

The relationship between malaria parasitaemia and availability of healthcare facility in Mpwapwa District, central Tanzania

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Abstract: A study was carried out in six villages located at different altitudes in Mpwapwa district of central Tanzania to determine malaria parasitaemia and transmission levels in villages with or without health care facilities. A total of 1119 schoolchildren (age= 5.9-12.3 years) were examined for malaria parasitaemia. *Plasmodium falciparum* was the predominant malaria species accounting for 92.8% of all species. The average malaria prevalence rate among schoolchildren was 25.8% (range 1.5-53.8%). The geometric mean parasite densities for *P. falciparum* was 361 (N= 286). Higher malaria prevalence was observed in villages at lower (<1000 m) than at intermediate (1000-1500m) or higher (>1500m) altitudes. Schoolchildren in areas with health care facilities were less at risk of acquiring malaria by 33.4% as compared with those living in areas without health facilities. Mean packed cell volume in schoolchildren was 38.5% (range= 35.2-41.0%). Splenomegaly was observed in 18.1% (0-40.2%) of the schoolchildren examined and it was higher among those in villages without health care facilities. *Anopheles gambiae* sensu lato was the only malaria vector found in the district and was found in all villages and at all altitudes. Sporozoite rate in *An. gambiae* s.l. ranged from 0-10.5%, with the lowland villages recording the highest rates. This study indicates that altitude and geographical accessibility to healthcare service are important determinants of malaria infection among rural communities in Tanzania.

Key words: malaria, schoolchildren, altitudes, health care facility, Tanzania

Introduction

Malaria remains a major public health problem in sub-Saharan Africa, with approximately 1 million deaths and more than 400 million cases a year. In Tanzania, it is the leading communicable disease problem. Of the total Tanzanian population of 34.5 million, over 95% is at risk of malaria. The disease is responsible for 33% of hospital attendance and 54% of hospital deaths (Ministry of Health, unpubl.). These deaths are only a small proportion of those, which occur at home, unreported.

Several factors have been shown to influence malaria transmission and malaria risk in sub-Saharan Africa. These include intrinsic factors such as the parasite, mosquito or host (Marsh, 1993; Lindsay *et al.*, 2001; Verhoef *et al.*, 2002; Koenraadt, 2003) as well as environmental and climatic conditions (Ondongo-Aginya *et al.*, 2005). Moreover, factors such as human activities (e.g. water and agricultural developments) and knowledge of the disease (Karanja *et al.*, 1999) have been described to closely influence malaria prevalence (Ondongo-Aginya *et al.*, 2005).

It has been established that in any given area, the most exposed households to malaria are those in the more remote part of a village or district. (Billingsely *et al.*, 2006). The reason for such variation has been attributed to heterogeneity in entomological inoculation rates (Charlwood *et al.*, 1995).

Interestingly, in a recent study in Iringa, Tanzania, higher malaria prevalence was observed among children living in villages without healthcare facilities than in those with healthcare facilities (Mboera *et al.*, 2006) indicating that there are still more other factors which influence malaria risk in any given area. This aspect has not been adequately studied. It was therefore, the objective of this study to determine the prevalence of malaria parasitaemia among schoolchildren living in village with or without healthcare facility in rural Mpwapwa in central Tanzania.

Materials and Methods

Study area

The study was carried out in Mpwapwa district (6°45'S, 36°20'E) of central Tanzania. The study area was stratified into low, intermediate and high altitudes. Wangi and Mwanawota (highland), Kibakwe and Kidenge (intermediate) and Chogola and Makose (lowland) were selected for the study. In each stratum, the selection of the villages was also based on the presence or absence of health facilities. Health facilities were available at Chogola, Kibakwe and Mwanawota. There were no health facilities at Makose, Kidenge and Wangi. Within each stratum, the villages were about 11 km apart. Coordinates were taken at the central point for each of the selected village using Global Positioning System.

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Malariometric survey

Malariometric surveys were carried out to cover approximately 200 schoolchildren in each village. Thick and thin blood smears were collected from each individual from a finger prick. The blood smears were stained with 10% Giemsa and examined under microscope in order to identify and quantify any malaria parasite species present.

Enumeration of the asexual malaria parasites was made against 200 leukocytes. A slide was considered negative if no parasite was seen after scanning 200 microscope fields under oil immersion with x100 objective. When gametocytes were present, they were enumerated against 500 leukocytes. Assuming an average of 8000 leukocytes per microlitre of blood, the number of parasite/ μ l was estimated by multiplying by a factor of 40 for asexual forms. In addition, a fingerprick blood from a representative sample of 50 pupils from each village was taken into heparinised capillary tubes for packed cell volume (PCV) determination (Hughes-Jones, 1975). Each child screened for malaria parasite was asked whether he/she slept under a mosquito net during the previous night.

Table 1: Village locations and altitudes and availability of health care facility in Mpwapwa

Village	Longitude °S	Latitudes °E	Altitude (m)	Health facility
Chogola	06°55'.070	36°19'.196	975	Dispensary
Makose	06°54'.503	36°21'.458	990	Absent
Kibakwe	06°42'.945	36°22'.564	1136	Health Centre
Kidenge	06°45'.759	36°28'.102	1219	Absent
Wangi	06°44'.523	36°16'.410	1798	Absent
Mwanawota	06°40'.219	36°17'.635	1859	Dispensary

Entomological survey

Mosquito collections were made using pyrethrum spray catch technique. In each village mosquitoes were collected from 10 houses. One room in each selected house was sprayed with pyrethrum during the morning hours, and after 10 minutes, the mosquitoes knocked down on the spread white cotton sheets were picked up and preserved in petri dishes lined with moist cotton wool and filter papers. All mosquitoes were morphologically identified (Gillies & De Meillon, 1987), sorted according to site of collection, house and species. Female *An. gambiae* were dissected to determine parity by observing the degree of coiling of ovarian tracheoles (Detinova, 1962). Salivary glands of parous mosquitoes were examined for malaria parasites using standard dissection techniques (WHO, 1975).

Data analysis

All malariometric and entomological data were entered into Excel and verified in database and analysed using version 8 of the STATA software package (Stata Corp, College Station, Texas).

Results

A total of 1119 schoolchildren (age= 5.9-12.3 years) were clinically and parasitologically examined for malaria in six villages. The villages were situated between latitude 975 and 1859 m (Table 1). Of the total schoolchildren screened for malaria parasites *Plasmodium falciparum* and *P. malariae* accounted for 92.8% and 1.4% of all malaria parasite species, respectively. Mixed infections of *P. falciparum*+*P. malariae* (4.1%) and *P. falciparum*+*P. ovale* (1.4%) and *P. falciparum*+*P. malariae*+*P. ovale* (0.3%) were also observed.

The overall mean malaria parasite rate was 25.8% (289/1119). Parasite rate was significantly lower in Chogola (with health facility) than in Makose (without health facility) ($P<0.001$) in the lowlands. At

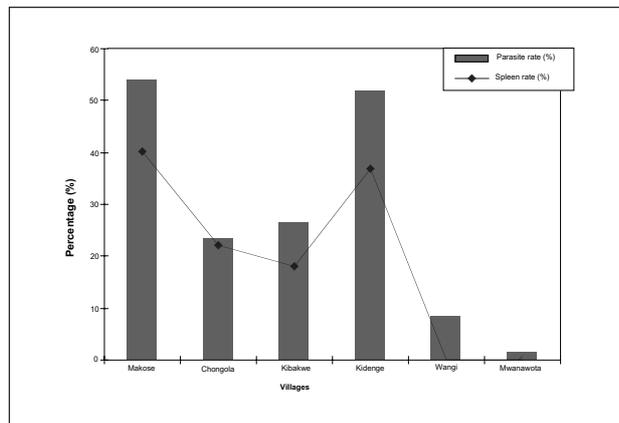
intermediate altitudes, parasite rate in Kibakwe, (with a health facility), was significantly lower than in Kidenge (without health facility) ($P<0.001$). Similarly, in the highlands, the parasite rate in Mwanawota (with health facility) was significantly lower than in Wangi (without health facility) ($P<0.001$). Communities living in areas with health care facilities were less at risk of acquiring malaria infection by 33.4% as compared with those living in areas without health facilities. Malaria prevalence in each of the three strata was 35.8% (119/332), 38.8% (150/387) and 5% (20/400) for the low, intermediate and high altitude areas, respectively.

Table 2: The number of schoolchildren, mean age, sex ratio, parasite rate, GMPD and spleen rate

	Makose	Chogola	Kibakwe	Kidenge	Wangi	Mwanawota
Number screened	200	132	200	187	200	200
Mean Age (years)	5.9	8.5	9.6	11	12.3	11.6
Sex ratio (M:F)	0.92:1	0.59:1	0.98:1	0.94:1	1.32:1	0.80:1
Parasite rate (%)	53.8	23.5	26.5	51.9	8.5	1.5
GMPD/ μ l	1448	364	299	214	276	880
Spleen rate (%)	40.2	22.0	18.0	36.8	0	0

The geometric mean parasite densities (GMPD) for *P. falciparum*, *P. malariae* and *P. ovale* were 361 (N= 286), 86 (N= 14), and 70 (N= 5) per microlitre of blood, respectively. The GMPDs were higher in Makose and Mwanawota villages and lower in Kibakwe and Kidenge villages (Table 2). The GMPD rates for *P. falciparum* varied significantly between villages with or without health facilities within similar altitudes.

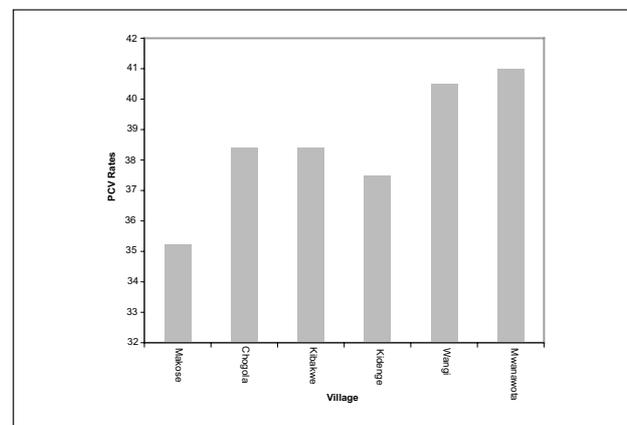
There was no direct association between altitude and parasite density in this district. However, the higher GMPD in Mwanawota was observed from a very small sample of infected individuals. Higher spleen rates were observed in Makose and Kidenge, villages (Figure 1). The overall gametocyte parasite density for the district was 145.3/ μ l of blood. Of the total individuals with gametocytes, 0.3% was from villages with health facilities whereas 99.7% were from villages without health facilities.

**Figure 1: Parasite and spleen rates among school children in Mpwapwa**

On average the district mean packed cell volume (PCV) among school children was 38.5%. The mean PCV was higher in villages in the highlands than lowlands (Figure 2). PCV was high in villages with health facilities, although this was not statistically difference ($P>0.05$).

The average spleen rate in the district was 18.1%. The spleen rates were significantly lower in villages with health facilities than those without health facilities within similar altitudes ($P<0.001$). In both low and intermediate altitudes people living in villages with health facilities were at lower risk of having an enlarged spleen by 39.6% (95%CI: 28.4 – 55.4%) when compared to those living in areas without health facilities.

Anopheles gambiae sensu lato was the only malaria mosquito collected in the study area. *An. gambiae* s.l. was found in all villages, both at low and higher altitudes. On average 1.5 *An. gambiae* s.l. per room was found in the study villages. Higher sporozoite rates were found in Wangi, Kibakwe and Makose (Table 3).

**Figure 2: Packed cell volume rates in Mpwapwa**

On average 2.1% of the schoolchildren were using mosquito nets for protection against malaria. Only 2.7% (5/187) and 9.5% (19/200) of the schoolchildren were sleeping under mosquito nets in Kidenge and Kibakwe, respectively. Significantly, a larger proportion of children were sleeping under mosquito nets in Kibakwe than in Kidenge ($P = 0.005$, $\chi^2 = 7.74$). All children in Wangi, Mwanawota, Chogola and Makose were not sleeping under a mosquito net.

Table 3: Number, parity and infectivity rates of *An. gambiae s.l.* collected in Mpwapwa district

Village	Number	Parity %	Sporozoite %
Wangi	12	90.1	8.3
Mwanawota	6	33.3	0
Kidenge	21	42.9	0
Kibakwe	21	76.9	10.5
Chogola	7	80	0
Makose	19	50	4.8
Total	86	68.9	5.3

Discussion

The district mean malaria parasite rate of 25.8% and spleen rate of 18.1% in school children indicate that malaria in the district is mesoendemic. A previous survey made in Hombolo, in the nearby district of Dodoma, revealed parasite rate of 31.4% among children 6-10 years (Clyde, 1967).

In our study, a variation of parasite rate was observed between villages within similar altitudes. Like in other studies, the malaria parasite rates were high at lower altitudes of Makose and Chogola than at higher altitudes of Wangi and Mwanawota. Previous studies in the district have shown similar results (Goosen, 1973).

The endemicity of the disease varied according to altitudes and the presence or absence of a health care facility. Higher proportions of the population were infected with malaria parasites in lower altitudes and villages without health facilities than the *vice-versa*. Interestingly, in this study malaria parasitaemia, though at a lower rate, could be detected in individuals living over 1800 m above sea level. Similar observations have been reported recently in the Usambara Mountains (Bødker *et al.*, 1997) and Ngorongoro (Mboera *et al.*, 2005), in north-east and northern Tanzania, respectively.

The relationship between malaria prevalence and altitude may be related to availability of optimal conditions for the development of malaria parasites in the mosquito vectors. It has been established that the developmental rates increase from zero at a low temperature threshold, reach a maximum at an optimal temperature and decrease rapidly to zero at an upper, lethal temperature (Lactin *et al.*, 1995).

In Africa, the efficient malaria mosquitoes are lowland sun-loving savannah species, and malaria is negatively associated with altitude. However, in north-eastern Tanzania, deforestation has led to the spread of malaria upward into the hilltop villages (*c.* 1000m

of the Usambara Mountains (Matola *et al.*, 1987). This was attributed partly to the creation of sunlit breeding sites, but also to the great increase in temperature (from 12.8-15.6°C to 17.7-20.8°C) that accompanied forest clearing.

Mixed malaria parasite infections were observed in Mpwapwa district. Infections due to two or more species of malaria parasites in other places are common (Gilles, 1993), but they are often overlooked. There is a tendency for one species of the parasite to predominate over the other. The most common types of mixed infections in tropical Africa are *P. falciparum* and *P. malariae*, although *P. falciparum* and *P. ovale* are also frequent. On rare occasions all three species can be found in one blood film as was observed in Mpwapwa.

The low PCV levels observed in this study correlated with the parasite density. It should be noted however, that the higher parasite density observed in Wangi is due to the small sample size. The few individuals observed carrying malaria parasites were heavily infected. The relatively higher packed cell volume observed in the district could be attributed to type and quantity of food available and/ or malaria endemicity. There seems to be a slight relationship between higher PCV levels and the presence of health facilities, as the levels were higher in villages with health care facilities. The possibility for early diagnosis and prompt treatment for those living close to health care facility is most likely to contribute to the low malaria parasite density and hence high packed cell volumes.

The overall proportion of the population in the study areas using mosquito nets was lower than expected. In the nearby Iringa district, mosquito net coverage was found to be 16.1% (Mboera *et al.*, 2006). Interestingly, the use of mosquito nets was high in larger settlement such as Kibakwe than in typical small rural villages.

The higher proportion of net use that was observed at Kibakwe, a village with health facility than in other villages, is most probably due to the presence of large number of nuisance *Culex* mosquitoes (data not shown) and health education that is likely to be provided by the health facility.

In conclusion, malaria prevalence among communities in Mpwapwa district varies with altitude and that the presence health care facility plays a significant role in the low malaria parasitaemia levels among the population in the vicinity. Similar observations have been made in a nearby district of Iringa (Mboera *et al.*, 2006). These results therefore, provide more evidence that individuals with easy access to health care services are likely to be less at risk of carrying malaria infection than those living far away. There is need therefore to strengthen health care provision for early diagnosis and treatment of cases and hence lower parasite infection among the population.

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