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Travel as a risk factor for uncomplicated *Plasmodium falciparum* malaria in the highlands of western Kenya

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Summary

In the 1980s, highland malaria returned to the tea estates of western Kenya after an absence of nearly a generation. In order to determine the importance of travel for the spread of malaria in this region, we prospectively collected blood films and travel, demographic and geographic information on well persons and outpatients on tea estates near the western rim of the Rift Valley. Risk factors for malaria asexual parasitaemia included: tribal/ethnic group, home province and home district malaria endemicity. Travel away from the Kericho tea estates within the previous two months showed an odds ratio (OR) for parasitaemia of 1.59 for well persons and 2.38 for outpatients. Sexual stages of malaria parasites (gametocytes) had an OR of 3.14 (well persons) and 2.22 (outpatients) for those who had travelled. Increased risk of malaria parasitaemia with travel was concentrated in children aged <5 years. An increase in population gametocytaemia is possibly due to increased chloroquine resistance and suppressed infections contracted outside of the tea estates.

Keywords

Plasmodium falciparum; Highland malaria; Travel; Kenya

1. Introduction

Most malaria encountered in western countries is among travellers returning from malaria-endemic areas. Population movement (migration and circular mobility) has also been implicated in the changing epidemiological risks of *Plasmodium falciparum* risk within Africa (Prothero, 1961; Van der Stuyft et al., 1993). In this paper we describe the effects of local, temporary travel upon the disease risks and local epidemiology of transmission among tea-estate workers in the western highlands of Kenya.

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2. Materials and methods

The Kericho tea estates and their malaria epidemiology have been described in detail elsewhere (Malakooti et al., 1998; Shanks et al., 2000, 2002). The present study was conducted under a protocol approved by the Kenyan National Ethical Review Committee (SSC 484) and the US Army Office of the Surgeon General (WRAIR 682). A structured one-page questionnaire was administered by trained fieldworkers to asymptomatic persons on the Kerenga tea estate during 1999–2000 and to outpatients presenting to the Kerenga Health Centre with symptoms suggestive of malaria during 1998–2002. The questionnaire asked for information on demography, symptoms and travel to the nearby (50 km) Lake Victoria basin lowlands (<1000 m) in an area of highland (2000 m) malaria transmission. A thick and thin blood film was made for each person; negative slides were defined as those with no parasites seen after examination of 100 fields on the thick film. Highland and lowland family origin was defined as being from a tribal/ethnic group whose traditional home area was either above 1500 m (Kalenjin and Kisii) or below 1500 m (Luhya and Luo). Travel destinations were assigned a malaria risk criterion using a countrywide determination of malaria transmission potential. Districts were defined as low/unstable transmission risk or stable, endemic malaria transmission (Omumbo et al., 1998; Snow et al., 1999). Data recorded on the study forms were entered into a computer database and analysed using EpiInfo 2000 (CDC, Atlanta GA, USA) and SPSS, version 11 (SPSS Inc., Chicago, IL, USA) software.

3. Results

We investigated 10 789 outpatient presentations suggestive of clinical malaria and 2210 persons recruited at their homes on the Kerenga tea estate. Table 1 shows that generally the prevalence of asexual malaria parasitaemia (>95% *P. falciparum*) increased with symptoms (well person < outpatient), increasing home area (province or district), endemicity for malaria (epidemic < endemic), and travel away from the tea estates of Kericho. The same trends were seen for gametocytaemia. The majority of those harbouring gametocytes were children aged <5 years who had travelled recently: 52% of the total gametocyte reservoir among sick patients and 62% among healthy household members. Furthermore, sick children aged <5 years had rates of gametocytaemia that increased with the length of time since they had returned from travel: 4.3% for those who had returned within 2 weeks, 6.4% among those who had returned within 2–4 weeks and 8.6% among those who had returned within 4–8 weeks, compared to 2.3% among those who did not travel.

The data presented in this study show that malaria parasitaemia and particularly gametocytaemia is associated with travel away from Kericho, particularly to highly endemic districts. Travel away from the tea estates within the previous 2 months showed an odds ratio (OR) for asexual parasitaemia of 1.59 and 2.38 for well persons and outpatients respectively. Sexual stages of malaria had an OR of 3.14 (well persons) and 2.22 (outpatients) for those who had travelled. This increased risk of malaria parasitaemia with travel was concentrated among young children who had returned more than 2 weeks previously.

4. Discussion

The first recorded epidemics of highland malaria on the western rim of the Rift Valley occurred when Kenyan soldiers recruited during the First World War (1914–1918) returned from Tanzania to their villages, infected with sufficient parasites to start an epidemic (Matson, 1957). Malaria epidemics occurred again during the Second World War (1939–1945) when a tented camp of transit soldiers placed near Kericho started a large and

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sustained epidemic within the tea estate work-force (Garnham, 1945). When chloroquine was effective as an antimalarial, epidemics appeared to be contained but then epidemics returned when this drug became ineffective (Shanks et al., 2000). Sulfadoxine–pyrimethamine (SP) replaced chloroquine in 1998 as the nationally recommended first-line therapy but, since 1998, the ability of SP to clear clinical infections has rapidly declined (East African Network for Monitoring Antimalarial Treatment, 2003; Shretta et al., 2000). Artemisinin-based combinations (WHO, 2001) may have a greater than anticipated public health role in areas such as Kericho where clinical infections acquired outside of the district may serve to promote localized epidemics through the introduction of new infectious reservoirs from initially poorly managed infections (International Artemisinin Study Group, 2004).

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Table 1

Risk factors for uncomplicated *Plasmodium falciparum* malaria in tea-estate workers in the western highlands of Kenya

	Well persons (n = 2210)					Outpatients (n = 10789)				
	Sample size[a]	Asexual parasitaemia		Gametocytaemia		Sample size[a]	Asexual parasitaemia		Gametocytaemia	
		Percentage positive	Odds ratio (95% CI)[b]	Percentage positive	Odds ratio (95% CI)[b]		Percentage positive	Odds ratio (95% CI)[b]	Percentage positive	Odds ratio (95% CI)[b]
Gender										
Male	1134	10.3	NS	0.9	NS	5556	24.7	NS	2.6	NS
Female	1073	11.6		1.4		5192	23.1		2.2	
Family origin[c]										
Lowland	1116	15.2	2.67	1.8	3.69	5226	28.5	1.62	3.1	1.77
Highland	1015	6.3	(1.96–3.65)	0.5	(1.3–*)	5523	19.7	(1.48–1.77)	1.8	(1.36–2.3)
Tribe										
Luo	742	17.1	6.92	2.0	NS	3157	31.1	1.82	3.4	2.03
Kalenjin	276	2.9	(3.23–15.47)	0.4		2703	19.8	(1.61–2.06)	1.7	(1.41–2.8)
Home province										
Nyanza	1452	11.9	4.42	1.2	NS	5801	24.5	1.58	2.6	1.84
Rift Valley	303	3.0	(2.17–9.34)	0.3		2820	17.1	(1.4–1.77)	1.5	(1.28–2.64)
Home district[d]										
Endemic	801	16.6	2.36	2.1	3.29	3799	29.3	1.8	3.2	1.83
Epidemic	1374	7.8	(1.78–3.12)	0.7	(1.38–8.0)	6634	18.6	(1.64–1.98)	1.8	(1.41–2.38)
Travelled in last 2 months										
Travelled	753	14.1	1.59	2.1	3.14	4334	33.5	2.38	3.6	2.22
No travel	1457	9.3	(1.2–2.1)	0.7	(1.34–7.47)	6455	17.5	(2.17–2.6)	1.6	(1.72–2.87)
Travel province										
Nyanza	515	13.4	12.4	1.7	NS	2756	34.4	1.95	3.7	NS
Rift Valley	81	1.2	(1.8–*)	0.0		649	21.4	(1.58–2.4)	2.9	
Travel district[d]										
Endemic	295	18.0	1.58	3.1	NS	2278	37.4	1.48	4.3	1.63
Epidemic	427	12.2	(1.02–2.44)	1.6		1922	28.7	(1.3–1.69)	2.7	(1.15–2.33)

*NS: not significant, Upper limit not accurate using Cornfield statistic.

[a]Sample sizes less than the total number in each study group reflect missing values.

[b]Odds ratio with 95% confidence interval for relationships with $P < 0.05$.

[c]Highland and lowland family origin defined as being from a tribal/ethnic group whose traditional home area was either above 1500m (Kalenjin and Kisii) or below 1500 m (Luhya and Luo).

[d]Endemic and epidemic areas defined by climatic suitability (Omumbo et al., 1998).