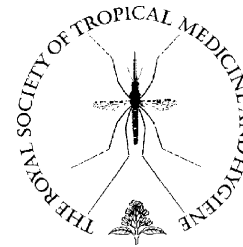




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Epidemiology of malaria transmission in forest and plain ecotype villages in Sundargarh District, Orissa, India

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Summary A study of the epidemiology of malaria transmission was undertaken in 13 tribal villages located in forest and plain areas of Sundargarh District of Orissa state, India, from January 2001 to December 2003. In forest areas, intense transmission of malaria is attributed to the highly anthropophilic vector *Anopheles fluviatilis* sibling species S and is complemented by *A. culicifacies* sibling species C. In plain areas, *A. culicifacies* sibling species C is responsible for malaria transmission. The entomological inoculation rate in the forest and plain areas was 0.311 and 0.014 infective bites/person/night, respectively, during 2003. Malaria transmission is perennial both in forest and plain areas but is markedly low in the plain area compared with the forest area. *Plasmodium falciparum* accounted for 85.0% of the total malaria cases during the study period. In forest and plain areas, the number of *P. falciparum* cases per 1000 population per year was 284.1 and 31.2, respectively, whereas the parasite rate was 14.0% and 1.7%, respectively. In forest areas, clinical malaria occurs more frequently in children aged 0–5 years and declines gradually with increasing age. The study showed that villages in forest and plain areas separated by short geographical distances have distinct epidemiology of malaria transmission. © 2006 Royal Society of Tropical Medicine and Hygiene. Published by Elsevier Ltd. All rights reserved.

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1. Introduction

Malaria is one of the major public health problems in tropical countries and an obstacle to the development of nations. Recent estimates indicate that more than 2 billion people around the globe are at risk and there are between 300–660 million episodes of clinical *Plasmodium falciparum* malaria cases (Snow et al., 2005). In India, according to statistics of the National Vector Borne Disease Control Programme (NVBDCP), approximately 1.7 million cases of malaria were reported during 2003, of which Orissa state alone contributed 24% of total malaria cases. Although Orissa state constitutes only 4% of the total population of India, it accounts for 47% of falciparum cases and 34% of all reported deaths due to malaria in India. The high malaria morbidity and mortality are mainly due to the high prevalence of falciparum malaria in areas of rural Orissa inhabited by tribals belonging to 62 ethnic tribal communities and constituting 44% of the total population of Orissa. According to an estimate, 54 million tribals of various ethnic origins residing in the forest areas account for 8% of the total population of India but contribute 30% of total malaria cases as well as 50–60% of total falciparum cases and malaria deaths in the country (Sharma, 1996). Persistent malaria transmission in tribal areas indicates that the disease is not responding to existing control measures such as indoor residual spraying, insecticide-treated mosquito nets in some areas and supported by fortnightly surveillance for malaria case detection and treatment. It is therefore imperative to understand the epidemiology of malaria as well as malaria transmission dynamics in these areas.

Malaria is a major public health problem in Sundargarh District. We used longitudinal and cross-sectional surveys to study the epidemiology of malaria in villages of two distinct ecotypes, namely villages located in forests at slightly elevated areas adjacent to clean water sources such as streams, and plain area villages located in deforested areas with proximity to a perennial river. Malaria transmission is lower in the plains relative to the forest and this could result in different degrees of immunity and, therefore, a different clinical pattern of the disease.

2. Materials and methods

2.1. Study area

Sundargarh District is located in the Garhjat hills of eastern Deccan plateau between 21°35'N and 22°35'N latitudes and between 83°32'E and 85°22'E longitudes, at an altitude in the range 200–900 m above sea level. Topographically, the area presents ideal ecological conditions for malaria transmission with undulating uplands intersected by forested hills, rocky streams and paddy fields. The area is characterised by a tropical humid climate and receives rainfall between June and September from the 'southwest monsoon' and in December and January from the 'northeast monsoon'. Average annual rainfall ranges between 160 cm and 200 cm and mean annual temperature ranges between 22 °C and 27 °C. The weather seasons are hot dry summer from April to mid June, monsoon from mid June to September, autumn from October to November, winter from December to January, and

spring from February to March. The maximum temperature during summer rises to 40–45 °C and the minimum temperature during winter falls to 5–10 °C. Fifty-one percent of the area is covered with forests and is inhabited predominantly by tribals, who constitute 62% of the total population. The area is rich in mineral resources, and industrialisation based on these resources has led to the development of new settlements, deforestation and ecological changes resulting in changes in malaria transmission patterns.

The present study was conducted in 13 villages of Sundargarh District, Orissa, from January 2001 to December 2003. These villages are grouped under Gurundia and Birkeria primary health centres (PHC) for the purpose of delivery of health services (Figure 1). Each PHC provides health services to a population of approximately 30 000. Of the 13 study villages, 8 villages with a population of 2058 at the start of the study in January 2001 were situated in deep forests at somewhat elevated areas close to perennial streams. The remaining five villages, which had a total population of 2163 in January 2001, were located in plain and flat deforested areas. Almost all (98%) of the residents of the 13 villages were tribal, predominantly of the Munda and Oram ethnic group. The average distance of all the study villages from the nearest PHC is 5–10 km. All the study villages are well connected by all-weather roads and are located at a distance of 25–60 km from the National Institute of Malaria Research (NIMR) Field Station, Rourkela.

The study protocol was approved by the Ethical Committee of the NIMR, Indian Council of Medical Research, New Delhi.

2.2. Entomological surveys

Whole-night human-landing mosquito collections were carried out in two indicator villages in each of the forest and plain areas at monthly intervals on human baits hired from the same village. Informed consent was obtained from those who served as baits during the night, who were also provided with prophylactic treatment for malaria (300 mg chloroquine every week) as long as they were involved in the study. Adult mosquito collections were made from 18:00 hours to 06:00 hours on human baits, one each indoor and outdoor. Mosquitoes landing on the bait were caught with the help of a suction tube and flashlight. Hourly collections of mosquitoes caught on human baits were kept separately in test tubes and the species were identified. The human biting rate (HBR; which is equivalent to the human landing rate) for each vector species was calculated.

In addition to human bait collections, indoor resting collections were also carried out with the help of a suction tube and flashlight from houses and cattle sheds in the morning between 06:00 hours and 08:00 hours to collect sufficient numbers of vector species for determining host feeding preference as well as sibling species composition in the study area. Human blood index (HBI), or proportion of mosquitoes that had fed on a human host, was determined for each vector species by blood meal analysis. The stomach blood of freshly-fed and semi-gravid females was smeared on Whatman No. 1 filter paper and assayed by gel diffusion technique (Collins et al., 1986) to determine whether the mosquitoes had fed on human blood.

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