areas, high parasite rates were observed among children in the age group 24-59 month, whereas the lowest rates were observed among the <12 months age group (Table 5).

Fifty per cent (1525/3018) of the reports collected regarding the use of drugs were obtained from a guardian who dispensed drugs for the early treatment of fever episodes. A total of 1066 (35.3%) and 459 (15.2%) reported dispensing antimalarial drugs and analgesics (aspirin and paracetamol), respectively. A total of 529 (35%) and 537 (36%) of the children receiving antimalarial treatment were from the lowland and highland areas, respectively. There was a significant difference in the usage of drugs in relation to each area (*P*-value<0.01). The lowland area was observed to have a higher level of home medication than the highland. On the other hand, the results show that the guardians in the highlands were less likely to dispense drugs than those in the lowlands. Overall, 21.9% of subjects (1191/5431) reported a history of fever during the previous one-week. A total of 642 (22.3%) and 549 (19%) guardians from the lowlands and highlands respectively, reported a history of fever.

Discussion

The positive blood slides of children aged 12-23 months had a higher parasite rate than other age groups. This type of distribution is usually attributable to the low level of immunity to malaria in children in this age group (Petersen *et al.*, 1991). Whereas the infants retained acquired immunity from mothers and are less prone to malaria attacks, the older children are likely to have developed their own immunity (Kitua *et al.*, 1996).

Additionally, the results of this study show that children who live in highland areas have a higher level of haemoglobin than those from the lowlands. These results, similar to the findings of Ellman *et al.* (1998) strongly suggest that reduced malaria transmission has the benefit of reducing anaemia. However, low haemoglobin levels may have contributed to high morbidity rates in both areas under study. Similar observations have been reported from a study by Genton *et al.* (1995) and suggest that haemoglobin level is a good indicator of malaria morbidity. In another study, it was reported that severe anaemia is the predominant symptom of severe malaria among children in high transmission areas, whereas cerebral malaria is more predominant among older children in lower transmission areas (Snow *et al.*, 1994).

Table 4: Total number and prevalence (%) of children with and without fever by age group

Age group (months)	Lowlands No. with fever	% fever	Highlands No. with fever	% fever
0-11	10	8.7	4	2.5
12-23	23	9.6	14	5.5
24-59	87	13.1	34	4.4
60-107	96	11.7	54	5.9
108+	68	10.6	25	4.1
Total	284	11.5	13	4.8

Table 5: Proportion of positive and negative blood slides in each age group

Age group (months)	Lowlands No. positive parasite	% positive parasite	Highlands No. positive parasite	% positive parasite
0-11	74	61.2	66	37.5
12-23	169	69.0	141	50.4
24-59	581	85.3	479	59.3
60-107	678	81.0	555	57.0
108+	438	67.0	348	54.0
Total	1940	76.3	1589	55.1

The observed difference in body temperature of 0.3°C between the two areas in this study was similar to that previously reported by Ellman *et al.* (1998) in the same study area. This suggests that it may not be necessary to use temperatures of 37.5°C as fever cut-off points for areas with different altitudes. Furthermore, fever alone as an indicator of malaria cases has been observed to be non-specific leading to high rates of false diagnosis (Massaga *et al.,* 1999). The combination of fever and other factors are likely to lower the false-positive rate (Schellenberg *et al.*, 1994).

There was a significant difference in the general usage of drugs including antimalarials and pain-killers in relation to each area. Residents of lowland areas practised more home-based medication than those residing in the highlands. Antimalarial drugs are often available over the counter and have been commonly used for treatment of all ranges of fever not necessarily caused by malaria (Mnyika *et al.*, 1995; Alilio *et al.*, 1997). This and other factors, including socio-economic aspects of individuals have lead to improper usage of antimalarial drugs thus, contributing to increased levels of drugs resistance (Alilio *et al.*, 1997). *Plasmodium falciparum* resistance to anti-malarial drugs has been reported in different parts of the district (Fowler *et al.,* 1993; Rønn *et al.*, 1996).

Although a significant difference between the areas in terms of parasite density was observed, the distribution patterns of the malaria transmission seemed to be similar in both study areas. An increased in malaria transmission on the highlands of Muheza has already been reported by Matola *et al.* (1987), who attributed this change to deforestation, climate change and movement of people between the two areas. The findings of this study confirm previous findings that malaria is firmly established in the Eastern Usambara Mountains.

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